CHAPTER 7

Reliability of memory

KEY KNOWLEDGE

- methods to retrieve information from memory or demonstrate the existence of information in memory, including recall, recognition, relearning and reconstruction
- the effects of brain trauma on areas of the brain associated with memory and neurodegenerative diseases, including brain surgery, anterograde amnesia and Alzheimer’s disease
- the factors influencing a person’s ability and inability to remember information, including context and state dependent cues, maintenance and elaborative rehearsal and serial position effect
- the reconstruction of memories as evidence for the fallibility of memory, with reference to Loftus’ research into the effect of leading questions on eye-witness testimonies

Methods to retrieve information from memory or demonstrate the existence of information in memory

Fallibility of memory reconstruction

Effects of brain trauma on memory

Factors influencing ability and inability to remember

The reliability of memory is crucial in various fields, including psychology, education, and law. Understanding the mechanisms of memory retrieval and the potential for errors in memory reconstruction is essential for accurate and effective communication.
Suppose someone asks you to describe your thirteenth birthday party. You may accurately recollect what took place based on your direct experience of what you saw, heard and felt at the time. But you have also stored information from conversations afterwards with friends who attended your party, from shared family stories, from previous times you've described the party to others, or from reflections on photographs and videos that you have viewed afterwards. You will take these bits and pieces and build an integrated version of your thirteenth birthday from them. This account is likely to include some accurate information. However, it is also likely to include inaccurate information that fills the gaps but were not part of the original experience.

Research findings indicate that much of what we retrieve from long-term memory is not an entirely accurate reproduction of what actually happened when encoding. Instead, it is a logical or plausible account of what might have happened, filtered and shaped by our pre-existing thoughts, attitudes and beliefs, by who we are as individuals and social beings, and by many other variables.

Although we usually retrieve accurate fragments of what we experience, human memory is prone to errors and distortions. Unlike a camera or audio recorder that captures a perfect copy of visual or auditory information, the details of human memory can change over time. Without our conscious awareness, details can be added, subtracted, exaggerated or downplayed every time we retrieve the memory. This is not an intentional distortion or manipulation of the memory. Instead, it is believed to be an adaptive process through which we assign logic and give meaning to the past, especially when our recollection of what we retrieve is unclear.

Research findings indicate that each of us has the potential to confidently and vividly remember the details of some event, yet be completely wrong. Confidence in memory is no guarantee that the memory is accurate. In fact, level of confidence has been found to be generally unrelated to the accuracy with which we retrieve information from memory. Some researchers have even found that strong confidence in the memory of minor details may actually indicate that the memory is inaccurate or even false (Reisberg, 2013).

In this chapter, we examine the reliability of memory with reference to some of the biological, psychological and social influences that can make it fallible. For example, we consider the effects of brain trauma and neurodegenerative diseases on memory (biological), how different types of rehearsal or retrieval cues can influence our ability and inability to remember information (psychological), and how memory can be manipulated by using leading questions so that it is unintentionally reconstructed in a specific way. In particular, findings of research studies on the reliability of eye-witness testimony used in courts have been a rich source of information on variables that can produce inaccuracies in what we remember (social). We start by examining methods we use to retrieve our memories.

**METHODS TO RETRIEVE INFORMATION FROM MEMORY OR DEMONSTRATE THE EXISTENCE OF INFORMATION IN MEMORY**

What methods do we use to retrieve information from memory? How can you find out whether information has been retained and therefore exists in memory? If you fail to retrieve some information does that mean the information is not actually in memory? Perhaps the information exists but you failed to retrieve it by not using an appropriate retrieval method? Perhaps the information is in memory but you can only partially retrieve it?

Research findings indicate that whether or not information is retrieved from memory and the amount of information that is retrieved depends, at least partly, on the type of retrieval method that is used. Three types of retrieval methods are called recall, recognition and relearning. Each method often involves some kind of memory reconstruction during the retrieval process.

**Recall**

Suppose that you were asked to name the seven dwarfs in the Disney production of the Snow White fairy tale. In order to correctly complete this task, you would have searched through your LTM to locate the...
required information and reproduce it in conscious awareness.

**Recall** involves reproducing information stored in memory. You bring the information into conscious awareness and doing so provides evidence that something previously learnt was retained. If you cannot recall targeted information, this does not necessarily mean it is not in memory. The use of a retrieval cue (prompt) may enable access. Whether or not a cue is used to assist the retrieval process, and therefore reproduction, depends on the type of recall method used. Three types of recall are free recall, serial recall and cued recall.

- **Free recall** involves reproducing as much information as possible in no particular order without the use of any specific cue. For example, you may attend a training course for a new job and afterwards remember a few important points without recalling the order in which they were presented. This recall method allows you to retrieve pieces of learnt information, 'freely' without following any specific order. You probably used free recall when retrieving the names of the seven dwarfs.

  In an experiment using free recall to assess some aspect of memory, participants might be required to learn a list of randomly selected numbers or words. Then, after a specific period of time they may be required to write, in any order, as many of the items from the list as they can. In everyday life, we tend to rely on free recall to retrieve all types of information, including 'bits' of information that represent an entire memory, and complex mixes of episodic and semantic information that form more substantial memories.

- **Serial recall** involves reproducing information in the order in which it was learnt. For example, if you are telling a friend about an overseas holiday and recall the names of the cities in the order in which you visited them, then you would be using serial recall. If the memory experiment described above used serial recall to assess memory, participants would be asked to recall the list in the order in which the words were presented.

  Serial recall is useful in everyday life as it enables us to recall events and other types of information chronologically, which can help give logic or meaning to the information in relevant situations. For example, serial recall is used in language to assemble sentences with words in a meaningful order, to tell someone about a personal experience you’ve just had and when recalling directions to navigate from one place to another.

- **Cued recall** involves the use of specific prompts ('cues') to aid retrieval and therefore reproduction of the required information. In the memory experiment above, participants might be given the first letter of the word in each list as a cue to assist the retrieval process. The more specific the cue, the more likely we are to locate and retrieve the sought-after information from LTM. For example, a cue for the seven dwarfs question might be the first letter of each of their names: B, D, D, G, H, S and S.

  If you could not name all seven dwarfs, it doesn’t necessarily mean that the information is not stored in your LTM (and therefore available). The required information may be stored but not immediately accessible. If you used a different method of retrieval, you may have been able to access the names of all the dwarfs. For example, the recognition method is likely to be more effective.

**Recognition**

Long after you can’t recall the names of people in your year 6 class, you may still be able to recognise them in a school photo or pick out their names from a list. This means that recognition can also indicate memory and may be effective when the recall method fails.

**Recognition** involves identifying ('recognising') the original, learnt information. The presence of the correct information acts as a cue for its retrieval from memory. For example, we might scan a list of email addresses in the hope of picking out the one we want to use or we might be called upon to identify the perpetrator of a crime from a Crime Stoppers photograph shown on TV. When the original, learnt information is in front of us and it is familiar, then we know it has been retrieved. It is like ‘knowing again’. The information has been matched to a stored representation in our memory.

  The essential difference between recognition and recall is that, with recall, the required information is not present for our identification whereas, with recognition, the information we seek to retrieve may be present and requires a judgment about whether it has been previously seen or experienced.

  Recognition usually requires identification of the required or 'correct' information from among alternatives that include incorrect information. For example, you may be able to recognise the names of the seven dwarfs if the following question was asked: ‘Which of the following are names of Walt Disney’s seven dwarfs?’

- Bashful
- Pop
- Sneezy
- Happy
- Sleepy
- Doc
- Grumpy
- Dopey
- Grouchy

When the recognition method is used, if alternatives are present, they do not necessarily have to include incorrect information, but they often do. In some cases, there may be no alternatives and we are presented with a stimulus which we will either recognise or not recognise, as with a Crime Stoppers photo. In a memory experiment, participants may be presented with test items one at a time and asked to make a yes or no decision to each.
Irrespective of the kind of information presented, we are more likely to retrieve more of the required information when using the recognition method than we will with the recall method. This suggests that more information is stored in memory than can be retrieved through recall. The recognition method provides more useful cues that assist in locating and retrieving information from LTM. For example, the name of each dwarf is a more useful cue than the first letter of the name (cued recall), let alone no name (free recall).

This is why, in an exam situation, many students tend to prefer multiple-choice or true/false questions to an essay or short-answer questions. Multiple-choice and true/false questions involve recognising the correct response from among a small number of alternatives (cues), whereas essay and short-answer questions require recall usually with few or no cues to assist retrieval of the correct information.

Research findings indicate that students consistently perform better on multiple-choice and true/false questions than on essay and short-answer questions when tested on the same material. However, there are exceptions, such as when incorrect alternative answers (‘distracters’) on multiple-choice questions are extremely similar to the correct answers, or when students expect an essay or short-answer question in an exam and use study techniques suited to that particular type of question.

**Relearning**

Most people have times when they are unable to recall or recognise information that is actually stored in LTM. Even though they are unable to retrieve this information, it does not necessarily mean it is unavailable or lost from LTM. For example, in chapter 4 you learned about the role of glutamate in synaptic plasticity. Despite now being unable to recall or recognise the specific role of glutamate, your relearning may reveal the memory.
Reloarning involves learning information again that has been previously learned (and was therefore stored in LTM). If information is learned more quickly the second time, it is assumed that some information must have been retained (or ‘saved’) from the first learning experience, whether the individual realises it or not.

Typically, relearning something takes less effort or time than it did to learn it originally. You may have discovered this for yourself when studying for a test or exam. You may believe you have forgotten some or all of the material, yet with even a small amount of reviewing you remember the information relatively quickly. By ‘restudying’, a weak link to the memory and/or a representation of the memory regains its original strength.

German psychologist Hermann Ebbinghaus (1885) is considered to be the first researcher to scientifically study relearning. Acting as his own research participant, Ebbinghaus memorised lists of three-letter ‘nonsense syllables’ such as jax, qir and kuv under various conditions of practice. When Ebbinghaus measured his memory for what he had learned, he found that, even if he could not remember a single item from the original list, he could relearn the list much more quickly a second time than he had learnt it initially. He assumed therefore that some information had been retained from the initial learning.

Relearning is also called the method of savings, or simply savings, because it can be used to measure the amount of information ‘saved’ from previous learning. For example, suppose you were a participant in an experiment and it took you ten trials (presentations) to learn a list of 12 nonsense syllables. In a subsequent experiment, perhaps six months later, it took you five trials to relearn the same list, then the savings would be 50% because it took you half the number of trials to relearn the information.

In this example, the savings are calculated using the formula:

\[
\text{Savings} = \left( \frac{\text{no. of trials for original learning}}{\text{no. of trials for relearning}} \right) \times 100\%
\]

A savings score can also be calculated on the basis of the time taken to relearn information. In this case, the formula would be:

\[
\text{Savings} = \left( \frac{\text{time for original learning}}{\text{time for relearning}} \right) \times 100\%
\]

A simple expression of the formula used to determine the savings score is:

\[
\frac{T^1 - T^2}{T^1} \times 100\%
\]

Table 7.1 Comparison of retrieval methods

<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recall</td>
<td>Reproducing information in no particular order</td>
<td>Name the last three prime ministers of Australia.</td>
</tr>
<tr>
<td>Free recall</td>
<td>Reproducing information in the order in which it was</td>
<td>Name the last three prime ministers of Australia in order from the most recent to the least recent.</td>
</tr>
<tr>
<td>Serial recall</td>
<td>learnt</td>
<td></td>
</tr>
<tr>
<td>Cued recall</td>
<td>Using a cue to assist the retrieval of information</td>
<td>Name the last three prime ministers of Australia. Their initials are MT, TA, KR.</td>
</tr>
<tr>
<td>Recognition</td>
<td>Identifying correct information from among a list of alternatives</td>
<td>Identify the last three prime ministers of Australia from the following list: Chifley, Gillard, Hawke, Abbot, Whitlam, Turnbull, Rudd, Howard, Keating, Menzies.</td>
</tr>
<tr>
<td>Relearning (method of savings)</td>
<td>Determining the amount of information saved when learning information again that has been previously learned</td>
<td>Time how long it takes to learn the last seven prime ministers of Australia. Time yourself two weeks later on the same task to test the amount of time saved in learning the information a second time compared with the first time.</td>
</tr>
</tbody>
</table>
Recall, recognition and relearning are commonly used as measures of retention to assess information stored in LTM. All differ in their relative sensitivity as measures of retention. The sensitivity of a measure of retention refers to its ability to assess the existence of information in memory and which is therefore available for retrieval. A very sensitive measure of retention is more likely to detect information that has been learned and stored in memory at some time in the past than would a measure that is not very sensitive. Research evidence indicates that:

- recall tends to be the least sensitive measure of retention
- relearning tends to be the most sensitive measure of retention
- recognition tends to be less sensitive than relearning but more sensitive than recall.

In one of the best-known experiments on the sensitivity of the three measures of retention, American psychologist Thomas Nelson (1978) used 102 university students as research participants. The students were required to participate in the study to meet one of their psychology course requirements. The experiment consisted of three stages: the initial learning stage, a stage in which recall and recognition of the initial learning were tested, and finally a relearning stage. At the beginning of the experiment, participants were not informed about their expected involvement in the second and third stages of the experiment.

In the first stage, participants were given a series of 20 number–word pairs to learn, such as ‘48–party’ and ‘95–horse’. These are called paired-associates. The second stage of the experiment occurred four weeks later, when the participants were required to undertake the testing and relearning stages of the experiment. In the testing stage, participants completed two different types of tests of their memory of the number–word pairs; activities they had not expected. Each participant was first given a test of recall. This test involved presenting the participant with the number (the cue), such as 48, then asking them to recall the target word associated with that cue, such as ‘party’. Following the test of recall, each participant was given a test of recognition. Participants were presented with a number from their original list paired with all 20 of the target words. This was something like a multiple-choice question with 20 possible correct answers. Following the test of recognition, participants were given a distraction task for 10 minutes.

The third stage of the experiment involved relearning ten of the previously learned paired associates that had been incorrectly recalled during the test of recall, as well as ten new paired associates. Participants were then given a test of recall on both the relearned information and the new information. They were then debriefed about the experiment and allowed to leave.

The results showed that a mean score of 48% of the target words were correctly recalled and 69% were correctly recognised in the testing (second stage) stage of the experiment. Furthermore, the percentage of target words correctly recalled during the relearning stage was significantly higher for old items (88%) than for new items. These findings further demonstrate that relearning is more sensitive than recognition as a measure of retention.

Reconstruction

Imagine yourself going to a fancy restaurant for dinner. You are seated at a table with a nice white table cloth. You study the menu. You tell the waiter you want the char grilled barramundi fish, with deep fried potato chunks and the salad with mayo dressing. You also order a lemonade from the drinks list. A few minutes later, the waiter arrives with your salad and drink. Later, the rest of your meal arrives. You enjoy it all, except the potatoes were a bit underdone.

If asked about your dining experience, you can probably retrieve a considerable amount of detail. For example, without looking back, answer the following questions:

- What kind of salad dressing did you order?
- Was the table cloth red checked?
- What did you order to drink?
- Did the waiter give you a menu?

