Memory

PHENOMENA, EXPERIMENT AND THEORY

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Memory

For Frances

Preface

In 1987 I published a book called Memory and Amnesia. Part of the book was an overview of basic research issues in human memory. I have subsequently discovered that those opening chapters have been used quite a lot for introductory teaching, and this has prompted me to write this more extensive text, which is aimed primarily at more advanced undergraduates and postgraduates. Inevitably my book covers material dealt with elsewhere, but I have gone to some lengths to include topics which are typically given less coverage. In particular I have laid some emphasis on what one might term the 'Toronto school' that is, the work of theorists such Craik, Schacter, and Tulving – as well as providing accounts of memory development and aging – areas usually avoided by textbooks on memory. Also, as a reflection of my own interests, I have included a substantial amount of neuropsychological material.

I would like to thank John Gardiner, Jane Oakhill, and Josef Perner for their comments on parts of this book, as well as the many students whose comments over the years have helped shape my approach to the subject. I would also like to thank Ann Doidge, Yumi Hanstock, and Sylvia Turner for help with production. I am also most grateful to Jean van Altena for her detailed and extremely helpful copy-editing. Finally, my deepest thanks to Frances Aldrich, not only for suggesting the cover illustration, but for putting up with my preoccupations while writing this.

I hope those who read this book will experience some of the enjoyment and fascination with human memory that has sustained my interest in the subject for the last twenty years.

Alan Parkin
Brighton, September 1992

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The Present and the Past

To remember is to live.

Martin Buber

In 1953 a young man was admitted to a Montreal neurological clinic for what was later described as 'frankly experimental' brain surgery. The man, who has become known to the scientific world as HM, was suffering from intractable epileptic seizures, and it was agreed that the only remaining option for treatment was to remove the regions of the brain where the seizures arose. The operation involved **temporal lobectomy**, in which parts of both the left and the right temporal lobe were surgically excised. In one important way the operation was a success, because HM's epileptic seizures were now controllable by drugs; but the operation also had a dramatic and wholly unexpected side-effect – HM became **amnesic**.

HM is still alive at the time of writing, but remembers little of the personal or public events that have occurred during the last 40 years (see Ogden and Corkin, 1991; Parkin, in press). Immediately after his operation HM lived with his parents, but his father died in 1967, and his mother in 1977. HM has lived in a nursing home since 1980, but in 1986 he thought that he was still living with his mother, and he was unsure about whether his father was still alive or not. He has learned only a handful of new words, and prominent public events like the Vietnam War or the Watergate scandal mean little to him. It is not without reason that HM says: 'Every day is alone, whatever enjoyment I've had, whatever sorrow I've had.'

At first sight 'amnesia' (literal meaning: without memory) seems an appropriate characterization of HM's condition, but further observation suggests that it may be inaccurate. For HM can still speak and understand language, and he has retained the various skills he acquired before his illness. He also has reasonable recall of events that happened in his early life, but less recall for the years immediately before his operation. Another indication that HM has preserved some memory function is that he is **conscious**.

Memory and Consciousness

For most of us memory is what allows us to recall things from the past – events that happened hours, days, or months ago. Few us of would concede, without some reflection, that being conscious is, itself, an act of memory. Consider hearing the sentence 'The sun, made hazy by the thin cloud, shone on the tin roof.' You perceive it as a whole, part of what you regard as the **present** moment. Yet, when we examine what must have happened in order for you to understand the sentence, we find that you must have stored the first part of the sentence, dealt with the relative clause, and then linked it with the final clause. This is a process that occurs across time, so the system underlying conscious awareness must itself depend on some form of memory.

The idea that conscious experience requires memory is not new. In his *Principles of Psychology* William James (1890) called the memory system supporting consciousness **primary memory**, to distinguish it from **secondary memory**, which comprises our permanent record of the past. James suggested that primary memory be thought of as 'the rearward portion of the present space of time', rather than the 'genuine past'. An important corollary of primary memory was that its contents were highly accessible and that it required little effort to retrieve them. By contrast, retrieving the contents of secondary memory required a deliberate, effortful act.

