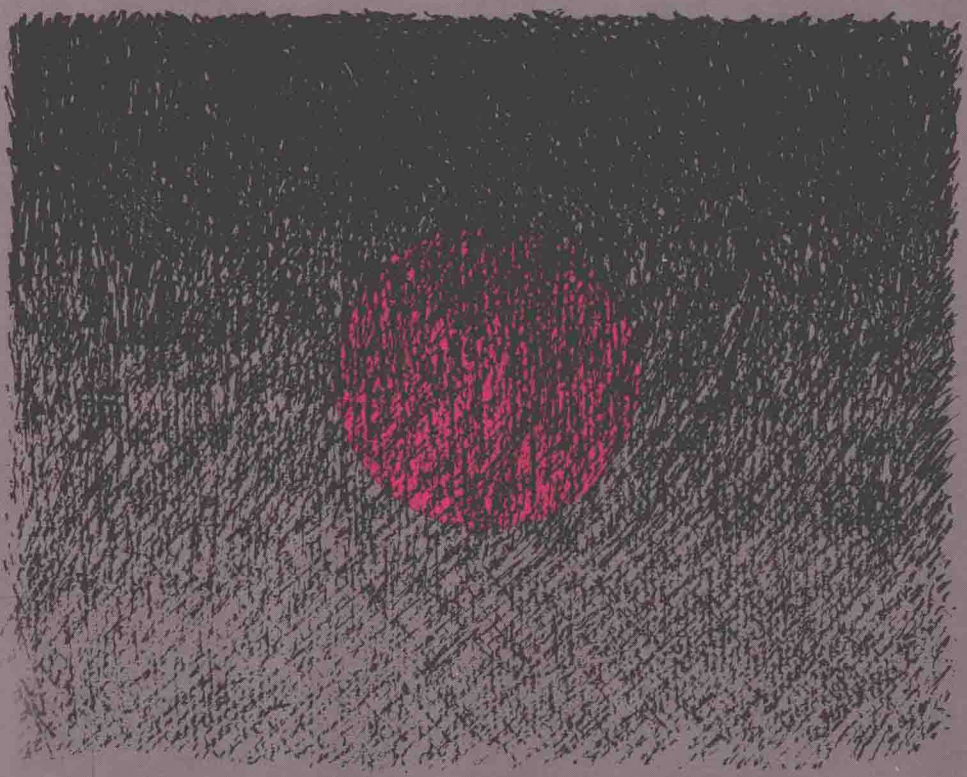
HUMAN MEMORY

THEORY AND PRACTICE



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HUMAN MEMORY
Theory and Practice

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Allyn and Bacon
Boston ■ London ■ Sydney ■ Toronto

Dedication
To Hilary

Series Editor: Diane McOscar
Production Administrator: Annette Joseph
Production Coordinator: Susan Freese
Cover Administrator: Linda K. Dickinson
Manufacturing Buyer: Bill Alberti

Library of Congress Cataloging-in-Publication Data

Baddeley, Alan D.
Human memory: theory and practice/Alan Baddeley.
p. cm.
Includes bibliographical references.
ISBN 0-205-12312-0
1. Memory I. Title.
BF371.B225 1990
153.1'2–dc20 89-48432
CIP

Printed in the United States of America

10 9 8 7 6 95 94 93

PREFACE

In 1970 I began to write a brief elementary memory text. It eventually emerged some six years later as a rather more ambitious enterprise, which attempted to serve as both an advanced undergraduate text and as a survey of the state of memory at the time that would be useful to my colleagues. It seems to have served both these functions reasonably well – I even received notification last year that it had finally achieved the status of a "citation classic", which entitles the author to bore the readers of *Current Contents* with his hoary recollections of how and why he came to write the book. It is, of course, now long out of date, so much so that rather than attempt to revise it, I have decided to write a completely new book.

The study of the psychology of memory has been enormously active in the last ten to fifteen years, with the result that the present book differs in a number of important respects from my earlier effort. First of all, the sheer volume and breadth of research means that I can no longer even attempt the depth of coverage that characterized at least some chapters of the earlier book. I suspect that this is not entirely a bad thing, particularly for the student reader whose commitment to the more arcane reaches of iconic memory or proactive inhibition may be less than total.