You were probably able to recall everything you ordered, and maybe even the colour of the table cloth. But did the waiter give you a menu? Not in the paragraph above, but many people answer ‘yes’ because that is a logical inference based on what they already know about restaurants through prior experience. What we retrieve is not always a perfect reproduction of what happened at the time of encoding. We reconstruct our memories during retrieval. During reconstruction, if the memory has gaps or is not clear, we tend to add information that helps ensure the retrieved memory is complete and ‘makes sense’. When doing so, we may draw on past and current knowledge to infer the way things ‘must have been’ (Myers, 2007).

Memory reconstruction generally involves combining stored information with other available information to form what is believed to be a more coherent, complete or accurate memory. It is an active process and is influenced by many factors such as our pre-existing knowledge, personal experiences, values, psychological state, cues in the environment, motivations, expectations and assumptions about what might have happened. Reconstructive memory, as it is commonly called, is most evident when we retrieve an episodic memory of a specific event for which we can’t recall or are uncertain about some of the details.

Memory reconstructions are often accurate, but may also contain errors and distortions. Since
the early 1900s, researchers have investigated memory processes in numerous experiments and found that reconstruction occurs regardless of whether memories are retrieved after short or long periods. Reconstructive errors in retrieval have also been found to occur in both semantic memories (e.g. words, prose, pictures) and episodic memories (e.g., scenarios, events) (Roediger & DeSoto, 2015).

How do errors and distortions creep into memories? When we form a long-term memory, we actively encode and organise the elements and details of the experience throughout different areas of the brain. These are linked together within neural networks or pathways. When we later attempt to access the memory, we do not retrieve a simple ‘readout’ of the entire memory. Instead, we retrieve the encoded elements and actively reconstruct the memory. In the process of doing so, various factors can contribute to errors and distortions — or more precisely, what we think we remember. With repeated retrieval, the memory is subject to further distortion and it becomes harder to distinguish the details of what actually happened in the original encodings from what was added later (Roediger & DeSoto, 2015).

A well-known experiment reported by British psychologist Frederick Bartlett in 1932 first drew attention to the reconstructive nature of human memory. Bartlett believed that Ebbinghaus studied human memory in an artificial way. For example, he suggested that by using nonsense material in order to control the influence of past knowledge, Ebbinghaus also excluded important variables that impact on everyday human memory in real life, such as the influence of our prior experiences, attitudes and expectations. Therefore, instead of using nonsense syllables, Bartlett had participants read prose (a story or essay) or look at a picture. He then asked them on several later occasions to recall and describe the prose passage or draw the picture.

Each time, the participants ‘remembered’ the original stimulus material it was reproduced a little differently. If the original story had contained unusual or unexpected events, the participants tended to describe it in a more logical or ‘sensible’ way, as if they had revised their memories to make the information more closely match their personal beliefs of what was likely to be true. Bartlett concluded that we tend to remember only a few key details of an experience, and that during recall we reconstruct the memory, drawing on our personal values, beliefs and expectations to make up and add missing bits in ways that complete the memory in a logical or plausible way. This is usually done without conscious awareness of it happening.

Many subsequent studies have confirmed Bartlett’s conclusions and extended his findings about the reconstructive nature of human memory. The best-known research has focussed on the fallibility of eye-witness testimony through manipulation of the reconstruction process.
LEARNING ACTIVITY 7.1

Review questions

1. Name and describe three different methods for retrieving information from memory or demonstrating the existence of information in memory. For each method, refer to an example not used in the text.

2. Explain a key difference between recall and recognition in relation to the presence or absence of sought after information.

3. In what way is cued recall like and unlike recognition?

4. Choose one concept you have studied this semester and write a question requiring the recall method and a question requiring the recognition method.

5. In what way does the re-learning method suggest that information that cannot be retrieved by recall or recognition may still exist in LTM?

6. (a) Describe two ways of measuring retention of information in LTM using relearning (the method of savings).

   (b) Ahmed took 30 minutes to learn a list of ten Spanish words when they were first given to him. When he had to relearn them before a test the following week, it took him 5 minutes.

   (i) Using a method of savings formula, calculate the amount of retention of information from the first learning session to the second learning session.

   (ii) Explain what this figure means in terms of Ahmed’s retention of Spanish words.

7. Refer to box 7.1 on the sensitivity of the three retrieval methods. Read Nelson’s (1978) research and answer the following questions:

   (a) Name the experimental design.

   (b) What is an advantage of using this design for this experiment?

   (i) What is a limitation of using this design for this experiment?

   (c) Name the sampling procedure.

   (d) What question about the ethical value of justice could be raised in relation to the study?

   (e) What do the results obtained indicate about the relative sensitivity or effectiveness of the three retrieval methods?

8. (a) List the three retrieval methods in order of effectiveness for accessing and recovering information in LTM.

   (b) Explain your choice of rankings.

9. Define the meaning of reconstruction in relation to memory.

10. Explain how and why memory construction is believed to occur.

LEARNING ACTIVITY 7.2

Identifying retrieval methods

For each of the following examples, identify one or more retrieval methods that is most likely being used: free recall (FR), serial recall (SR), cued recall (CR), recognition (RG) or relearning (RL).

- remembering a friend’s mobile phone number with no cues
- playing hangman
- using photos from a trip to describe your experiences
- identifying a friend who appears in a news report
- remembering the directions to a friend’s house
- writing out the words of a song from memory
- reading back over your course notes before an exam
- writing out the words of a song with the music of the song playing in the background.

LEARNING ACTIVITY 7.3

Reflection

Without reading further, suggest a way in which the reconstructive nature of memory may be intentionally manipulated to create a false memory, either for a positive or a negative purpose.
FALLIBILITY OF MEMORY RECONSTRUCTION

Reconstruction of memories provides evidence for the fallibility of memory. This has been demonstrated by numerous research studies conducted by American psychologist Elizabeth Loftus and various colleagues on eye-witness testimony.

**Eye-witness testimony** is any firsthand account given by an individual of an event they have seen. It is best known for its use by police to acquire details about a crime and even to identify the perpetrators. Eye-witness testimony is used often in court and juries tend to view it as a reliable source of information.

Loftus has found that eye-witness testimony is not always accurate because eye-witnesses reconstruct their memories and their reconstructed memories can be manipulated by leading questions that contain misleading information. Many of her studies typically involve showing participants a short video or set of slides on an event such as a car accident. Participants are then asked specific questions about the scene they ‘witnessed’. Sometimes, information that was not present in the actual scene or which contradicts the scene is introduced. At other times, leading questions are asked.

Loftus’s research makes it clear that leading questions can be used to manipulate memory reconstruction and therefore information that is reported by eye-witnesses. A **leading question** has content or is phrased in such a way as to suggest what answer is desired or to lead to the desired answer. For example, suppose that you witness a car accident and are later asked, ‘How fast was the car going when it ran the stop sign?’ According to Loftus (1975), this is a leading question because it contains a **presupposition** — information that should or must be true for the question to make sense. The question presupposes, or ‘assumes’, that there was a stop sign. But what if there was no stop sign? You might answer the question anyway because it was a question about how fast the car was going and not a question about the presence of a stop sign or whether the car ran a stop sign. Loftus proposes, however, that because of the way the question was worded, you might add the new false information about the stop sign to your memory of the event. Then you will be more likely to recall it as a part of your reconstructed memory when answering a question about it, such as ‘Did you see the stop sign?’, at a later time.

**Research by Loftus**

One of the most influential of Loftus’s research studies on memory reconstruction was conducted with her student John Palmer (1974). The study consisted of two laboratory experiments that investigated the influence of question wording on memory reconstruction, particularly how information supplied after an event can distort a witness’s memory for that event.

In the first experiment, 45 volunteer students from the university where Loftus worked were each shown seven short videos of car accidents. These videos ranged from 5 to 30 seconds in duration. After viewing each video, the participants (‘eye-witnesses’) were asked to write a description of the accident and to answer some specific questions about the accident, including a critical ‘leading’ question that required them to estimate the speed of the cars involved in each collision.

There were five conditions in the experiment, with nine participants randomly assigned to each condition. In each condition, a different word (verb) was used to complete the critical question, so different groups of participants were given different versions of the question. The question asked, ‘About how fast were the cars going when they _____ each other?’ It was completed with each of the following words: **smashed**, **collided**, **bumped**, **hit** and **contacted**.

For example, in condition 1, the critical question was ‘About how fast were the cars going when they smashed into each other?’ In condition 2, the critical question was ‘About how fast were the cars going when they collided with each other?’, and so on. In order to control the potential influence of the order in which the videos were viewed, the videos were presented in a different order to each group of participants.
As shown in table 7.2, the wording of the question influenced the speed estimates given by the participants, with the most ‘intense’ verb (*smashed*) bringing about the highest speed estimates (a mean of 40.8 miles per hour) and the least ‘intense’ verb (*contacted*) bringing about the lowest speed estimates (a mean of 31.8 miles per hour). The differences in speed estimates were found to be statistically significant, which means that chance factors could not account for the results. Loftus and Palmer suggested that the results could be due to participants’ memories being distorted by the verbal label used to describe the intensity of the car crash. However, they also recognised that the results could have been influenced by an uncontrolled extraneous variable called *response bias*; that is, participants were uncertain about the exact speed of the cars and may therefore have adjusted their estimates to fit in with the expectations of the researcher.

**TABLE 7.2** Speed estimates for each verb used

<table>
<thead>
<tr>
<th>Verb</th>
<th>Mean estimate of speed (mph)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smashed</td>
<td>40.5</td>
</tr>
<tr>
<td>Collided</td>
<td>39.3</td>
</tr>
<tr>
<td>Bumped</td>
<td>38.1</td>
</tr>
<tr>
<td>Hit</td>
<td>34.0</td>
</tr>
<tr>
<td>Contacted</td>
<td>31.8</td>
</tr>
</tbody>
</table>


In the second experiment, a procedure similar to that for the first experiment was used. This time, 150 different university students who volunteered for the experiment were randomly assigned to one of three groups (conditions) and viewed a 1-minute video that included a 4-second scene of a multiple car crash. The participants were then questioned about the accident. Group 1 was asked ‘About how fast were the cars going when they smashed into each other?’ Group 2 was asked ‘About how fast were the cars going when they hit each other?’ Group 3 was not asked a question about the speed of the cars. The results obtained showed that the mean speed estimate for the question with *smashed* into was 10.46 miles per hour and the mean speed estimate for the question with *hit* was 8.00 miles per hour. The difference in the mean scores was found to be statistically significant.

One week later, the participants returned for the second part of the experiment. Without viewing the video again, they were required to answer a series of 11 questions about the car crash. This time, the critical question was ‘Did you see any broken glass?’ This question was ‘hidden’ among the other questions that served as ‘distracters’. It was also placed in a random position on each participant’s question paper. There was, in fact, no broken glass at the accident scene.

As shown in table 7.3, the wording of the original question in the first part of the experiment influenced whether or not participants reported seeing broken glass. Although most participants accurately reported not seeing any broken glass, more participants who had been given the question with the word *smashed* into (16) reported seeing broken glass than did those who had been given the question with the word *hit* (7). These results were also found to be statistically significant.

**FIGURE 7.8** Loftus found that the wording of a question influenced the participants’ memory reconstruction of the accident they had viewed. The more intense verbs brought about the highest speed estimates.
In explaining the results, Loftus and Palmer suggested that in the first part of the experiment, participants formed a memory of the car crash they witnessed on viewing the video. Integrated with this memory was the additional piece of ‘new’ false information supplied after the event about the cars having either ‘smashed’ into or ‘hit’ each other.

This information was included as a presupposition in the critical question on the speed of the cars. When asked one week later whether they saw any broken glass at the accident scene, participants remembered broken glass that wasn’t really there.

Over time, information from the two different sources (events witnessed when viewing the video and the presupposition in the leading ‘critical’ question asked afterwards) had been integrated in the reconstruction of a new distorted memory. Participants were unable to tell that key information in their memory had now come from different sources. This has been described as source confusion. Source confusion arises when the true source of the memory is forgotten or when a memory is attributed to the wrong source. In Loftus’s studies, ‘misinformation’ provided in leading questions after the event become confused with the details of the original memory.

Numerous other research studies by Loftus as well as other researchers have confirmed that the memories of eye-witnesses are reconstructions, not exact replicas of the events witnessed. They have also confirmed Loftus’s original findings that eye-witness memories can be altered by post-event exposure to inaccurate information introduced during questioning. For example, people have incorrectly recalled stop signs as give-way signs, green stop lights as shining red, non-existent barns along empty country roads, non-existent mothers with prams, a blue car used in a crime scene as white and even Minnie Mouse when they really saw Mickey Mouse (Loftus, 1993).

Although eye-witnesses in a laboratory setting may think, feel and behave differently when observing a crime compared to eye-witnesses in a real-world setting, eye-witness testimony cannot be regarded as infallible, even when the witness is making every possible effort to be truthful. Among many other variables, eye-witness testimony can be distorted by leading questions that contain ‘misleading’ information. This is the main reason why leading questions by prosecutors and barristers are disallowed in courtroom proceedings.

Loftus has proposed that any model of memory should include the process of reconstruction that occurs when new information is integrated into the original memory of an event. Figure 7.9 shows a traditional model of recall from LTM compared with Loftus’s model, which includes an extra step of integrating new information. New information acquired after the original experience is integrated with information in the original memory, resulting in recall of a reconstructed or altered version of the original memory. Later, if you are asked a question about the original experience, your recall will not be of the actual original experience, but of your reconstruction of the experience.

**Figure 7.9** A comparison of Loftus’s model of recall from LTM with the traditional model. Loftus’s model includes an extra step of integrating new information acquired after the original experience, which may be used in a reconstructed memory that does not accurately reflect the original experience.
PLANTING FALSE MEMORIES

Elizabeth Loftus has also extensively researched and written about false memories. These are memories of events that are distorted or made up and that an individual believes to have experienced but that never actually took place. Following is an extract from one of Loftus’s articles on false memories.

It is one thing to change a stop sign into a yield sign, to turn Mickey into Minnie, or to add a detail to a memory report for something that actually did happen. But could one create an entire memory for an event that never happened? My first attempt to do this used a procedure whereby participants were given short narrative descriptions of childhood events and encouraged to try to remember those events. While participants believed that all of the descriptions were true and had been provided by family members, one was actually a pseudoevent that had not occurred. In this study, approximately 25% of participants were led to believe, wholly or partially, that at age 5 or 6 they had been lost in a shopping mall for an extended time, were highly upset, and were ultimately rescued by an elderly person and reunited with their family. Many added embellishing details to their accounts.

The method of using family members to help plant false memories can simply be called the lost-in-the-mall technique. Many investigators have used the lost-in-the-mall technique to plant false memories of events that would have been far more unusual, bizarre, painful or even traumatic had they actually occurred. Participants have been led to believe that they had been hospitalised overnight or that they had an accident at a family wedding. They have been convinced that they had nearly drowned and had to be rescued by a lifeguard. They have been persuaded by the suggestion that they were once the victims of a vicious animal attack.

Most studies find that a significant minority of participants will develop partial or complete false memories. In one set of studies reviewed by a team of psychologists, the average false memory rate was 31% (but in individual studies, the data can vary). Sometimes people have been resistant to suggestions, as they were when investigators tried to plant false memories of having received a rectal enema. Conversely, sometimes false memories have been planted in the minds of more than 50% of exposed individuals, as they were when investigators tried to plant false memories of having gone up in a hot-air balloon ride. Particularly striking are the complete false memories, or what might be termed rich false memories, which are experiences about which a person can feel confident, provide details, and even express emotion about made-up events that never happened.