William James was the most prominent psychologist of his time, and was read widely during the latter years of the nineteenth century and the first half of the twentieth. However, his ideas about memory did not start to influence experimental psychology until the 1960s. This extraordinary delay can be attributed to the direct influence of **behaviourism** (which we will consider in more detail in chapter 6). The behaviourists believed in a purely objective approach to the explanation of behaviour, and they rejected any theoretical concepts that embodied subjective elements. The concept of consciousness, which was critical to James's account of primary memory, is purely subjective, so it is perhaps not surprising that the behaviourists showed little interest in James's important insight into human memory.

Experimental Method in the Study of Human Memory

Before considering any experimental research into human memory, we need to examine the rationale underlying the various techniques used. The dominant approach to human memory research stems from the tradition established by Hermann Ebbinghaus (1885). Ebbinghaus took the view that human memory could not be investigated rigorously unless every effort were made to exclude the influence of extraneous factors on the outcome of experiments. He realized that a major contaminating factor could be the prior knowledge that subjects bring to an experiment. Subjects might exhibit different amounts of remembering simply because they knew differing amounts about the material they were required to learn before the experiment started.

To solve this problem, Ebbinghaus suggested the use of nonsense syllables as **target** stimuli in memory experiments. These would be unknown to the subjects, and thus any differences in the memory for these items under different conditions would represent a genuine property of the memory system. Ebbinghaus conducted most of his research on himself. His basic technique involved repetition of a list of nonsense syllables until he could recall it perfectly. In one classic experiment he examined his rate of forgetting by examining how easily he could relearn a list after different time intervals. Figure 1.1 shows the amount of savings in relearning after different retention intervals. At first, forgetting is rather rapid, but after about 8 hours further forgetting occurs at a relatively slow rate.

The methodological approach developed by Ebbinghaus still dominates experimental work on memory (e.g. Young, 1985), but not all psychologists are convinced that this is the right course. Their objection is that the use of nonsense syllables and other meaningless stimuli to investigate memory lacks any **ecological validity**; for human beings do not, in real life, ever have to learn nonsense, so theories derived from experiments using this method have little or no value.

An alternative approach, first put forward by Bartlett (1932), is that

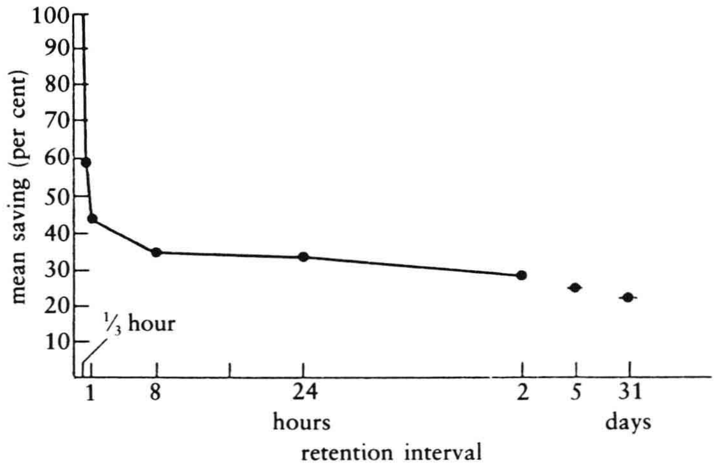

Fig. 1.1. Forgetting rate, as measured by Ebbinghaus. From Baddeley, 1976, p. 8. Reproduced with the permission of Harper and Row Publishers.

human memory can be properly understood only by getting subjects to learn and recall material that means something to them. The problem with this approach is that it introduces many of the extraneous factors that Ebbinghaus tried to avoid. A very striking example of how the recall of 'real' memories can mislead is provided by the unique case of John Dean.