However, while the coverage of memory is far from encyclopaedic, I believe that it is important to give a reasonably detailed account of major experiments and paradigms and to provide enough examples of closely argued theorectical discussion to give a genuine feel of the psychology of memory as a living and developing area of science. The reader will perhaps not be too surprised to discover that the areas chosen for more detailed treatment tend to be those in which I am most closely involved; these are obviously topics about which I can write with particular knowledge and enthusiasm. I assume that teachers using the book as a text will supplement it with their own areas of expertise, hence redressing the balance. While I anticipate that the typical reader will be either a student taking a lecture course on memory or a colleague updating his knowledge of the field, I have tried to write in a way that would make the study of memory accessible to the interested general reader. Anyone with no prior familiarity with the study of memory, however, might find it useful to begin with my brief overview entitled *Your memory: A user's guide* (Penguin Books, 1982).

The study of memory has changed and developed over the last decade, and a number of these developments are reflected in the

nature of the present book. One of the most striking changes has been the increase in the number of studies of ecological or everyday memory. During the 1970s, the psychology of memory was predominantly the psychology of the verbal learning laboratory. I attempted in my previous book to speculate as to the real-world significance of these findings observed, but for the most part, this was speculation and nothing more. It is this lack of a clear link between the laboratory and the world that prompted Neisser (1978) to comment so negatively about the sterility of memory research.

Since that time there has been a burgeoning of interest in naturalistic studies of cognition, and I must confess that I began this book intending the rather ambitious, perhaps even gradiose task of providing an ecologically based account of the psychology of memory. The aim was to begin with the problems that memory has to tackle, to work from these to the theoretical questions that must be asked, and, via a combination of laboratory and real-world studies, to their answers. Perhaps unsurprisingly, this proved overambitious; although the links between theory and practice are much more extensive than ever before, there are still far too many gaps to allow a coherent text to be written.

The question of the importance of everyday memory is currently rather controversial, with protagonists such as Neisser (1978) denigrating the standard laboratory approach, while Banaji and Crowder (1989) complain of the "bankruptcy of everyday memory". I trust that what follows will make a powerful case for the view that neither of these extreme views is readily defensible. We need the control and simplicity of the laboratory to develop and test out theories, but at the same time we need to explore their adequacy and generality outside the laboratory by carrying out studies which at this stage may often be little more than natural history. At some point we shall have accumulated sufficient good observations to make such comparatively atheoretical study no longer necessary, but we are as yet far from reaching that point. For that reason, I make no apology for including data collected under natural or semi-structured conditions from barmen and divers, mothers in labour and first-aiders, and indeed anyone who has to make use of his or her memory in the rich and complex conditions of the real world. I similarly make no apology for describing many well-controlled, theorectically driven laboratory studies. We need both.

Another feature that I have tried to incorporate is an awareness of the historical continuity of work on the study of memory. Psychology has perhaps tended to be excessively driven by fashions and enthusiasms, with the danger that we are perpetually rediscovering what was known and then forgetting it again. Consequently, I have tried to emphasize the continuity of work by referring to its historical origins and make no apology for including memory phenomena that are perhaps slightly less fashionable than they were a few years ago.

A related concern has been to emphasize the continuity across

fields of psychology that perhaps typically tend to be taught as separate courses. The link between memory and other aspects of cognition is, of course, particularly clear within the area of working memory; the storage capacity of any cognitive system is an integral part of its capacity to perceive, attend and reason. Similarly, the study of memory without learning is clearly a nonsense. And yet for practically a quarter of a century, theories of learning appear to have been overtly developed only in the animal laboratory. I suspect that this stemmed largely from the fact that the information-processing models of the 1960s and '70s were based on a computer model that provided a particularly implausible analogy for the process of human learning, while providing much more fruitful metaphors for other aspects of cognition. Whatever their ultimate success, I believe that the new developments in parallel distributed processing or connectionist models of learning will bring the study of theories of learning back to the centre of the scientific stage.