**LEARNING ACTIVITY 7.4**

**Review questions**

1. What is eye-witness testimony?

2. (a) Explain what a leading question is with reference to the use of a presupposition.
   (b) Give an example of a leading question with a presupposition, other than one given in the text.

3. (a) Explain, with reference to research evidence, how a leading question can be used to manipulate memory reconstruction by eye-witnesses.
   (b) What does this evidence suggest about the fallibility or reliability of eye-witness testimony?

4. Explain whether Loftus’s research findings on the reconstructive nature of memory are relevant to long-term memories other than episodic memories.

5. When deciding whether or not a particular event occurred just as it was described to you by the sole eye-witness, what are three factors that should be considered?
LEARNING ACTIVITY 7.5

Reflection
Memory provides means of recording our life experiences and developing our self-concept or personal identity. Comment on whether your knowledge that memory is fallible should influence your confidence in what you know about your past and your sense of self.

LEARNING ACTIVITY 7.6

Analysis of data
1 (a) Graph the results in table 7.2.
   (b) Describe and explain the results in the graph with reference to the experimental procedures used by Loftus and Palmer (1974).
2 Explain whether or not conclusions drawn from table 7.2 are influenced by the lack of a control group in the experiment.
3 (a) Graph the results in table 7.3.
   (b) Explain why 16 participants in the ‘smashed’ verb condition reported seeing broken glass.
   (c) Suggest an explanation for six control group participants reporting that they saw broken glass.
   (d) What do the data in table 7.3 indicate about participant attrition?

LEARNING ACTIVITY 7.7

Evaluation of research by Loftus and Palmer (1974) on memory reconstruction
Evaluate the research study conducted by Loftus and Palmer (1974). You may present your evaluation of the two experiments as an annotated diagram such as a flowchart. You are required to:
- formulate a research hypothesis that could have been tested by the procedures used in each experiment
- identify the sample in each experiment and the population from which they were drawn
- identify the participant selection and allocation procedures
- identify the operationalised variables in each experiment
- identify the conditions of each experiment
- identify the type of experimental design used
- briefly state the results obtained
- briefly state a conclusion based on the results obtained
- briefly state what the conclusion suggests about the accuracy of eye-witness testimony
- briefly state the researchers’ explanation of the results
- identify a potential extraneous or confounding variable that could impact on the results obtained if uncontrolled and explain how it was controlled
- comment on the extent to which the results can be generalised.

EFFECTS OF BRAIN TRAUMA ON MEMORY

Many causes of memory failure or loss have a neurological basis, which results from some sort of injury or damage to the brain, usually in a specific area associated with memory. The term brain trauma is an ‘umbrella’ term that refers to any brain injury that impairs the normal functioning of the brain. The effect can be mild or severe, temporary or permanent. Some brain injuries may be congenital (inherited), but most are acquired at some time after birth through an event such as impact to the head that jolts the brain, a stroke, infection, lack of oxygen, a drug use episode, prolonged alcohol or substance abuse, a tumour, or by a neurodegenerative disease (Brain Injury Australia, 2016).

A neurodegenerative disease is a disorder characterised by the progressive decline in the structure, activity and function of brain tissue. Essentially, neurons within the brain tissue (‘neuro’) gradually become damaged or deteriorate (‘degenerate’) and lose their function, hence the term ‘neurodegenerative’. With neurodegenerative diseases, the gradual deterioration is usually age-related. For example, Alzheimer’s disease is an age-related neurodegenerative disease linked to damaged neurons, resulting in progressive memory failure and loss as well as a range of other problems. It is age-related because it is more common in older people and the problems usually worsen with age.

The term amnesia is used to refer to loss of memory that is inconsistent with ordinary forgetting. Memory loss may be either partial or complete, temporary or permanent. Brain trauma commonly results in some kind of amnesia. The nature, location and severity of the injury determine the specific characteristics of the amnesia.

There are many different kinds of amnesia, each of which has a different pattern of symptoms. Generally, someone with amnesia may be unable to access information from LTM or have difficulties forming new memories. Often there are difficulties with certain types of information, for example, loss of explicit memories but not implicit memories. Cases studies have been reported of people who become amnesic for the meaning of nouns, but not verbs, and vice versa. There are other case studies of people who become amnesic for animals, but not people, or who become amnesic for human faces but not for other objects. Though having no sense of who you are is often depicted in movies, it is rare for amnesia to cause a sudden loss of self-identity.

One type of amnesia with a specific kind of memory loss is called anterograde amnesia. In this section, we examine anterograde amnesia with reference to brain trauma and neurodegenerative diseases. We then examine the effects of brain trauma...
on areas associated with memory, focusing on damage due to brain surgery or Alzheimer’s disease, which is the most common type neurodegenerative disease.

**Anterograde amnesia**

If brain trauma causes loss of memory for information or events after the trauma occurs, it is called **anterograde amnesia** (antero means forward — in this case, forward in time). People with anterograde amnesia lose the ability to form or store new long-term memories. They typically have little difficulty retrieving memories stored before their brain injury, but they cannot remember what has happened since. They usually don’t remember new information for more than a very short period and their problem becomes clear when interrupted for some reason. For example, they may read a newspaper article and, if distracted, read the article again as if it were new because they are absolutely unable to remember what they have just read. In some cases they may forget what they have done in the instant before. They may meet a person, have a conversation, go into another room for a moment and on returning will have no recollection of having already met and spoken with that person. New experiences seem to leave no enduring record, as though nothing new can get from STM to LTM.

Anterograde amnesia is often found to be associated with damage to the medial temporal lobe area, particularly the hippocampus and connections linking the medial temporal lobe with the frontal lobes. A common cause among younger people is a traumatic brain injury caused by a blow to the head or by the head being forced to move rapidly forward or backward, usually with some loss of consciousness. When the head is struck hard, the brain slams against the inside of the skull. As a result of this blow or rapid movement, brain tissue may tear, twist or bleed.

Among older people, anterograde amnesia is a common symptom of Alzheimer’s disease. It is also common among people with another type of neurodegenerative disease called Korsakoff’s syndrome. This disease primarily damages an area within the middle of the brain where the thalamus is located as well as large areas of the frontal lobes. **Korsakoff’s syndrome** occurs mainly in people who are chronic alcoholics and is linked to the prolonged loss of thiamine (vitamin B) from their diets. Alcoholics who obtain most of their calories from alcohol and neglect their diet most often have this thiamine deficiency. Although Korsakoff’s syndrome is considered to be a neurodegenerative disease, the symptoms may appear suddenly within the space of days (Kolb & Whishaw, 2014).

**People with anterograde amnesia do not necessarily have a problem forming new implicit memories, providing evidence of the independence of explicit and implicit memories. In many tests of implicit memory, the results of patients with anterograde amnesia are indistinguishable from those of ordinary individuals. For example, they can satisfactorily learn new procedural motor skills and acquire conditioned responses.**

Among the earliest evidence is a report based on classical conditioning. In 1901, Swiss psychologist Édouard Claparède secretly positioned a pin in his hand before shaking hands with a female patient who had anterograde amnesia due to Korsakoff’s
syndrome. The patient received a pinprick and the following day was reluctant to shake hands when Claparède reached out to do so. She gave no indication that she recognised Claparède or of having remembered anything about the previous encounter when questioned about it. However, the refusal behaviour indicated she had actually remembered something about the previous day’s event. More conventional experiments have confirmed that these types of conditioned responses are indeed preserved in amnesic patients (Baddeley, 1999; Reisberg, 2013).

Anterograde amnesia is believed to result from a failure of memory encoding and storage because of disruption to consolidation. New information is processed, but almost immediately forgotten, never making it into the cortical regions where long-term memories are stored. Regardless of its specific cause, STM tends to remain intact (Andreasen & Black, 1996).

Anterograde amnesia can be contrasted with retrograde amnesia for which there is loss of memory for information or events experienced before the trauma occurs. The memory loss may extend back a few moments, days, weeks or sometimes years. Older memories may be accessible, whereas more recent memories are not. Retrograde amnesias are often caused by a blow to the head which jolts the brain too, such as one received in a car accident, a boxing match or a sporting accident. It is also commonly experienced by people with severe depression who have been treated by electroshock therapy (ECT) involving administration of brief jolts of electricity to the brain.

**BOX 7.3**

**Retrograde amnesia**

If brain trauma affects memory for information or events experienced before the trauma occurs, it is called retrograde amnesia (retro means backwards — in this case, backwards in time).

A very detailed case study of retrograde amnesia was reported by English neurologist Ritchie Russell (cited in Baddeley, 1999). The case involved a 22-year-old greenkeeper who was thrown from his motorcycle in August 1933. There was a bruise in the left frontal lobe area and slight bleeding from the left ear, but no fracture was seen on X-ray examination. A week after the accident he was able to converse sensibly, and the nursing staff considered that he had fully recovered consciousness. When questioned, however, he said that the date was February 1922 and that he was a schoolboy. He had no recollection of five years spent in Australia, two of which were spent working on a golf course.

Two weeks after the injury Russell remembered the five years spent in Australia, and remembered returning to England, but the previous two years were a complete blank. Three weeks after the injury he returned to the village where he had been working for two years. Everything looked strange, and he had no recollection of ever having been there before. He lost his way on more than one occasion. Still feeling a stranger to the district, he returned to work. He was able to do his

(continued)
work satisfactorily, but he had difficulty in remembering what he had actually done during the day. About ten weeks after the accident, the events of the past two years gradually returned and finally he was able to remember everything up to within a few minutes of the accident.

Typically, people who experience retrograde amnesia find that their inability to remember information and events leading up to the brain trauma gradually disappears. The period for which the memory is lost shrinks as the person gradually recovers their memory. However, people who have experienced retrograde amnesia typically find that their memory for the period immediately before the accident is never recovered.

In addition, episodic memory is more severely affected than semantic memory, so that the person may remember words and general knowledge (such as who their country’s leader is, how everyday objects work, colours, and so on) but not specific events in their lives. Procedural memories are typically not affected at all.

**Figure 7.14** The 2002 movie *The Bourne Identity* with Matt Damon in the lead role portrays retrograde amnesia. Retrograde amnesia involves a loss of memory for information or events experienced before brain trauma event.

### LEARNING ACTIVITY 7.8

**Review questions**

1. What is amnesia?
2. Explain the meaning of the phrase ‘amnesia resulting from brain trauma and neurodegenerative disease’.
3. Why are Alzheimer’s disease and Korsakoff’s syndrome considered to be neurodegenerative diseases?
4. What distinguishes a neurodegenerative disease from other types of brain trauma?
5. In what way is the onset of amnesia due to a neurodegenerative disease likely to be different?
6. (a) Explain the meaning of anterograde amnesia, with reference to explicit and implicit memories.
   (b) How does anterograde amnesia impact on learning?
   (c) In what way do learning and memory problems typically associated with anterograde amnesia provide evidence of the independence of explicit and implicit memory?
7. Voula was involved in a car accident as a passenger. She was not wearing a seatbelt and hit her head on the front windscreen when the two cars collided. She was unconscious for a short time. Brain scans showed there was no permanent brain damage, however, Voula experienced memory problems for some time after the accident.
   If Voula suffered anterograde amnesia, what memory problems is she likely to experience?

### LEARNING ACTIVITY 7.9

**Media analysis/response on anterograde amnesia**

The movie *Memento* referred to in figure 7.12 is widely described in the popular media as accurately depicting amnesia and memory processes.

Comment on how accurately the movie depicts anterograde amnesia and other aspects of memory, with particular reference to each of the following:

1. The likelihood of the lead character Shelby acquiring anterograde amnesia from the reported cause.
2. Whether it is possible for Shelby to have a vivid memory of the cause of his amnesia.
3. The movie’s depiction of symptoms involving explicit memory
4. The movie’s depiction of symptoms involving implicit memory
5. Whether the myth that amnesia is marked by a loss of identity is perpetuated.
6. Whether Shelby, as he states, actually has ‘no short-term memory’ and whether it is possible for him to have no STM.
Brain surgery

In 1957, the publication of a case study drew the attention of psychologists to the importance of the medial temporal lobe area in memory and provided compelling evidence for the separation of explicit and implicit memories. The case study documented memory problems experienced by American patient H.M. who had undergone brain surgery. The patient, whose real name was Henry Molaison, subsequently participated in hundreds of research studies on memory until he died in 2008 at age 82. However, until his death, he was known only by the initials H.M. to protect his privacy.

In 1953, when Molaison was 27 years old, he agreed to brain surgery to treat the severe epilepsy from which he had been suffering since the age of ten. Molaison's epilepsy was unresponsive to anti-convulsant medications and other treatments. It was also extremely debilitating and he had difficulty holding even a simple job. At the time, doctors knew that, in many patients with epilepsy, seizures started in either the right or left hemisphere, usually in the medial temporal lobe (Scoville & Milner, 1957).

Because Molaison's seizures were so severe, and because their precise origin could not be determined, his neurosurgeon decided to remove the medial temporal lobe from each hemisphere. Altogether, over 5 centimetres of tissue was 'sucked out' from each lobe. This included about two-thirds of each hippocampus, most of each amygdala, and adjacent cerebral cortex from around the hippocampus and amygdala. Although some of the hippocampus and amygdala remained in each lobe, these structures and surrounding neural tissue were so damaged ('lesioned') that what was left was believed to be useless (Milner & Corkin, 2010).

Medically, the surgery was successful in terms of its goals. Molaison's seizures declined in their frequency and severity, and could also be controlled with medication. His personality was basically unchanged and almost all cognitive functions remained unaffected. Molaison could conduct a conversation as normally as most people, as long as he was not distracted. He had a good vocabulary, normal language skills and slightly above-average intelligence. However, there was a huge cost. The surgery left him with serious memory problems.

Molaison could not remember things that happened in the period leading up to his operation. This memory loss was virtually ‘total’ for about 2 years pre-surgery and ‘partial’ back to about 10 years pre-surgery. Overall, in relation to episodic memories, he could not remember any event that happened at a specific time and place but he had retained the gist of personal experiences. He could describe in a general way his life up until his operation. He could talk about experiences, but could not report specific details.

**Figure 7.15** (a) Location of the hippocampus and amygdala in the medial temporal lobe area. (b) Molaison had the hippocampus, amygdala and surrounding cortex in the medial temporal lobe area of each hemisphere surgically removed to treat his epileptic seizures. As a result, he lost certain past episodic memories and was incapable of forming new long-term explicit memories — both episodic and semantic memories.
More significantly, Molaison had anterograde amnesia and was therefore incapable of forming new episodic or semantic memories. For example, Molaison could no longer remember what he had eaten for breakfast when asked shortly afterward, or why he was in hospital. He had to be reintroduced to his doctors every time he visited them, including Brenda Milner, his neuropsychologist who tested him regularly for some 50 years. Molaison had almost no knowledge of current events because he forgot the news almost as soon as he had seen or heard something. He had no idea of what time of day it was unless he had just looked at a clock, and each time he was told his uncle died he reacted with surprise but could never actually experience sadness.