John Dean was an aide to Richard Nixon at the time of the Watergate scandal, and was party to many conversations relating to the infamous cover-up. Dean produced extensive accounts of conversations with the President and his aides, and his facility for recalling details was so impressive that some reporters dubbed him 'the human tape recorder'. Unknown to Dean at the time, the conversations he was describing were being secretly recorded, thereby providing a basis on which his apparently amazing memory could be evaluated.

Neisser (1982) examined the relationship between Dean's testimony and the recordings. Far from being accurate, Dean's testimony was found to contain many inaccuracies; but it would be unfair to describe it as dishonest. Rather, it seems to have been based on what Neisser termed 'repisodes' – statements that are essentially correct but are not a literal account of any one event. Furthermore, Dean added an egocentric flavour to these accounts so as to enhance his apparent role in the affair.

The case of John Dean is extreme, but it illustrates the ability of human subjects to distort and bias the retrieval of memories that are meaningful to them. There are certainly occasions when the study of bias and distortion in memory are of major importance (e.g. inaccuracies due to racism); but, when it comes to producing experimental evaluations of theories, the control offered by the Ebbinghaus tradition is still favoured by most investigators.

Although nonsense syllables are not used very often now, experimenters still rely heavily on techniques involving the learning of 'meaningless' material, such as lists of unrelated words. There are a number of reasons for this. First, current human memory research derives from the behaviourist tradition, in which control of stimulus variables was an absolute principle. Second, this kind of experimentation lends itself more easily to the development of theories. Later we will see how certain theories of memory are tied very closely to the use of verbal stimuli as memory items. However, research into more meaningful aspects of memory is also carried out. There is, for example, active research into autobiographical memory – the way people organize and retrieve information about their personal past (Conway, 1990).

Primary and Secondary Memory Revisited

Waugh and Norman (1965) were impressed with James's idea that remembering from primary memory was a virtually effortless experience, and set out to investigate this using the **probe digit task**. This involved the subject listening to a sequence of 16 digits which was then followed by a probe digit. The subject's task was to name the digit that occurred after the probe. Thus in the sequence *5824972537196435* **6** the correct answer is 4.

Figure 1.2 shows that as the number of items occurring after the probe digit increased, performance on the probe task became poorer, declining at a steeper rate with five or fewer intervening items. The much better performance when only a few items intervened between the probe and the target was attributed to the items still being in primary memory and thus very easy to recall. The change in the gradient was taken as indicating the transition from primary to secondary memory, and its occurrence at the five-item point provided the first empirical demonstration of separate primary and secondary memories and the first est e of primary memory capacity.

An important feature of the probe digit task is that it prevents subjects from engaging in **rehearsal**. This term describes the natural human

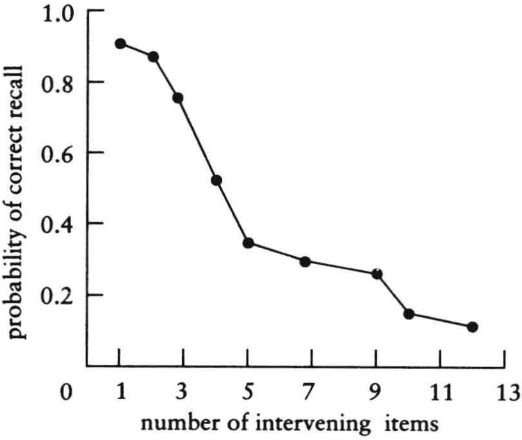

Fig. 1.2. Performance on the probe digit task. Adapted by Gregg (1986) from Waugh and Norman (1965), p. 91. Reproduced with the permission of Routledge.