One final feature that differentiates the present book from its predecessor is its concern for clinical evidence. Studies of the memory performance of amnesic patients, once regarded as largely irrelevant to normal memory, now play an increasingly important role in memory theorising. There is little doubt that the unfortunate patients with memory problems have helped us understand human memory; the final chapter considers the question of whether the psychology of memory can in turn help these patients.

ACKNOWLEDGEMENTS

I have been fortunate in writing this book to be able to draw on the advice of a very wide range of friends and colleagues; I am particularly grateful to those who have helped me to approach intriguing but unfamiliar topics. My venture into behavioral approaches to learning was greatly helped by advice from Archie Levey, David Shanks and John Teasdale, while my treatment of connectionism would have been even more limited without the help of discussions with Dennis Norris, George Houghton and my son, Roland. The chapter on cognition and emotion benefited greatly from talks with Mark Williams and Fraser Watts, while my views on the application of behavioral methods and single case designs to the treatment of memory deficits were clearly much influenced by discussions with Barbara Wilson.

I am particularly grateful to a number of colleagues who were prepared to read and comment on a draft version of this book, often under unreasonably constrained time pressures. They include Robert Bjork, University of California (Los Angeles); Deborah Burke, Pomona College (Claremont, CA); Gillian Cohen, The Open University (Milton Keynes, England); John Gardiner, City University (London, England); Richard Hanley, University of Liverpool (Liverpool, England); Janet Jackson, Groningen University (The Netherlands); John Mueller, University of Missouri (Columbia) and Alan Parkin, Sussex University (Brighton, England). I am sure that the final version has benefited immeasurably, despite the fact that it has not invariably been possible to follow all their excellent suggestions.

I find that the most successful way of writing is by walking and talking into a portable taperecorder; I therefore owe a particular debt to my secretary, Julia Darling, who has regularly performed miracles of turning my garbled mumblings into beautifully typed prose. Without her help, this book certainly would not have been written. It was, in fact, principally written over a period of three summers, a process that was made much more enjoyable by the north Norfolk countryside in which it was written, and by the unfailing support of my wife, Hilary, to whom it is dedicated.

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Chapter One

WHY DO WE NEED MEMORY?

UNDERSTANDING LEARNING AND MEMORY

The Scientific Approach

Philosophers have speculated about memory for at least 2,000 years, but its scientific investigation only began about 100 years ago. A German scholar, Hermann Ebbinghaus decided to apply the experimental methods that had recently been developed for the study of perception to the more ambitious investigation of "higher mental processes" and more specifically to human memory. He chose to avoid the richness and complexity of memory in everyday life, by studying the learning and forgetting of artificial materials by a single subject, himself, under rigidly controlled conditions of learning and recall. By means of this ruthless simplification, he was able to demonstrate important characteristics of human memory that were not known to earlier investigators.

The true importance of his work, however, lay less in his new discoveries than in his demonstration that the experimental method could be used to investigate something as complicated as human learning and memory. This theme, that even complicated mental functions could be studied given sufficiently simplified and controlled conditions, has dominated the scientific study of human memory ever since.

There was, however, a price to be paid for adopting this approach. Many of the richer and more intriguing aspects of human memory are difficult if not impossible to capture within the laboratory, while theories developed on the basis of simplified and artificial laboratory-based material often proved difficult to apply in the outside world. This has led to the criticism that much research on the psychology of memory is concerned with trivial and unimportant questions, being excessively concerned with exploring and developing new laboratory tasks, and paying little attention to the applicability of results to remembering in the outside world. One of the most trenchant critics of traditional memory research is Ulrich Neisser who has suggested the following "law", that "If X is

an important or interesting feature of human behavior, then X has rarely been studied by psychologists" (Neisser, 1978, p.2).