However, Molaison’s short-term ‘working’ memory was relatively normal. For example, he could amuse himself doing crossword puzzles. And, if given a series of numbers to learn during psychological testing, he could recall about seven numbers like most people. As long as he paid attention to a task and thought about or actively repeated it aloud, he could retain information in short-term memory (and therefore conscious awareness) for as long as required. However, as soon as he was distracted and his attention was therefore diverted to something else, he immediately forgot about it. The information vanished without a trace and could not be recalled thereafter (Ogden & Corkin, 1991).

Furthermore, Molaison could also learn and retain new motor skills, so formation of these types of procedural memories was also relatively normal. For example, he learnt a new motor skill involving ‘mirror drawing’ for which he had to trace around a shape such as a star that could only be seen in a mirror. He progressively improved with practice on this and other motor learning tasks over a period of three days. However, he could never recall having seen and therefore been exposed to the test materials or engaged in practice on the task at any previous time.

Molaison’s case and studies of other people with amnesia following brain surgery provide similar evidence for the crucial roles of various brain structures and regions in memory processes, in particular, the roles of the hippocampus, cerebral cortex, amygdala and cerebellum which we will examine in the next section. When considering their roles, it should be kept in mind that they are all anatomically interconnected and interact with each other in memory processes together with other structures and regions. They are all part of an integrated learning and memory system that extends throughout the brain. However, each structure has distinguishable roles that can be isolated and studied.

**Hippocampus**

Molaison’s case illustrates that removal of (or damage to) the hippocampus in each hemisphere disrupts identifiable memory processes. It does not seem to affect the formation, storage or retrieval of procedural memories, but the formation of semantic and episodic memories and their transfer to the cerebral cortex for storage may be affected. For example, a person can still learn how to serve in tennis or use an elevator, but will not remember any aspect of the learning experience such as when, where or how the learning occurred.

Removal of H.M.’s hippocampi is likely to have impaired the consolidation process, which probably accounts for why Molaison was incapable of forming new long-term episodic or semantic memories. Consolidation was unable to occur due to the lack of structures that undertake the process, not only through the loss or most of the hippocampus in each hemisphere, but also other medial temporal lobe areas and synaptic connections that may be involved in the formation and transfer of explicit memories.

Other studies have also provided evidence that supports this. For example, monkeys and people who lose both hippocampi to surgery or disease also lose most of their explicit memories of whatever they learned during the preceding month, though their older memories tend to remain intact. This includes the explicit content of emotional memories formed when highly aroused (but not the expression of the emotional qualities or reactions, such as an elevated heart rate if fearful). The longer both hippocampi and their pathways to the cortex are left intact after learning, the smaller the memory loss, most likely because of the time available for consolidation and transfer to cortex. Removal of one hippocampus — either one — does not seem to cause much memory impairment. It is only when both are removed or severely damaged that profound difficulties are experienced in forming new memories. The greater the loss or damage, the greater the impairment (Di Gennaro et al., 2006; Gluck, Mercado & Myers, 2008; Schacter, Gilbert & Wegner, 2009).

The fact that H.M. was able to learn the hand-eye coordination skills required for mirror drawing, despite having absolutely no memory of having practised the task before, also provides evidence of the existence of explicit and implicit memories and that they are distinctively different. In addition, H.M. had retained a good deal of previously stored long-term memories suggesting the hippocampus is not entirely responsible for their retrieval.

Although H.M. was unable to remember anything that left STM, his STM was still functional. Given that hippocampal removal did not affect H.M.’s STM in any significant way, this provides evidence that STM
is different from LTM and that the hippocampus is not involved in STM encoding, storage or functioning, other than possibly the transfer of information about facts and events from STM to LTM.

Molaison’s task was to trace between the two outlines of a star (and other shapes) while looking only at his hand in a mirror.

**FIGURE 7.16** Despite surgical removal of the hippocampus in each hemisphere, Molaison could learn mirror drawing and improve with each training session (so procedural memory for motor skills was intact). However, he could never recall ever having seen the materials (so formation of new explicit memories was impaired).

**BOX 7.4**

**The hippocampus, spatial learning and spatial memory**

The earliest evidence that the hippocampus is involved in spatial learning and memory comes from studies with animals. In one of the best-known studies, British psychologist Richard Morris and his colleagues (1982) conducted an experiment with rats in what they called a water ‘maze’, which is an unusual choice of terms because the task is performed in an open wading pool and not in a labyrinth-like series of pathways.

The researchers set up a circular tank about one metre in diameter, filled with opaque, milky water that obscured a platform submerged just below the surface. The water temperature was sufficiently stressful to motivate the animals to escape, but not so stressful as to inhibit learning. The platform provided a means of escape from the water. This apparatus was used to compare the performance of three groups of rats in swimming through the water maze to the platform.

Group 1 comprised rats with a cerebral cortex that had been surgically damaged in the upper area of the frontal lobe. Group 2 comprised rats with a surgically damaged hippocampus. Group 3 comprised rats with no surgically damaged brain region or structure.

**FIGURE 7.17** A rat in a Morris water maze test swimming to find the submerged platform.

(continued)
When a group 3 ‘normal’ rat was placed in the tank, it would swim around until it found the platform and then pull itself up. Each time it was placed in the tank, it located the platform more quickly, eventually working out the most direct route and thereby demonstrating spatial learning and memory. When a group 1 rat (with cortical damage) was placed in the tank, it performed about as well as a group 3 ‘normal’ rat. After several trials, it would learn a direct route through the maze to the platform. However, whenever a group 2 rat (with hippocampal damage) was placed in the tank, it showed little evidence of learning or memory. As shown in Figure 7.18, these rats failed to learn a direct path to the platform, performing in each trial as if it was the first trial. The results of this study indicate that the hippocampus is important in spatial learning and memory. It also suggests that LTP, which is known to occur in the hippocampus, was prevented by the hippocampal damage.

**Figure 7.18** Typical swimming paths shown by rats within a water maze. Normal rats (c) rapidly acquire a direct path, as do rats with cortical damage (a), whereas hippocampal damage results in a failure to learn (b).


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**LEARNING ACTIVITY 7.10**

**Review questions**

1. Who is H.M. and why is he well known to memory researchers?
2. List the STM and LTM memory impairments experienced by H.M. after his surgery and what these indicate about the roles played and not played by the hippocampus in explicit and implicit memories.
3. What does the H.M. case study suggest about where LTM is stored in the brain? Explain with reference to the case study.

**LEARNING ACTIVITY 7.11**

**Evaluation of research by Morris et al. (1982) on the role of hippocampus in spatial learning and memory**

Consider the experiment by Morris et al. (1982) with rats in a water maze and answer the following questions.

1. Identify the experimental and control groups.
2. Identify the operationalised independent and dependent variables for the experiment.
3. Formulate a research hypothesis that would be supported by the results obtained for the experiment.

4. Why are the results considered to be evidence of the role of the hippocampus in (a) spatial learning and memory? (b) LTP?
5. Which of the two hippocampi would have most likely been damaged by the researchers?
6. What variable other than hippocampal damage or spatial learning and memory may be a possible explanation of the results?
7. What conclusion can be drawn from the results?
8. To what extent can the results be generalised to humans?

**Amygdala**

Studies of people who have had either or both amygdalae surgically removed indicate that their loss tends not to result in STM, procedural or explicit memory problems. The separate roles of the left and right amygdala, however, are still not yet fully understood (Feinstein, et al., 2013; McGaugh, 2013).

Given the crucial role of the amygdala in the formation of emotional memories, problems are usually experienced with aspects of these types of memories when it is damaged. For example, an individual without an amygdala may remember the semantic and episodic details of a traumatic or joyful event stored in long-term memory, but not the emotional qualities of that event. Nor are emotionally arousing events that trigger the release of adrenaline likely to be well-remembered given the critical role played by the amygdala in enhancing storage of these memories. There may also be an impaired ability to recognise facial expressions of emotions, especially
fear. Loss of the right amygdala tends to more severely impact on this type of facial recognition. Problems with emotional memories are more likely when both amygdalae are lost, but not necessarily all types of emotions. Impairments in facial recognition of emotions after amygdala damage may be highly variable across different individuals and across different types of emotion. If either or both amygdalae are damaged, the degree of impairment will depend on the site, extent and nature of the damage (Cristinzio, Sander & Vuilleumier, 2007; Feinstein, et al., 2013).

Acquisition of conditioned fear responses appears to critically involve the amygdala. People (and other mammals) without an amygdala or severe damage to both are unable to acquire a conditioned fear response. These individuals can usually form conscious explicit memories of the details of the experience, but not implicit classically conditioned memories that would enable them to express fear, such as fight, flight or other fear reactions. Removal of the amygdalae may also abolish all signs of fear to an unlearned or previously learned stimulus. For example, a rat typically reacts with an unlearned fight-flight-freeze response to a cat. But without a fully functional amygdala, as observed in one study, the rat may climb on a cat and try to bite it (Thomson, 2000).

**BOX 7.5**

Research on the role of the amygdala in the acquisition of a classically conditioned fear response

One of the best-known studies with human participants on the role of the amygdala in implicit classically conditioned memories involving fear responses was conducted by American psychologist Antoine Bechara and his colleagues (1995). The study involved three participants, each with significant brain damage:

- **S.M.**, who had a damaged amygdala in each temporal lobe (called **bilateral amygdala damage**) but no damage to either hippocampus
- **W.C.**, who had a damaged hippocampus in each temporal lobe (called **bilateral hippocampal damage**) but no damage to either amygdala
- **R.H.**, who had damage to each amygdala and each hippocampus (called **bilateral amygdala and hippocampal damage**).

All three participants were shown a series of coloured lights and each time a blue light was presented a loud, startling boat horn was sounded. After several presentations (i.e. trials), the blue light was presented alone and each participant’s ‘skin conductance response’ was measured as an indicator of their level of conditioned fear.

The results are shown in table 7.4. When all participants were asked to report contextual information about what had happened during the experiment, only participant S.M., with amygdala damage, could accurately report details such as ‘A light comes on, followed by the horn’. However, S.M. failed to show a conditioned fear response when the blue light was presented alone, indicating that he had not acquired a conditioned fear response. In contrast, participant W.C., with hippocampal damage, showed a conditioned fear response to the blue light but could not remember and therefore report any details of the experiment. Finally, participant R.H., with both amygdala and hippocampal damage, showed neither a conditioned fear response nor any recollection of the trials. The results of this study indicate that damage to the amygdala interferes with the acquisition of a conditioned fear response, providing evidence for the crucial role of the amygdala (but not the hippocampus) in acquiring and expressing a conditioned fear response (LeDoux, 2007).

**FIGURE 7.19** A rat typically reacts with an unlearned fight-flight-freeze response to a cat. But without a fully functional amygdala, the rat may show no signs of fear of an aggressive cat.

**TABLE 7.4** Results of experiment on conditioned fear response and recollection in participants with brain damage

<table>
<thead>
<tr>
<th>Participant</th>
<th>Conditioned fear response (implicit memory)</th>
<th>Conscious recollection of experiment (explicit memory)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S.M. (bilateral amygdala damage)</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>W.C. (bilateral hippocampal damage)</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>R.H. (bilateral amygdala and hippocampal damage)</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>
LEARNING ACTIVITY 7.12

Evaluation of research by Bechara et al. (1995) on the role of the amygdala in classically conditioned fear responses

Consider the experiment by Bechara et al. (1995) summarised in box 7.5 and answer the following questions.
1. (a) Identify the experimental research design.
   (b) Why was this design most likely used rather than another type?
2. Name the type of sample used.
3. Identify the operationalised independent and dependent variables for the experiment.
4. Formulate a research hypothesis that would be supported by the results obtained for the experiment.
5. Explain whether sample size for this experiment enables generalisations to be made from the results.
6. Identify the NS, UCS, CS, UCR and CR.
7. Callie was terrified by her neighbour’s dog yesterday. Describe what would happen if Callie saw the dog today under each of the following conditions:
   (a) no amygdala or hippocampal damage
   (b) bilateral amygdala damage
   (c) bilateral hippocampal damage.

Cerebral cortex

Surgical removal of one or more cortical areas can result in serious memory impairments. The fact that Molaison could still recall information and events experienced long before his surgery means that these memories must have been stored somewhere other than the medial temporal lobe area. His cerebral cortex was left relatively intact and this helps explain why he could retrieve old memories. The memories were located in the cortex and had already been formed and stored with well-established neural connections linking the components.

Although explicit memories are stored throughout the cortex, some areas specialise in different memory processes and/or storing different kinds of information. For example, studies of people with damage to the frontal lobes indicate these are primarily involved in memory processes rather than storage. Differences have been observed between hemispheres as well as at more specific areas within the different lobes. For example, greater injury in the left hemisphere is often worse for recall of verbal material (such as a name or phone number) than non-verbal ‘visual’ material (such as a face or spatial location). At the same time, damage to a cortical area that originally processed information for a memory and has become its storage site can disrupt its storage and retrieval. Surgical removal is likely to result in loss of the information stored there because this area has to be reactivated as part of the memory reconstruction process during retrieval (Gazzaniga, Ivry & Mangun, 2014; Thompson, 2000).

Molaison’s ability to retrieve old memories suggests a crucial role of the cortex in the retrieval process, most likely independent of the hippocampus and amygdala if consolidation has already occurred. This has been confirmed by studies in other patients with amnesia following brain surgery and also by studies that have used neuroimaging techniques.

Frontal lobe loss in particular disrupts the retrieval process. For example, memories of events themselves are remembered, but problems are experienced recalling where and when they were experienced or who said something. In addition, difficulties can be experienced making judgments about the contents of their memory. Different lobes are more or less involved in different memory processes. For example, neuroimaging studies indicate the right frontal lobe is activated when retrieving an episodic memory more so than the left lobe, and that the left frontal lobe is more involved in the encoding of an episodic memory (Kolb & Whishaw, 2014; Suss & Alexander, 2005).

If a specific area of prefrontal cortex just behind the forehead is surgically removed, then individuals are greatly impaired in remembering the sequence of events, regardless of whether a recall or recognition method is used to test them. For example, a patient may be shown a series of paintings, one at a time, and at some point the patient is shown two paintings and then asked which was seen first. Patients with prefrontal damage are significantly impaired on this task (which is usually easy for non-impaired people) although they remember perfectly well having seen both paintings earlier (Thompson, 2000).

It seems that damage to the frontal lobes, particularly the prefrontal cortex, also interferes with the efficiency of other memory processes, such as attention that is required for transfer of information from sensory memory to STM, and organising and activating information for efficient retrieval from LTM, including coordination and manipulation of information for transfer from cortical storage areas into STM to enable conscious awareness.

The parietal lobe is also involved in attention so damage to cortical areas within this lobe may also massively impair STM, but not necessarily our ability to maintain information in STM. However, surgical removal of temporal lobe areas can impair explicit memory retrieval and aspects of spatial memory such as spatial awareness and navigation. There are also differences between the left and right parietal lobes. For example, damage to the right parietal lobe is more likely to impair spatial memory and awareness. And damage to a particular part of the left parietal cortex is likely to
massively impair STM of verbal materials and likewise the right parietal cortex for STM of non-verbal materials (Suss & Alexander, 2005; Thompson, 2000).