tendency to repeat information when trying to remember it. Waugh and Norman assumed that the amount of rehearsal an item received directly influenced the probability of its entering long-term store. Preventing rehearsal enabled them to examine two competing theories of why information was lost from primary memory. They distinguished between a time-based **decay** process in which new memory traces deteriorated with time and a **displacement** process in which the contents of primary memory were retained until displaced by new information. To distinguish these theories, they examined performance on the probe digit task at different rates of presentation. Because rehearsal was prevented, they could assume that items passed into memory in an orderly fashion and that any failure to remember items could not be attributed to the recycling of earlier items due to rehearsal. They found that variations in presentation rate still produced results similar to those shown in figure 1.2. This supported the displacement theory, because if decay were responsible for forgetting, the effect of intervening items should have been more pronounced at slower presentation times.

Testing HM's Primary Memory

Wicklegren (1968) became interested in HM, and, in particular, was curious to know how HM performed on a task assumed to require only primary memory. He employed a similar but easier version of the probe digit task used by Waugh and Norman. Following an auditory signal, HM was shown a sequence of eight digits followed by a single test digit. His task was to decide whether or not the digit had been in the list. His performance was very accurate, and varied little as a function of the test digit's position in the list, thus suggesting that his primary memory function was normal.

Further evidence of normal primary memory in HM can be found by looking at his ability to do the **digit span** task. This task measures the ability to repeat a random series of numbers in the correct order immediately after seeing or hearing them. This task is widely assumed to measure our span of awareness, and normal subjects behave very consistently on the task, scoring an average of seven plus or minus two (Miller, 1956). HM's digit span has varied a little over the years, but when last evaluated, it was seven, thus indicating normal primary memory.

HM's case is not unique, and psychologists have studied many other patients with amnesia. Figure 1.3a shows the performance of a range of different amnesic patients on verbal and non-verbal memory span tasks, and, in every case, their performance is well within the normal range. This stands in marked contrast to their extremely poor ability on tests requiring the retention of information over longer periods of time (figure 1.3b). With evidence like this, there can be little doubt that what we have so far called primary memory exists independently of the secondary memory that allows us to retain information over longer periods of time.

The Importance of Neuropsychology

Already in this chapter we have twice referred to data from a brain-damaged subject as evidence for a particular theory about the organization of normal memory. Before drawing on this type of evidence any further, it might be wise to look at the logic underlying the use of this sort of evidence. K. Craik (1943) writes: 'In any well-made machine one is ignorant of the working of most of the parts – the better they work the less we are conscious of them . . . it is only a fault which draws attention to the existence of a mechanism at all.'

This quotation appears at the beginning of Ellis and Young's influential book *Human Cognitive Neuropsychology* (1988), and it neatly summarizes the rationale for what has become known as 'cognitive neuropsychology'. Basically, cognitive neuropsychology assumes that the

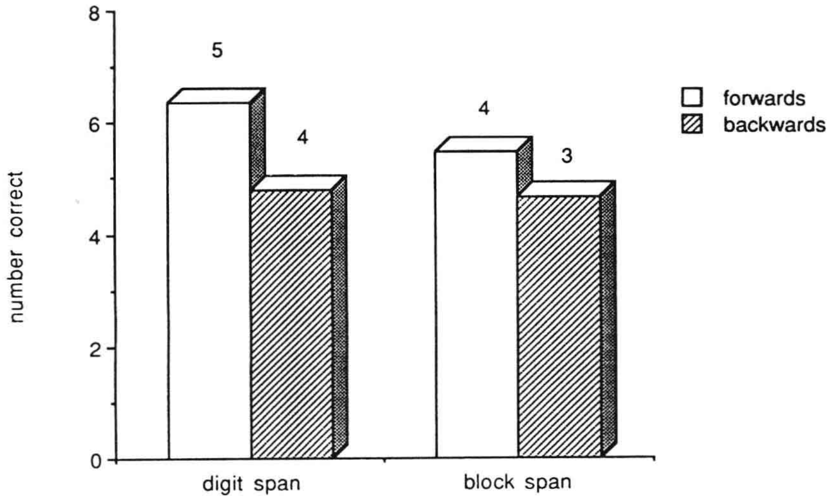

Fig. 1.3a. Performance of amnesic patients on digit span and block span tests. Block span is a non-verbal equivalent of digit span. Forward span requires the subject to reproduce items in the same order as the experimenter. Backward span requires the subject to reproduce them in reverse order. The numbers indicate the minimum score within the normal range.