In sum, it should be kept in mind that the cortex is part of a larger interconnected learning and memory system. Removal of any cortical area may also disable connectivity with another part of that system and its functionality, making it difficult to isolate the actual source of a memory impairment.

**Cerebellum**

Classically conditioned motor responses involving simple reflexes such as an eye blink, leg movement or head turn in response to a conditioned stimulus are stored in specific locations within the cerebellum. This was first discovered by American psychologist Richard Thompson when investigating the roles of the cerebellum. Thompson conditioned rabbits to blink in response to a beep that had been associated with a puff of air. When the relevant area of the cerebellum was surgically removed, the rabbit’s memory of the learned response disappeared. It no longer blinked when the beep was sounded (the CS). But when the puff of air was re-introduced, the rabbit blinked, indicating the rabbit could still blink normally so this reflex had not been destroyed. However, the conditioned response could not be learned again (Thompson, 2000).

Further research by Thompson and others confirmed the results and obtained evidence that classically conditioned learning and memory of very specific reflexive movements critically involves the cerebellum. These findings are also believed to apply to people too because individuals with damage to that very same area of the cerebellum have been found to be unable to store a long-term memory of a conditioned eye blink and other simple conditioned reflexes. All components of the conditioned response to the CS are abolished but there is no effect on the reflex itself (Thompson, 2000).

There are rare cases of people who have been born without a cerebellum and a small number of cases who have had it surgically removed because of a malignant tumour or some other life-threatening disorder. These individuals cannot acquire a classically conditioned reflex response such as the eye blink response, but do remember the experiences of hearing sounds and feeling puffs of air to the eye during the conditioning procedure (Boyd, 2009; Silveri & Misciagna, 2000; Thompson, 2000).

A spatial function of the cerebellum has also been clearly demonstrated in a variety of experiments with small mammals, such as rats and mice in the Morris water maze task shown in box 7.4. The cerebellum has two hemispheres and surgical removal of either of these results in severely impaired spatial learning and memory. However, the exact role of the cerebellum in spatial functions remains unclear, especially its role in relation to the hippocampus. Its role is believed to be more related to the ability to organise and execute complex and effective exploration behaviours (the implicit procedural component of navigation) than to an inability to develop an internal map of the environment (the explicit semantic component of navigation) (Passot et al., 2012; Rochefort, Lefort & Rondi-Reig, 2013).

The few documented case studies of people born without a cerebellum report only minor to moderate problems with spatial abilities. Although all symptoms are highly variable, most of these individuals are described as having lived relatively normal lives despite motor impairments and were not discovered as not having a cerebellum until post-mortem examination after their death. It appears that neural plasticity after birth eventually resulted in the hippocampus and other brain regions compensating for the lack of cerebellar tissue.
Problems ordinarily expected of people without a cerebellum, especially coordination and timing of voluntary movements for a range of motor activities, are common during infancy and childhood, but many seem to eventually develop normal or near-normal motor skills as well as most other abilities involving the cerebellum. Loss of the cerebellum during adulthood is far more debilitating. Significant motor impairments are evident and recovery of function through neural plasticity tends to not be as extensive as that which may occur among individuals born without a cerebellum (Glickstein, 1994; Lemon & Edgley, 2010; Poretti, Bolzshauser & Schmahmann, 2012).

**LEARNING ACTIVITY 7.13**

**Summarising effects of brain surgery on memory processes**

**Part A**

Make a copy of the table below to summarise the effects of brain surgery on memory processes associated with different brain regions.

<table>
<thead>
<tr>
<th>Brain region</th>
<th>STM</th>
<th>Explicit memory</th>
<th>Implicit memory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>semantic</td>
<td>procedural</td>
</tr>
<tr>
<td>hippocampus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>amygdala</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cerebral cortex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cerebellum</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Part B**

Refer to the table you completed for learning activity 6.14 to summarise the roles of different brain regions in the storage of implicit and explicit memories.

Construct a table that combines the information in the table above with the table in learning activity 6.14 to provide a single summary of the roles of all four brain regions in long-term storage and other memory processes.

**Alzheimer’s disease**

**Alzheimer’s disease** is a type of dementia characterised by the gradual widespread degeneration of brain neurons, progressively causing memory decline, deterioration of cognitive and social skills, and personality changes. As brain cells die the brain shrinks. The outer part of the brain is usually the area affected first by the disease. Short-term memory loss is therefore one of the first symptoms of Alzheimer's disease. But as the disease progresses to deeper parts of the brain, long-term memory is also impaired. Explicit memories are primarily affected. Implicit memories tend to remain intact. The disease also affects other brain functions and consequently, many other aspects of behaviour are also disturbed (Alzheimer’s Australia, 2016; Guzmán-Vélez, Feinstein & Tranel, 2014; Machado, et al., 2009).

Alzheimer’s disease is the most common type of dementia, accounting for about 50% to 75% of all dementia cases worldwide. The biggest risk factor for having Alzheimer's disease is increasing age. Although it occurs relatively frequently in older people, regardless of family history, it is not a natural part of ageing. It is estimated that more than 100,000 Australians suffer from Alzheimer's disease. The disease is most common among older people with dementia, particularly among women (Australian Institute of Health and Welfare[AIHW], 2016a).

There is currently no single or simple diagnostic test for Alzheimer’s disease (or any other dementia). An accurate diagnosis can only be made after death when an autopsy involving microscopic examination of brain tissue is conducted. Because physical signs are not readily detectable in the living patient, a person's memory, general knowledge, intellectual and personal skills and overall functional capacity are assessed. The assessment process often includes input from others such as family members, carers and service providers. However, no one symptom is reliable, making diagnosis difficult (Alzheimer's Australia, 2016).

In the initial stage of the disease, deficits are evident in a number of areas but the person can still function with minimal assistance. Moderate memory loss, especially for recent events, confusion, unusual irritability, impaired decision-making, reduced interest in hobbies and social activities, and needing to be prompted about personal care tasks are often early symptoms of the disease. These continue to feature prominently as the disease progresses.

As well as experiencing a general decline in cognitive abilities, a person in the latter stages of the disease may be unable to recognise their own family members or regular carers, or may even forget their own identity. Severe personality changes are also associated with Alzheimer's disease. For example, someone who was formerly quiet and polite may become obnoxious, swear a lot and continually make insulting sexual comments to friends and strangers alike. Alternatively, someone who was caring and outgoing may become apathetic and socially withdrawn.
Both the loss of past memories (retrograde amnesia) and difficulties in retaining newly learned information (anterograde amnesia) distinguish Alzheimer's disease from many other disorders involving amnesia. Both explicit and implicit memories are also impaired, gradually eroding as the disease progresses. Memory loss in the latter stages may include:

- **events** — forgetting part or all of a significant event such as a wedding and career
- **words or names** — forgetting words and names of well-known people and objects
- **directions** — inability to remember and follow written or verbal directions
- **stories** — inability to follow a story on television, in a movie or a book
- **stored knowledge** — forgetting known information such as historical or political information
- **everyday skills** — inability to perform tasks such as dressing, cooking, cleaning, using the toilet and taking medication (due to physical rather than memory impairment).

**Brain damage associated with Alzheimer's disease**

Post-mortems of people who died with Alzheimer's disease expose a brain with cortical and sub-cortical areas that look shrivelled and shrunken due to the widespread death of neurons. The area of the brain that appears most affected is the medial temporal lobe, particularly the hippocampus. Autopsies have revealed that up to three-quarters of the neurons in this area may be lost in Alzheimer's patients, and the remaining neurons are often damaged. This makes shrinkage in the hippocampal area especially severe.

Microscopic examination of neural tissue in a brain with Alzheimer's disease usually reveals high levels of abnormal structures that interfere with neural communication within and between neurons, and therefore impair normal brain function. These abnormalities involve plaques and tangles.

The **plaques** are fragments of the protein called beta amyloid that the body produces normally. In a healthy brain, these are broken down and eliminated from the brain naturally. In a brain with Alzheimer's disease, the fragments accumulate over time to form clumps of hard, insoluble plaques outside and around the neurons, thereby impairing synapses and inhibiting communication between brain cells.

Within the neurons, another protein called **tau** also accumulates in an insoluble form. Gradually, the tau deposits form another type of abnormal structure called a **neurofibrillary tangle**. These tangles look like twisted fibres and inhibit transport of essential substances throughout the neuron. This failure of the transport system is believed to eventually kill the brain cells.
Both amyloid plaques and neurofibrillary tangles can occur as part of the normal ageing process of the brain, but they are much more abundant in individuals with symptoms of Alzheimer's disease. It remains unclear whether the build up of plaques and tangles cause Alzheimer's disease or result from the disease process.

The brains of people with Alzheimer's disease also have greatly reduced levels of the neurotransmitter acetylcholine (ACh). The amount of ACh in the brain decreases naturally as we age. With Alzheimer's disease, however, it decreases much faster than normal. It is believed that the build-up of amyloid and tau may contribute to this by destroying ACh-transmitting neurons.

The risk of Alzheimer's disease and other dementias increases after a moderate or severe traumatic brain injury, such as a blow to the head or injury of the skull that causes amnesia or loss of consciousness for more than 30 minutes. Individuals who sustain repeated brain injuries, such as footballers, boxers and those in combat, are also at a higher risk of developing dementia and impairment of thinking skills (Alzheimer's Association, 2016).

There is no cure for Alzheimer's disease. However, the use of medications that boost the level of ACh in the brain in the early or middle stages of Alzheimer's disease can slow the rate of development of the symptoms. These drugs improve the efficiency of damaged neurons.

Medications can also ease some of the ‘secondary' symptoms of Alzheimer's disease, such as depression.

Neuroimaging techniques such as CAT, MRI and PET can be used to identify the extent of brain damage resulting from Alzheimer's disease. The resulting scans make it possible to identify the parts of the brain that have deteriorated. The images in Figure 7.23 show the marked deterioration in brain areas associated with Alzheimer's disease.

FIGURE 7.23 Abnormal structures associated with Alzheimer's disease that interfere with neural communication within and between neurons

FIGURE 7.22 (a) A PET scan of a normal brain. High levels of brain activity are indicated by the red and yellow areas. (b) A PET scan of a brain with Alzheimer's disease. Note the reduced areas of activity compared to the scan of the normal brain. The lack of activity is most significant in the temporal and parietal lobes, which indicate their involvement in memory.
**BOX 7.6**

**Dementia**

*Dementia* is an umbrella term used to describe a syndrome — a group of symptoms associated with more than 100 different neurodegenerative diseases and other disorders that are characterised by progressive decline in mental functioning, behaviour and the ability to perform everyday tasks.

One of the main symptoms of dementia is memory loss. We all forget things from time to time, but dementia is different. For example, normal forgetfulness may include misplacing your sunglasses, but a person with dementia may lose their sunglasses and then forget what they’re used for. Other common symptoms include a decline in mental abilities such as reasoning, problem-solving and decision making, as well as behaviour and personality changes such as becoming more assertive, more withdrawn or less flexible, losing interest in things that have mattered previously, becoming absent-minded or repeating the same story or question. However, every individual experiences dementia in a different way and their experience depends on the type or cause of their dementia (AIHW, 2016a; Dementia Care Australia, 2016).

Dementia is often described as progressing in stages, with memory loss typically being one of the first signs of its onset. Memory decline is persistent rather than occasional and worsens as the dementia progresses. It may affect a person’s ability to continue to work or carry out familiar tasks. It may mean they have difficulty finding the way home. Eventually it may mean forgetting how to dress or how to bathe. With advanced dementia in the final stage, a person will become dependent on their carer(s) in most, if not all, areas of daily living.

Dementia mostly affects people over the age of 60 years, but it can have a younger onset and affect people in their 50s, 40s or even their 30s. It usually develops over a number of years, gradually worsening. However, dementia is not a normal part of the ageing process. Most people who age do not develop dementia. More than 100 known diseases, many of which are neurodegenerative, can cause dementia symptoms. When caused by neurodegenerative factors, the onset of the disease and its symptoms cannot be reversed. In 2013, dementia was the second leading underlying cause of death in Australia, accounting for 7.4% of all deaths. Twice as many women as men died from dementia (AIHW, 2016b).

An estimated 342,800 Australians had dementia in 2015. About 1 in 10 were aged 65 and over, and 3 in 10 were aged 85 and over. Over 50% of permanent residents in Australian Government-funded aged care facilities in 2013–14 had been diagnosed with dementia (AIHW, 2016a).

There are many different types of dementia, each with different causes and overlapping symptoms. The most common types are described in table 7.5.

---

**TABLE 7.5** The most common types of dementia

<table>
<thead>
<tr>
<th>Type of dementia</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alzheimer’s disease</td>
<td>- Damage and changes to brain neurons caused by the build-up of deposits called amyloid plaques and neurofibrillary tangles which affect communication within and between neurons and ultimately kill the cells&lt;br&gt;- The most common type of dementia&lt;br&gt;- Accounts for about 50% to 75% of all dementia cases worldwide</td>
</tr>
<tr>
<td>Vascular dementia or multi-infarct dementia</td>
<td>- Caused by problems of blood supply to the brain being cut off due to clotting or blood vessels bursting in the brain (aneurism) destroying surrounding tissue and triggering strokes&lt;br&gt;- The second most common type of dementia&lt;br&gt;- Classified as a non-degenerative dementia&lt;br&gt;- Accounts for about 20% to 30% of cases</td>
</tr>
<tr>
<td>Frontotemporal dementia including Pick disease</td>
<td>- A group of dementias whereby there is degeneration in one or both of the frontal or temporal lobes of the brain&lt;br&gt;- Accounts for about 5% to 10% of cases</td>
</tr>
<tr>
<td>Dementia with Lewy bodies</td>
<td>- A build-up of Lewy bodies — accumulated bits of alpha-synuclein protein — throughout the brain (including the hippocampus)&lt;br&gt;- Dementia symptoms are characterised by pronounced fluctuations in mood with periods of confusion, followed by greater lucidity and disturbed visual experiences. These symptoms make it different from Alzheimer’s disease.&lt;br&gt;- Accounts for up to 5% of cases</td>
</tr>
<tr>
<td>Dementia due to Parkinson’s disease</td>
<td>- A degenerative disease with motor and non-motor symptoms due to depletion of dopamine-producing neurons in the brain&lt;br&gt;- Some people with Parkinson’s disease may develop dementia in the latter stages of the disease.</td>
</tr>
<tr>
<td>Dementia due to Korsakoff’s syndrome (alcohol-related dementia)</td>
<td>- A dementia caused by long-term alcohol abuse, especially combined with a poor diet low in Vitamin B (thiamine).&lt;br&gt;- Classified as a non-degenerative dementia</td>
</tr>
<tr>
<td>Dementia due to Huntington’s disease</td>
<td>- An inherited, degenerative brain disease caused by a defective gene&lt;br&gt;- It usually appears between the ages of 30 and 50, and is characterised by intellectual decline and irregular involuntary movements. Other symptoms include memory disturbance, personality change, slurred speech and impaired judgment. Dementia occurs in the majority of cases.</td>
</tr>
</tbody>
</table>

**BOX 7.7**

**How good is your memory?**

The self-rating questionnaire shown below was developed by British psychologist and prominent memory researcher Alan Baddeley. He uses questionnaires such as this to determine memory lapses in everyday life and in people experiencing memory problems from head injuries. The questionnaire lists some of the memory lapses that we can experience from time to time. How often do they happen to you? In order to complete the questionnaire, refer to the response key and then rate yourself by writing the appropriate number in the box beside each item.

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Response key</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Forgetting where you have put something; losing things around the house.</td>
<td>1 Not at all in the last six months</td>
</tr>
<tr>
<td>2 Failing to recognise places that you are told you have often been to before.</td>
<td>2 About once in the last six months</td>
</tr>
<tr>
<td>3 Finding a television difficult to follow.</td>
<td>3 More than once in the last six months but less than once a month</td>
</tr>
<tr>
<td>4 Not remembering a change in your daily routine, such as a change in the place where something is kept, or a change in the time something happens. Following your old routine by mistake.</td>
<td>4 About once a month</td>
</tr>
<tr>
<td>5 Having to go back to check whether you have done something that you meant to do.</td>
<td>5 More than once a month but less than once a week</td>
</tr>
<tr>
<td>6 Forgetting when something happened; for example, forgetting whether something happened yesterday or last week.</td>
<td>6 About once a week</td>
</tr>
<tr>
<td>7 Completely forgetting to take things with you, or leaving things behind and having to go back and get them.</td>
<td>7 More than once a week but less than once a day</td>
</tr>
<tr>
<td>8 Forgetting that you were told something yesterday or a few days ago, and maybe having to be reminded about it.</td>
<td>8 About once a day</td>
</tr>
<tr>
<td>9 Starting to read something (a book or an article in a newspaper or magazine) without realising you have read it before.</td>
<td>9 More than once a day</td>
</tr>
<tr>
<td>10 Letting yourself ramble on about unimportant or irrelevant things.</td>
<td></td>
</tr>
<tr>
<td>11 Failing to recognise by sight close relatives or friends whom you meet frequently.</td>
<td></td>
</tr>
<tr>
<td>12 Having difficulty picking up a new skill; for example, learning a new game or working some new gadget after you have practised once or twice.</td>
<td></td>
</tr>
<tr>
<td>13 Finding that a word is on the tip of your tongue — you know what it is but cannot quite find it.</td>
<td></td>
</tr>
<tr>
<td>14 Completely forgetting to do things you said you would do, and things you planned to do.</td>
<td></td>
</tr>
<tr>
<td>15 Forgetting important details of what you did or what happened to you the day before.</td>
<td></td>
</tr>
<tr>
<td>16 When talking to someone, forgetting what you have just said — maybe saying: ‘What was I talking about?’</td>
<td></td>
</tr>
<tr>
<td>17 When reading a newspaper or magazine, being unable to follow the thread of the story; losing track of what it is about.</td>
<td></td>
</tr>
<tr>
<td>18 Forgetting to tell somebody something important; perhaps forgetting to pass on a message or reminded someone of something.</td>
<td></td>
</tr>
<tr>
<td>19 Forgetting important details about yourself; for example, your birthday or where you live.</td>
<td></td>
</tr>
<tr>
<td>20 Getting the details of what someone has told you mixed up.</td>
<td></td>
</tr>
<tr>
<td>21 Telling someone a story or joke that you have told them already.</td>
<td></td>
</tr>
<tr>
<td>22 Forgetting details of things you do regularly, whether at home or at work; for example, forgetting details of what to do, or forgetting at what time to do it.</td>
<td></td>
</tr>
<tr>
<td>23 Finding that the faces of famous people seen on television or in photographs look unfamiliar.</td>
<td></td>
</tr>
</tbody>
</table>
Questionnaire

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 Forgetting where things are normally kept or looking for them in the wrong place.</td>
<td></td>
</tr>
<tr>
<td>25 (a) Getting lost or turning in the wrong direction on a journey, during a walk or in a building where you have only been once or twice before.</td>
<td></td>
</tr>
<tr>
<td>(b) Getting lost or turning in the wrong direction on a journey, during a walk or in a building where you have often been before.</td>
<td></td>
</tr>
<tr>
<td>26 Doing some routine thing twice by mistake; for example, putting two lots of tea in the teapot, or going to brush or comb your hair when you have just done so.</td>
<td></td>
</tr>
<tr>
<td>27 Repeating to someone what you have just told them or asking them the same question twice.</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
</tr>
</tbody>
</table>

To score the questionnaire, add up the numbers you wrote in the response box. According to Baddeley, a total score of 27–58 means that your memory is generally good, 58–116 means it is average and 116–252 means it is ‘below average’. He suggests, however, that you ‘should not be alarmed if your score is below average’. In his view, this may simply mean that you lead a very busy life that puts considerable demands on your memory. Statistically, the greater the number of situations in which memory lapses are possible, the greater the number of lapses you will report overall.


### LEARNING ACTIVITY 7.14

**Review questions**

1. What is Alzheimer’s disease?
2. Why is Alzheimer’s disease irreversible?
3. Explain why Alzheimer’s disease may be attributable to neurological factors, with reference to plaques and tangles.
4. Consider the list on page 000 <rs page 32> outlining memory impairments that can be experienced in the latter stages of Alzheimer’s disease. For each item in the list, identify (a) the general and specific type of LTM involved (b) whether anterograde amnesia is involved.

### FACTORS INFLUENCING ABILITY AND INABILITY TO REMEMBER

Have you ever forgotten when someone’s birthday was, the location of a place you’ve been to before or the time you were supposed to meet a friend? Have you ever sat for an exam and been unable to remember something that you know you know? Why is some information unable to be retrieved when we need it? Is this information completely lost from memory or is it that we cannot access it at a specific point in time? What causes us to forget? You know that brain damage is one explanation of why some people forget. However, there are also psychological factors that can explain forgetting from LTM when there is no brain damage.

**Forgetting** refers to the inability to access or recover information previously stored in memory. When you forget something, it means that it is inaccessible to you at the time you are trying to remember it. The information may still be stored in your memory and therefore available, but for some reason you cannot access it when you want to.

When describing forgetting, psychologists often distinguish between accessibility and availability of information previously stored in memory. If information is stored in memory then it is said to be available. If information can be recovered from memory and brought into conscious awareness at a specific time and/or place, then it is said to be accessible. If information is not available, then it cannot be accessed.

Although forgetting results in the loss of information and skills, if you did not forget, your mind would become cluttered with so much information that you would have great difficulty locating and retrieving the information you needed. Remembering might take hours instead of seconds! If you think about it, would you really like to be able to remember everything? With a perfect memory you could retrieve not only what you wanted to, but also life experiences that are perhaps best forgotten. Like remembering, forgetting has an adaptive purpose and contributes to our survival and our sanity (Squire & Kandel, 1999).

There are various psychological explanations of why we forget and how we can minimise forgetting. For instance, forgetting may occur because an appropriate retrieval cue is not used. In addition, psychologists have identified conditions under which we are more likely to retrieve information. We start with an examination of different types of retrieval cues.
Context and state dependent cues
If you have ever experienced a ‘mental blank’ for a question in an exam, only to recall the exact information you needed when discussing the question with a friend after the exam, then you have had firsthand experience of retrieval failure.

Most of the time, we can retrieve information from LTM with relative ease. For example, for the next 5 seconds, think of as many different types of animals as you can. Next, recall five words that rhyme with ‘mum’, then three things you did yesterday, three things that are round and four types of food that you like. In completing these tasks, you were able to retrieve information from LTM using a retrieval cue that assisted you to locate relevant information.

A retrieval cue is any stimulus that assists the process of locating and recovering information stored in memory. A retrieval cue acts as a prompt or hint that guides the search and recovery process within LTM. Being asked a question is an example of a cue. A question focuses your search for information in specific areas of LTM, much like the call number on a library book or a URL for a website. For example, a question such as ‘Who was at the party last Saturday night?’ focuses on the specific information among all the information associated with the party. Other cues are less direct and might not even be recognised as memory prompts. For example, the smell of a particular perfume or aftershave, the look of someone’s face, a photograph, an emotional state or a particular situation or place may each act as a cue that can unintentionally trigger a specific memory or related group of memories.

According to retrieval failure theory we sometimes forget because we lack or fail to use the right cues to retrieve information stored in LTM. For example, you might have forgotten where the summer Olympic Games were held in 2016, but if you went through the letters of the alphabet, the letter R might be a cue for the retrieval of the name Rio. This explanation of forgetting suggests that memories stored in LTM are available and not actually forgotten. However, the memories are temporarily inaccessible because of an inappropriate or faulty cue.

An effective way of enhancing retrieval from LTM is to re-create the conditions under which the required information was originally learned. This approach is based on the encoding specificity principle (Tulving & Thomson, 1973).

The principle involves a general ‘rule’ that the more closely a retrieval cue matches the original learning conditions, the more likely it is that the information will be retrieved. More specifically, the principle states that memory is improved when information available at encoding is also available at retrieval. Therefore, re-creating the external environment (context) in which the original learning occurred, or the learner’s internal environment (state), has been found to provide valuable cues that aid the retrieval process.

Context dependent cues
Why is it that police investigating a crime take an eye-witness back to the crime scene, particularly if the witness is having trouble recalling some details of what they saw that are crucial to the investigation? The
answer to this question is based on research findings that cues in the environment may be important in helping to locate and retrieve related memories.

**Context dependent cues** are environmental cues in the specific situation (‘context’) where a memory was formed that act as retrieval cues to help access the memories formed in that context. These cues may include the sights, sounds and smells within the specific situation.

[Figure 7.25](#) The influence of context was evident in a study in which participants learned lists of words either while on the beach or while submerged under 5 metres of water. In this graph, it is apparent that when the conditions of learning and retrieval matched, participants were able to recall more words (Godden & Baddeley, 1975).

![Figure 7.25](image)

The context dependency of certain memories was demonstrated in an experiment undertaken to compare the efficiency of land training and underwater training of deep-sea divers. British psychologists Duncan Godden and Alan Baddeley (1975) presented divers with a list of 40 unrelated words in either of two settings: on the beach or under about 5 metres of water. After they had heard the words, the divers were tested for recall of the words, either in the same environment or in the alternate one. The results showed that the divers recalled up to 20% more words when the words were learned and retrieved in the same context (see Figure 7.25).

The context dependency of certain memories helps explain why an eye-witness may recall apparently forgotten information about a crime when they return to the crime scene. When they return to the scene (the context where the memory was originally formed), the environmental cues act as additional retrieval cues that assist the recall of additional information.

A number of research studies have tested whether students perform better if their final exams are taken in the same room where they learned or studied the test material. Typically, the results suggest that any differences are sufficiently small so as not to be of concern for students (Saufley, Otaka & Baveresco, 1985). However, these results have been consistently obtained only when the learning environment and the testing environment are similar; for example, if the learning and recalling occurred in different rooms in the same school. But if the testing environment is substantially different from the learning environment, the differences in performance are likely to be more noticeable (Baddeley, 1999).

[Figure 7.26](#) When the learning environment and the testing environment are similar, performance on tests is likely to be improved compared with testing in a totally different environment. Context dependent cues assist retrieval when the learning and testing environments are similar.
When Margaret Mead, an eminent American anthropologist, lived with Aboriginal people in South Australia, she learned that some important aspects of the culture are transmitted through storytelling. Stories of significant events are memorised so that the next generation can learn about the cultural past. These stories are sometimes long and contain many important details.

Mead observed that in order to be able to tell a long story accurately, the storytellers had to walk through the places involved in the story. Thus, features of the environment were context dependent cues that triggered the storytellers’ memories. If the storytellers were tested in a laboratory setting without the retrieval cues of their physical environment, their memories probably would not be so remarkable.

**Figure 7.27** Aboriginal storytellers often use specific cues in the environment to help them recall details of their stories.

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**State dependent cues**

Internal cues that are related to a specific experience may also trigger the retrieval of associated memories. These are called state dependent cues. State dependent cues are associated with an individual’s internal physiological and/or psychological state at the time the memory was formed, and act as retrieval cues to help access those memories. For example, if you learn information when you are happy, sad, intoxicated, sober, calm or aroused, that information is more likely to be retrieved when you are in the same ‘state’ (Bower, 1981; Eich, McCauley & Ryan, 1994).

In a pioneering research study on state dependent cues, American psychiatrist Donald Goodwin and his colleagues (1969) conducted an experiment on the effects of alcohol on memory. They were interested in why many of their patients who were heavy drinkers and who hid alcohol or money when intoxicated were often unable to remember where it was hidden once they were sober. On becoming intoxicated again they tended to remember where the items were hidden. So they asked male volunteers to perform various memory tasks that involved learning and recalling words while sober or under the effect of alcohol (well in excess of BAC 0.05). They found that participants who were intoxicated when learning and during recall performed almost as well as participants who had been sober on both occasions. Their results led them to conclude that ‘learning which the subject acquires while he is intoxicated may be more available to him while he is intoxicated than when he is sober’.

The findings led to a variety of follow-up studies by other researchers. Many found that the effect of alcohol on memory could be generalised to other physiological states. For example, research studies have found that when participants learn information while under the influence of other substances or drugs such as caffeine, nicotine or marijuana, they tend to recall the information better when they are again under the influence of the same substance than when they are not under its influence (Baddeley, 1990; Roediger, 1992).

It seems that consuming certain substances can produce an internal state with unique psychological and physiological characteristics, aspects of which may become encoded with new memories. At a later point,
the same internal state can provide additional retrieval cues that assist recovery of information from memory. Thus state dependent retrieval involves better recall of information when the physiological and/or psychological states of learning and retrieval match. Does this mean that substances or drugs such as alcohol and marijuana improve memory? Absolutely not — they actually impair memory, as they interfere with encoding. For instance, Goodwin also found that participants who were intoxicated when learning and sober at recall performed the worst.

Your mood also provides state dependent retrieval cues. Mood is an emotional state and we seem to associate good or bad events with their accompanying emotional state. Thus, the emotional state becomes a retrieval cue when we feel good or bad again because it triggers memories that are consistent with the mood. More specifically, some memories of events can become mood dependent when associated with particular moods, particularly moods involving strong emotions. In such cases, details of such events will tend to be retrieved more quickly and remembered better at a later date when we are in the same or a similar mood (Bower, 1990; Eich, 1995).

Retrieval failure involving context- or state-dependent cues is a widely described and comprehensive theory of forgetting based on substantial research evidence, but it does not account for all forgetting and therefore has limitations. For example, retrieval failure does not explain forgetting that may be due to:

- failure to access certain anxiety-laden memories (e.g., these experiences may be repressed and ‘unconsciously’ blocked from entering conscious awareness because of the upset or distress they cause)
- disrupted or lost memories as a consequence of brain trauma (e.g. brain injury) or a neurodegenerative disease (e.g. Alzheimer’s disease)
- memories interfering with one another due to the similarity of information being retrieved.

It is also suggested that a limitation of retrieval theory is that it does not account for forgetting due to ineffective encoding during memory formation. However, in such cases, the information is never stored in LTM in the first place so it is not available to be forgotten.