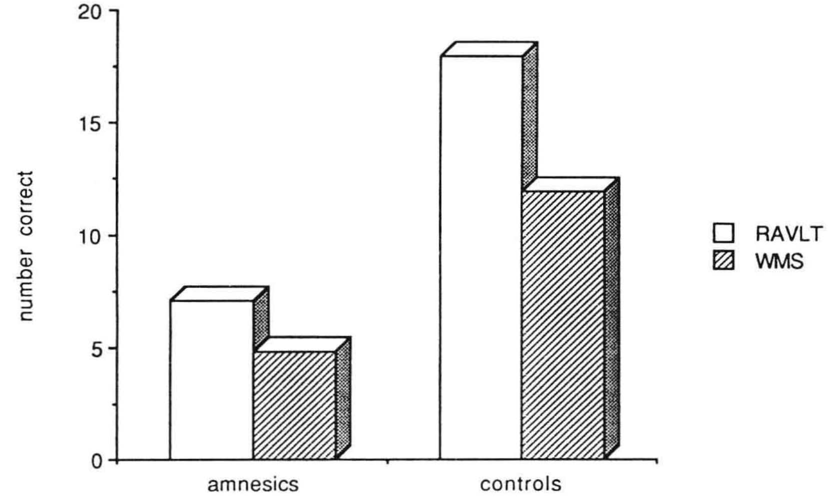

Fig. 1.3b. Performance of amnesic patients and controls on two tests of longer-term retention, *The Rey Auditory Verbal Learning Test* (RAVLT) and *The Wechsler Memory Scale* (WMS). Adapted from Corkin et al. (1985), pp. 26–7. Reproduced with permission.

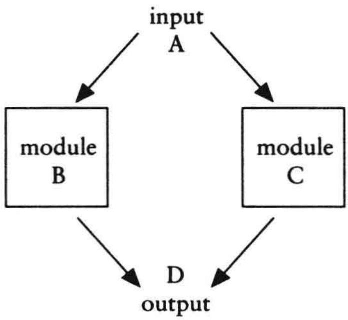

Fig. 1.4. Hypothetical modular system in which the input A can give rise to the output D via processing by either of two intervening modules.

various components of cognition, including memory, are spatially distributed within the brain and that, furthermore, each of these mental functions is **modular**. A modular system is one in which several components interact to perform a function, but each component, or **module**, is functionally autonomous – i.e. it can continue to operate if other modules cease to work for any reason. When the brain is damaged, either by accident or by illness (so-called natural experiments), it is assumed that modules may become dissociated from each other in a meaningful way and thereby reveal something about the underlying organization of the system.

Consider the hypothetical case illustrated in figure 1.4. Here an input A can give rise to an output D via two modules, B and C. It is assumed that these two modules achieve the output in different ways, but under normal circumstances it is not possible to observe the independent operation of these two modules, and so their separate existence is not proved. However, if we were to observe two brain-damaged patients producing output D, but in different ways, we would have evidence that two processes were involved, and by analysing the patients' behaviour in detail, we might gain an insight into how each of the modules works.

When the pattern of behaviour consistent with B intact and C inactive and vice versa is observed, we have what is known as a **double dissociation**, which indicates that a particular function has two components, each of which can operate independently of the other. When we observe a dissociation of one kind only – i.e. evidence that B is intact and C inactive but *not* vice versa – we have a **one-way dissociation**.

Double dissociations constitute a more compelling basis for arguing that a system comprises several functionally independent modules, but