**Figure 7.28** A strong emotion may act as a state-dependent retrieval cue.

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**BOX 7.9**

**Tip-of-the-tongue phenomenon**

You have probably experienced the feeling of trying to recall a person’s name, or the name of a place or an object, that you’re sure you know. You are certain you are just on the verge of remembering but can’t quite recall the information right then. You know that you know the answer and can almost, but not quite, bring it forth. Psychologists call this tip-of-the-tongue phenomenon. *Tip-of-the-tongue (TOT)* is a state, or ‘feeling’, that occurs when you are aware of knowing something, and confident you will eventually remember it, but you are not able to retrieve it from memory at that time. When the sought-after information is eventually remembered, it tends to occur suddenly, seeming to ‘pop’ out of a memory, often when you are not consciously thinking about it.

When we experience TOT, we can usually remember certain features of the sought-after item in memory, but not all the features. For example, when trying to recall a specific word, we seem to have some information about the word we are searching for even though we can’t actually state it. Sometimes we can tell how many syllables it has, the beginning and ending letters, or what it rhymes with. But we cannot say the entire word. We can often confidently eliminate words that are incorrect because they don’t have the proper sound or length.

These observations suggest that TOT involves a partial retrieval process in which bits of information can act as retrieval cues for the required information, helping to ‘home in’ on this information.

One of the earliest investigations of the TOT state was conducted by American psychologists Roger Brown and David McNeil (1966). They used a simple technique for producing the TOT state in their research participants. The technique was to give participants dictionary definitions of uncommon objects and ask for the name of the defined object, such as:

*A small boat used in shallow water in the Orient that is rowed from behind using a single oar.*

Attempts to recall this name will produce a TOT state in many people. Brown and McNeil were not interested in people who knew and could immediately recall the

(continued)
correct answer. Neither were they interested in cases in which the participant had no idea of the correct name. Their interest was to re-create the TOT state and analyse attempts by participants to recall the name during TOT.

The participants experiencing TOT were usually able to recall some information about the name ('It starts with s' or ‘It sounds like Siam'), or recall a word related to the name ('It looks like a junk'), even though they usually knew a related word was not the one they were trying to retrieve. And then moments later, for some participants, the word would pop into memory, indicating that it was there all the time but could just not be retrieved at that moment.

It is possible that all information stored in LTM is still there, but just cannot be retrieved until the right cue is used to call it out of storage. For instance, both phonetic (the sound of the word) and semantic (the meaning of the word) features of a word can assist its retrieval. Through remembering such features, you will probably recall the word that has caused you so much frustration (Lahey, 1992). Interestingly, it has been found that people are often able to tell beforehand if they are likely to remember something (Nelson, 1987).

The occurrence of TOT has also been explained in biological terms, taking account of how memory is stored in the brain. For example, the storage of a specific memory can involve a number of different locations, and for the complete memory to be retrieved, each of these locations must be accessed. Therefore, retrieval failure occurs because we have accessed only one or two of the locations, resulting in retrieval of only part of the entire memory.

![Figure 7.29](image.png) The name of the boat used in Brown and McNeil’s 1966 experiment was sampan.

**LEARNING ACTIVITY 7.16**

**Review questions**

1. (a) Define the meaning of forgetting.
   (b) Explain whether sensory memory and STM are subject to forgetting.
2. Define the meaning of retrieval cue with reference to an example of one you have recently used.
3. What is retrieval failure theory?
4. Explain the difference between context dependent and state dependent retrieval cues with reference to relevant examples.
5. Give an example of an everyday life situation involving both context and state dependent cues.
6. Explain how context and state dependent cues can improve or enhance retrieval of explicit and implicit memories. For each type of cue, give two relevant examples linked to memory improvement.
7. What are two limitations of retrieval failure theory as an explanation of forgetting?

**Maintenance and elaborative rehearsal**

Information can be kept in STM (or ‘working memory’) for longer than the usual maximum of about 18 to 30 seconds if it is rehearsed in some way. In the study of memory, **rehearsal** is the process of consciously manipulating information to keep it in STM, to transfer it to LTM or to aid storage and retrieval. The two main types of rehearsal are called maintenance rehearsal and elaborative rehearsal.

**Maintenance rehearsal**

Maintenance rehearsal involves repeating the information being remembered over and over again so that it can be retained (or ‘maintained’) in STM. When you hear something for the first time and simply ‘go over and over it’ so that you don’t forget it, you are using maintenance rehearsal.

Maintenance rehearsal not only involves simple repetition of words or auditory information such as the sounds of words, but it can also involve visual or spatial information such as images or ‘mental maps’. When the information involves words and sounds, maintenance rehearsal can occur **vocally**, by repeating the information aloud over and over again, or **sub-vocally**, by silently repeating the words or a tune ‘in your head’.

When the information is visual and/or spatial, maintenance rehearsal involves using something like an ‘inner eye’ to maintain the image of the object or scene in STM for a period after you first see it. Whether maintenance rehearsal involves words or auditory, visual or spatial information, provided it is not interrupted, the information can be retained indefinitely in STM.

Although maintenance rehearsal can be very effective for retaining information in STM, it does not...
always lead to long-term retention. In one experiment, participants were asked to memorise pairs of numbers; for example, 295–417, 381–620, 749–836. After the presentation of each pair, participants were told to repeat one word per second, out loud, to prevent rehearsal of the numbers. However, unexpectedly for the participants, the memory test given at the end of the paired number presentations involved recalling the words they thought were distractions, and not the numbers. The results showed that merely repeating the words did not guarantee retention. Furthermore, the number of times a person rehearsed a word — four, eight or 12 times — had no effect on the ability to recall that word (Rundas, 1977).

Nonetheless, maintenance rehearsal is a useful technique for coping with the limited duration of STM. A limitation of maintenance rehearsal, however, is that when information is continually renewed and therefore retained in STM through the rehearsal process, the amount of new information that can enter is restricted because of the limited storage capacity of STM.

To transfer information to LTM, where it may be stored indefinitely, it is more effective to use elaborative rehearsal as the information will be more ‘deeply’ processed.

**Elaborative rehearsal**

Unlike maintenance rehearsal, elaborative rehearsal involves focusing on the meaning of the information. More specifically, elaborative rehearsal is the process of linking new information in a meaningful way with other new information or information already stored in LTM to aid in its storage and future retrieval from LTM. For example, rather than ‘memorising’ a definition of memory for the end-of-year exam by repeating the definition aloud or writing it down over and over again, your ability to recall an appropriate definition will be enhanced if you link it to learning and think about the nature of its relationship to learning, biologically and psychologically. You might note that learning comes before memory (as does the $l$ in learning and the $m$ for memory), or that memory is an expression of learning. You might also think about key processes of memory such as encoding, storage and retrieval. You might analyse a personal example of when you successfully and unsuccessfully stored and retrieved information that was important. The more you elaborate, or ‘flesh out’, the various features of the concept and link it to your own experience, the more likely you are to remember it.

When we relate new information to personal experiences and our personal situation in some way, we are more likely to remember it. This is called the **self-reference effect**. For example, if the word ‘win’ is on a list of words to remember, you might link it to the last time you won something, or if the word ‘cook’ appears, you might link it to the last time you cooked a meal (Matlin, 2002; Rogers, Kniper & Kirker, 1977).

Elaborative rehearsal is a more active and effortful process than maintenance rehearsal. It is also more effective than maintenance rehearsal for remembering new information because it helps to ensure that information is encoded well. Consequently, it is much better to process material that you want to store for long periods in a meaningful way, rather than memorise it in a meaningless, repetitive, rote way. Why is elaborative rehearsal a more effective way of encoding new information than maintenance rehearsal? The most common explanation emphasises that elaborative rehearsal involves a deeper level of information-processing that enhances encoding and consolidation for long-term storage.

**FIGURE 7.30** When a teacher gives verbal feedback on coursework during a lesson, maintenance rehearsal can be used to keep the information in STM until the advice can be written down or implemented.
Is cramming effective when studying?

Many students believe that if they cram (doing the majority of their revision the night before a test or exam) the information will be available to them when they need it the next day.

Some believe that one or two extended study sessions over a very short time (called massed rehearsal) is more effective than spacing out the study sessions over an extended period (called spaced or distributed rehearsal).

However, research findings suggest that if long-term retention of information is required, spaced rehearsal is a more effective strategy.

In one study, researchers tested the long-term effects of spaced rehearsal on the retention of 300 foreign-language words. They compared the retention of information in three different conditions, when study sessions were spaced at intervals of 14 days, 28 days and 56 days. Participants were tested on retention of information subsequently each year for five years.

The results indicated that longer intervals between rehearsal sessions resulted in greater retention of the learned information one, two, three and five years after the last training session (Bahrick et al., 1993). These findings have been replicated by other studies that used different material and memory tasks (Toppino & Schneider, 1999).

The results have important implications for students, especially those who want or need to retain information learned for a longer time.

LEARNING ACTIVITY 7.17

Review questions
1 Describe two key roles of rehearsal in memory.
2 (a) Define the terms maintenance rehearsal and elaborative rehearsal.
   (b) Identify two important characteristics that distinguish these two forms of rehearsal.
3 Explain why elaborative rehearsal is more effective than maintenance rehearsal in enhancing retention of information in LTM.
4 Describe three different ways to elaborate information.
5 Apply your understanding of maintenance and elaborative rehearsal to respond to the following question a teacher was asked by a student: ‘Is it best to read my notes over and over again, or is there something else I could do to study for the exam?’ Give two reasons for your answer.

LEARNING ACTIVITY 7.18

Using elaborative rehearsal for deep processing
Choose one of the concepts below and draw a diagram to show how it could be processed deeply using elaborative rehearsal so that is more likely to be retained in LTM. Figure 7.33 may be used as a model. Alternatively, complete the task for a brain region or structure involved in memory.
• independent variable
• sensory memory
• dependent variable
• iconic memory
• extraneous variable
• confounding variable
• echoic memory
• reconstruction
• research hypothesis
• encoding
• maintenance rehearsal
• elaborative rehearsal
• short-term memory

Serial position effect
Considerable research evidence supports the view that memory has at least two distinguishable storage components or systems, most commonly referred to as LTM and STM (or working memory). Some of this evidence comes from studies of patients with amnesia or brain damage and some of this evidence comes from observations of the serial position effect.

To test whether STM is a component of memory that is distinguishable and possibly separate from LTM, psychologists have conducted experiments on memory for lists of words, numbers, images and various other types of information. Typically, participants are presented with a list of about 15 words for a short time such as 30 seconds. Then, participants are required to recall as many words as possible in any order using free recall rather than serial recall (the order the words were presented in).

These types of studies usually obtain similar results. The words in the list that are more likely to be recalled seem to depend on their serial position; that is, where they are located in the list. This research finding is called the serial position effect.

The serial position effect is a finding that free recall is better for items at the end and beginning of the list than for items in the middle of the list. More specifically, the recall of items tends to be best for items at the end, and then the beginning, and worst for items around the middle. When retention of all the items is plotted on a graph, the result is a U-shaped curve, as shown in Figure 7.33.

FIGURE 7.33 The serial position effect shows that recall is better for items presented at the end and the beginning of a list than for items in the middle of the list. Items from the end of the list are most likely to be recalled, and those from the middle of the list are least likely to be recalled.
The **primacy effect** describes superior recall of items at the *beginning* of a list. The **recency effect** describes superior recall of items at the *end* of a list. Together with the relatively low recall of items from the middle of the list, this pattern makes up the serial position effect.

Experiments testing the serial position effect with different kinds of information, such as numbers or even sketches of objects, have consistently found a similar U-shaped curve with a strong recency effect (Buchner, Irmen & Erdfelder, 1996; Page & Norris, 1998; Tremblay & Jones, 1998).

**FIGURE 7.34** Prince William is more likely to remember the names of the people he has just met (recency effect) and those of the people he first met (primacy effect) than those in between.

What causes the serial position effect? A widely accepted explanation is in terms of differences between STM and LTM. Many researchers have argued that, if recall occurs *immediately* after the list is learned, the last few items are remembered best because they are still in STM. The first few items in a list are remembered well probably because they received more attention and rehearsal than other items and are therefore transferred into LTM. Items around the middle of a list are presented too late to be adequately rehearsed and transferred into LTM and too early to be held in STM without rehearsal, so they are more likely to be forgotten (unless they are distinctive in some way). Many experimental investigations provide evidence in support of an explanation that distinguishes between STM and LTM.

One of the best-known studies was conducted by American psychologists Murray Glanzer and Anita Cunitz in 1966. They conducted an experiment in which participants were asked to memorise a list of 15 words. As shown in Figure 7.35, the serial position effect was clearly found when the participants were asked to recall the list immediately after learning it. Recall was better for items at both the beginning and the end of the list. But when the participants were asked to recall the list after a delay of 30 seconds — beyond the limits of STM — the serial position effect was not entirely observed.

According to Glanzer and Cunitz (1966), recall was better at the beginning of the list, probably because those items were rehearsed more and were therefore more likely to have been stored in LTM. However, as for words at the end of the list, where no recency effect was evident, recall was not as good probably because the participants could not hold the last items in STM long enough.

The findings of numerous research studies on the serial position effect have not only enabled psychologists to more confidently identify LTM and STM (or working memory) as different components, systems or sub-systems when referring to the *structure* of memory, but also to describe LTM and STM as *interacting* when referring to their functions in memory.

**FIGURE 7.35** The serial position effect is clearly evident when testing recall immediately after learning a list of items (i.e. with no time delay). However, when recall is delayed for 30 seconds, participants tend to forget the latter items and no recency effect is evident.
LEARNING ACTIVITY 7.19

Review questions

1. (a) Describe the serial position effect.
   (b) What are the primacy and recency effects? Why do they occur?
   (c) Why are items in the middle of a serial list recalled least?

2. What implications does the serial position effect have for:
   (a) a prosecutor or barrister presenting their case to a jury?
   (b) three politicians before an election, each delivering a brief policy speech one after the other on television?
   (c) a potential employee deciding on their interview time when allowed to choose from an interview schedule?

3. You have just begun casual work at the local supermarket. On your first day you are introduced to 15 other employees, one after the other. According to the serial position effect, which names are you most likely to remember and why?

LEARNING ACTIVITY 7.20

Reflection

What properties of memory make it highly functional or useful, what properties make it prone to error or unreliable and what properties make it both functional and prone to error?

BOX 7.11

Minimising forgetting

Some day we might be able to effortlessly encode, store and retrieve information by taking some kind of ‘memory pill’, or by hooking up through a direct electrical link from our brains to a mobile phone app. In the meantime, however, those of us who want to improve our memories must rely on specific mental strategies.

Of course, some things are very easy to remember. If you arrived at school one day and saw the principal sitting on top of the flagpole you would not have to rehearse this information to remember it. Observing such an unusual event would be enough to ensure that the scene remained with you always. Similarly, you would probably easily learn and remember the name of the next prime minister of Australia when they were elected. But often we must learn and remember information that is much more difficult. This requires conscious effort. Mere exposure, even very frequent exposure, to information is often insufficient to produce efficient remembering.

To make sure that information goes beyond sensory memory, attention must be given to it. It must also be organised and integrated into the information already stored in LTM. However, while this may sound like a tedious process, improving or enhancing your memory is not very difficult.

Techniques for improving or enhancing memory are known as mnemonics (from the Greek word Mnemosyne, the goddess of memory). They can be as basic as an acronym or complicated strategies that themselves take considerable time to learn. Many of these techniques were developed in ancient times by scholars, politicians, orators, actors and priests when written records were scarce or non-existent. It is only in relatively recent times that psychologists have examined them and recognised their value in improving memory.

Mnemonic techniques use information that is already stored in LTM. The devices do not simplify information; they actually make it more elaborate. More information is stored, not less. However, the additional information makes the material easier to locate and retrieve because it has enhanced organisation in LTM. Mnemonic devices tend to organise new information into a cohesive whole, so that retrieval of part of the information generally assists retrieval of the rest of it. These facts suggest that the ease or difficulty with which we learn new information depends not on how much we must learn, but on how well it fits with what we already know. The better it fits, the easier it is to retrieve.

Many mnemonic techniques emphasise the logical organisation of information to be remembered, and use a particular structure to facilitate this; for example, acronyms, rhymes, acrostics and narrative chaining.

Acronyms

When using acronyms, organisation of information is important. Acronyms are pronounceable words formed from the first letters of a sequence of words. The acronym doesn’t have to be a real word. An acronym is often a pronounceable abbreviation. The letters of the abbreviation act as a retrieval cue for recall of more complex material.

Acronyms are formed using a type of chunking procedure. ANZAC, for example, is an abbreviation of ‘Australian and New Zealand Army Corps’, and EFTPOS is an abbreviation of ‘electronic funds transfer (at the) point of sale’. For both examples, the abbreviation is a pronounceable word. Similarly, a large number of organisations are known by their acronyms rather than by their names: UNESCO, NATO, SEATO and so on.

Acronyms can also be used for remembering other types of information. For example, the colours in the rainbow or visual colour spectrum can be remembered by relating them to the pronounceable name ‘Roy G Biv’ (red, orange, yellow, green, blue, indigo, violet).

(continued)
Rhymes
As with acronyms, you are also likely to have used rhymes as a way of improving memory. A rhyme is a phrase or string of words (such as a jingle), often with an emphasis on similar sounding key words. For example, the rhyme ‘i before e, except after c’ assists memory for the correct spelling of words containing ie and ei, and the rhyme ‘Big fat Italy kicked poor Sicily into the Mediterranean Sea’ assists memory for a specific geographic location.

These types of rhymes organise information by associating the information with a particular rhythm (sound) and with rhyming words. If we make an error in using a rhyme mnemonic, the rhythm is broken or the rhyme is ruined or both. Consequently, we immediately know an error in retrieval has occurred.

Another rhyme, used to remember the number of days in each month, is:

Thirty days hath September, April, June and November; all the rest have thirty-one, except February alone, which has twenty-eight days clear, and twenty-nine in each leap year.

Some people, however, find this rhyme difficult to remember. There are many different ways to remember the same information. You need to find a mnemonic that works for you.

Acrostics
Acrostics involve making verbal associations for items to be remembered by constructing phrases or sentences using the first letters of the information to be remembered. You may have used this method if you recall the names of the original planets (in order from the sun) by linking them to a phrase such as ‘my very energetic mother just sits up near pop’ (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto). Similarly, in music classes you may have learned the phrase ‘every good boy deserves fruit’. The first letters of these words are the same as the names of the musical notes on the lines of a staff (E, G, B, D, F).

Acrostics can also be useful when you have to remember information in sequential order, such as sets of points for an essay or lists of information. For example, if you wanted to remember several reasons for the colonisation of Australia you could choose key words (e.g. convicts, staple, imperialism) and organise them into a sentence. You could then recall the sentence and each word in the sentence would act as a retrieval cue for the recall of specific related information.

Narrative chaining
Narrative chaining involves linking otherwise unrelated items to one another (‘chaining’) to form a meaningful sequence or story (‘narrative’). For example, consider all the following words that have no apparent relationship:

bird, costume, letterbox, head, river, nurse, theatre, wax, eyelid, fireplace

Research studies have found that you will be far more likely to remember all of them if you linked them in a story such as the following:

A man dressed in a bird costume and wearing a letterbox on his head was seen leaping into the river. A nurse ran out of a nearby theatre and applied wax to his eyelid, but her efforts were in vain. He died and was tossed into the fireplace (Bower & Clark, 1969).

In one experiment conducted by Elizabeth Loftus (1980), participants who used narrative chaining remembered six times more information than participants who learned by simply repeating the words to themselves. These results provide strong evidence that using a technique that adds organisation and meaningfulness to otherwise meaningless material is a form of elaborative rehearsal that will improve retrieval. Narrative chaining is a particularly useful mnemonic technique when you want to remember information in a particular order. However, a narrative will not be helpful if it hangs together so loosely that you cannot remember the story (Matlin, 2002).
CHAPTER SUMMARY

- Recall
- Recognition
- Relearning
- Reconstruction
- Fallibility of memory reconstruction
- Anterograde amnesia
  - Brain surgery
    - Hippocampus
    - Amygdala
    - Cerebral cortex
    - Cerebellum
    - Alzheimer’s disease
      - Brain damage associated with Alzheimer’s disease
- Effects of brain trauma on memory
- Context and state dependent cues
  - State dependent cues
- Maintenance and elaborative rehearsal
  - Maintenance rehearsal
  - Elaborative rehearsal
- Serial position effect
- Factors influencing ability and inability to remember
- Methods to retrieve information from memory or demonstrate the existence of information in memory
  - Research by Loftus

RELIABILITY OF MEMORY

CHAPTER 7 REVIEW
### KEY TERMS

- Alzheimer's disease p. 000
- anterograde amnesia p. 000
- brain trauma p. 000
- context dependent cues p. 000
- cued recall p. 000
- elaborative rehearsal p. 000
- eye-witness testimony p. 000
- forgetting p. 000
- free recall p. 000
- leading question p. 000
- maintenance rehearsal p. 000
- neurodegenerative disease p. 000
- amnesia p. 000
- primacy effect p. 000
- recall p. 000
- recency effect p. 000
- recognition p. 000
- reconstruction p. 000
- rehearsal p. 000
- relearning p. 000
- retrieval cue p. 000
- serial position effect p. 000
- serial recall p. 000
- state dependent cues p. 000

### LEARNING CHECKLIST

Complete the self-assessment checklist below, using ticks and crosses to indicate your understanding of this chapter's key knowledge (a) before and (b) after you attempt the chapter test. Use the 'Comments' column to add notes about your understanding.

<table>
<thead>
<tr>
<th>Key knowledge I need to know about</th>
<th>Self-assessment of key knowledge I understand before chapter test</th>
<th>Self-assessment of key knowledge I need to revisit after chapter test</th>
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CHAPTER TEST

SECTION A — Multiple-choice questions

Choose the response that is correct or that best answers the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will not be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

Question 1
Anything that assists recovery of information stored in LTM is called a _____ cue.
A. retrieval
B. recovery
C. constructive
D. reconstruction

Question 2
Which retrieval method will most effectively demonstrate the existence of information in memory?
A. recall
B. relearning
C. reconstruction
D. recognition

Question 3
When the recognition method is used, the required information
A. is reproduced in no particular order.
B. acts as a retrieval cue.
C. is unavailable for retrieval unless it can be seen.
D. must be selected from among incorrect alternatives.

Question 4
A neurodegenerative disease is best described as a
A. brain trauma.
B. brain injury.
C. brain-related disorder associated with older people.
D. progressive decline in the structure and/or function of brain neurons.

Question 5
Anterograde amnesia involves loss of memory of events occurring
A. backward in time.
B. before brain trauma.
C. after brain trauma.
D. before or after brain trauma.

Question 6
Someone with anterograde amnesia involving only semantic and episodic memories probably experienced brain trauma that impacted at the
A. synapse.
B. hippocampus.
C. amygdala.
D. cerebellum.

Question 7
Which structure is primarily involved in memory formation of classically conditioned fear responses?
A. cerebellum
B. hippocampus
C. cerebral cortex
D. amygdala

Question 8
Memory reconstruction typically involves
A. re-creating a memory using all accessible information in long-term memory.
B. building up a new memory using information planted in leading questions.
C. re-creating a distorted memory that has been manipulated by a researcher.
D. building up an accurate account of what was actually experienced at some time in the past.

Question 9
On recovering consciousness, a cyclist who was knocked unconscious in an accident is unable to recall events that occurred in the half hour or so before the accident. How would his amnesia be explained by the consolidation process?
A. lack of time for consolidation of sensory information in short-term memory
B. lack of time for completion of structural changes in neurons and synapses
C. lack of attention during the half hour before the brain trauma
D. lack of processing by the hippocampus in the parietal lobe

Question 10
Blake learns to play poker at his friend’s house. When he gets home, he decides to teach his younger sister, but can’t recall whether ‘three of a kind’ is a better hand than a ‘full house’. When he returns to his friend’s house a few days later and plays poker again, he recalls with ease that a ‘full house’ beats a ‘three of a kind’.
A probable explanation for Blake’s inability to recall the information at home is
A. source confusion.
B. context dependent memory.
C. lack of savings.
D. state dependent memory.
Question 11
The amygdala is located
A. in the medial lobe.
B. next to the hippocampus.
C. in the cerebral cortex.
D. next to the temporal medial lobe.

Question 12
Brain surgery resulting in severe damage to both amygdalae is unlikely to affect
A. retrieval of the details of an emotional memory such as where and when it was experienced.
B. acquisition of a conditioned fear response.
C. expression of a fight, flight or freeze reaction to a conditioned fear stimulus.
D. implicit, classically conditioned memory formation.

Question 13
Studies of animals and people with brain damage provide evidence that the _______ stores some relatively simple classically conditioned motor responses.
A. cerebellum
B. hippocampus
C. cerebral cortex
D. amygdala

Question 14
Forgetting as a result of retrieval failure usually occurs when
A. we fail to encode the to-be-remembered information.
B. we use an incorrect cue to locate and recover information.
C. the hippocampus is severely damaged.
D. the neural representation of a memory degenerates.

Question 15
Enhancing memory by weaving otherwise unrelated information into a meaningful event is an example of
A. context dependent memory.
B. maintenance rehearsal.
C. elaborative rehearsal.
D. the encoding specificity principle.

Question 16
A professional cyclist falls off her bike on day one of the Great Victorian Bike Ride. She breaks various bones in her body and is very upset about not being able to continue in the race. However, she does not sustain significant brain trauma, as she was wearing protective headgear. Afterwards, she remembers very little about the events leading up to, during and following the accident. She eventually recovers and enters the Around Tasmania Bike Race. Again she has an accident on day one, breaks various bones in her body, gets upset, but doesn’t suffer significant brain trauma. However, soon after falling, the events surrounding the fall in the Great Victorian Bike Ride come flooding back.
The cyclist’s recovery of memory of the first fall is an example of the
A. memory consolidation process.
B. memory reconstruction process
C. context dependency of certain memories.
D. state dependency of certain memories.

Question 17
Short-term memories are probably formed and stored in the
A. hippocampus.
B. amygdala.
C. cerebral cortex.
D. cerebellum.

Question 18
The serial position effect for superior recall of items at the end of a list is called the _____ effect.
A. recency
B. primacy
C. serial
D. recall

Question 19
Which of the following could serve as a state dependent retrieval cue?
A. happiness
B. a face
C. a sound
D. a location

Question 20
Which of the following memory processes is most likely to be experienced if there is damage to the frontal lobes?
A. reconsolidation
B. retrieval of explicit memories
C. retrieval of classically conditioned fear responses
D. expression of classically conditioned fear responses

SECTION B — Short-answer questions
Answer all questions in the spaces provided. Write using black or blue pen.

Question 1 (2 marks)
Explain how the relearning method could be used to demonstrate the existence of information in long-term memory that could not be retrieved using another method.
Question 2 (4 marks)
(a) What is Alzheimer’s disease? 1 mark

(b) What type of long-term memory is primarily affected? 1 mark

(c) What is a possible biological or neurological explanation of the increasingly severe memory decline associated with the disease? 2 marks

Question 3 (2 marks)
Distinguish between the recall of an episodic memory using context dependent and state dependent retrieval cues.

Question 4 (3 marks)
Explain how the serial position effect provides evidence for the existence of separate short-term and long-term memory stores.

Question 5 (7 marks)
(a) State two key components of a reconstructed memory following manipulation of memory, as proposed by Loftus. 2 marks

(b) Explain why the reconstruction of memories is evidence for the fallibility of memory, with reference to Loftus’s research on the effect of leading questions on eye-witness testimony. 5 marks

Question 6 (12 marks)
Patient A.B. had life-saving brain surgery to remove a malignant tumour that was aggressively spreading in the medial temporal lobe area. The surgeon removed the hippocampus in each hemisphere, along with areas of adjacent sub-cortical limbic system tissue and cortical tissue. The amygdala and cerebellum were left intact.

A.B. was subsequently found to have serious memory problems. These included:
- loss of memory for information and events experienced in the period leading up to the surgery, but only partial loss off episodic and semantic memories formed many years previously
- a ‘working’ STM but loss of new episodic or semantic information unless maintained through rehearsal
• anterograde amnesia for episodic or semantic memories
• deficits in spatial awareness in new locations and some familiar places e.g. got lost very easily when in new or unfamiliar location (e.g. a hospital ward not previously visited) but not in familiar well-known locations (e.g. own home).

A.B. was found to have no loss of motor skills that have been well-learnt over many years prior to the surgery, such as bicycle riding and golf putting. In addition, A.B. retained abilities to:
• acquire a conditioned fear response
• learn and retain simple conditioned reflex responses
• learn and retain more complex motor skills never previously experienced, such as mirror drawing and serving a table tennis ball (but unable to retain a memory of ever having participated in a training session).

(a) Explain why A.B.’s case provides evidence for the separation of explicit and implicit memories. 2 marks

(b) With reference to A.B’s brain surgery, abilities and inabilities, explain the likely roles of each of the following in the formation, storage and retrieval of STM and specific types of LTM. 10 marks

(i) cerebral cortex
(ii) hippocampus

Question 7 (15 marks)
The following graph below shows the results of a pioneering study conducted on sleep and memory. The researchers were interested in finding out whether it was better for recall of newly learned information to go to sleep immediately after learning.
Jenkins and Dallenbach (1924) had two groups of first-year psychology students at their university learn a list of nonsense syllables. Immediately after the learning, group A participants were required to go to sleep, whereas group B participants continued with their usual activities for 30 minutes before going to sleep. When tested for recall on the nonsense syllables at different times after awakening, it was found that retrieval was lower for group B.

(a) Which data in the graph shows the results for group B? Explain your answer. 2 marks

(b) Suggest a possible explanation of the results. 2 marks

(c) Formulate a research hypothesis for the experiment. 2 marks

(d) Identify the operationalised variables. 2 marks

(e) Suggest two extraneous or confounding variables that may not have been adequately controlled and explain your choice of each variable. 4 marks

(f) Write a possible conclusion for the experiment, ensuring you refer to your answers above. 2 marks

(g) To what extent can the results of the experiment be generalised? 1 mark

Return to the checklist on page xx and complete your self-assessment of areas of key knowledge where you need to do more work to improve your understanding.

**eBookplus**

The answers to the multiple-choice questions are in the answer section at the end of this book and in eBookPLUS.

The answers to the short-answer questions are in eBookPLUS.

Note that you can also complete Section A of the chapter test online through eBookPLUS and get automatic feedback. **int-0000**