I have a good deal of sympathy with this view. I believe that experimental psychologists have often been excessively timid, being obsessed with the need for experimental control, and because of this quite unwilling to step out of the laboratory to see if such theories as they have created are indeed applicable to the world outside. Far too much psychological research consists of experiments merely investigating other experiments which in turn were based on yet other experiments. It is of course necessary to examine the experimental and methodological tools that we use, but it is at least as important to concern ourselves with the validity of such tools. Elegant methods are not enough if they limit us to studying trivial questions.

The reason for these shortcomings is not difficult to see. Human memory is extremely complicated, and attempting to investigate it under uncontrolled real-world conditions is often frustratingly hard. Even merely collecting reliable results can be time-consuming and costly, while carrying out the sort of experimental test necessary for deciding between competing theories is often quite impossible.

Nonetheless, there is a tradition of memory research within the real world that extends back at least to Sir Frances Galton who was carrying out important, though largely observational work on memory at the same time as Ebbinghaus was earnestly mastering his lists of nonsense syllables. An interest in memory in the real world continued to flourish in the earlier years of this century, notably in the work of Bartlett in Britain, and of the Gestalt psychologists in Germany. In North America, where the influence of behaviorism was much stronger, the Ebbinghaus approach with its emphasis on simplification and experimental control, dominated the study of human memory up to the 1960s when the cognitive approach rapidly came to dominate the study of memory.

Cognitive Psychology and Ecological Validity

The term "cognitive psychology" is a rather loose label applied to a more flexible approach to psychology. In the case of memory, this approach was often associated with theories based on, or influenced by, the development and use of the electronic computer, which influenced psychological theory by offering new concepts and a new language, that of information processing. Computer-based terms such as "buffer store", "feedback", "encoding" and "retrieval" rapidly became absorbed into the field of memory research.

There is no doubt that this influx of new ideas substantially enriched the study of memory, and within a remarkably short period of time the older experimental techniques and concepts began to disappear from the journals. It could, however, be argued that the Ebbinghaus tradition has continued to dominate North American psychology, with a continued preoccupation with

experimental control and an unwillingness to risk exposing the results of the experimental laboratory to the rigors of the world outside. This critical view of the field is cogently argued by Neisser (1976) whose earlier book entitled *Cognitive Psychology* published 10 years before had named and launched the North American cognitive psychology boom.

In his later book, Neisser (1976) makes an eloquent plea for a concern for "ecological validity". This term, associated with the work in perception of Brunswik (1957) and of Gibson (1979) emphasizes the importance of studying perception in the world rather than the laboratory.

Strongly influenced by Gibson, Neisser argues for a move away from the excessive preoccupation with laboratory control and towards an understanding and analysis of the world outside. This approach has had some success in the area of perception despite the rather Messianic fervor of some of its advocates, but has so far been much less influential in the area of human memory. Neisser's initial contribution to this area, was the publication of a book of readings entitled *Memory Observed* (Neisser, 1982) in which research on everyday memory from a wide variety of sources is collected together. It is a delightful book that is very well worth browsing through, but it does, I am afraid, tell us more about Neisser's enthusiasm and tastes than about how human memory should be studied. It offers many fascinating observations and a few intriguing experiments, but is as far from a coherent approach to the study of memory as the Victorian collections of natural history exhibits were from a modern biology laboratory. Perhaps we are still waiting for our Darwin?

While sympathizing with many of Neisser's criticisms, I myself am more of an optimist. I believe that we have made and are making very substantial progress in understanding human memory, and that much of the work carried out in the laboratory does have direct applications in the world outside. I am not of course by any means unique in this view. The comments by Neisser quoted earlier were from an address to a meeting in Wales in 1978 on "practical aspects of memory" (Neisser, 1978). It was a very large meeting in which the numerous participants discovered, with some surprise I suspect, that they were not alone in their preoccupation with memory outside the laboratory.

The proceedings of that meeting formed a landmark in research in this area, and it is now the case that far from being regarded as eccentric, or even reprehensible, work on memory outside the laboratory runs the risk of appearing too concerned with the fashion of the moment. In his closing address to the second conference on practical aspects of memory, some nine years later, Neisser acknowledges that "Time present is very different from time past. Then we were barely at the margin of respectability; now we are somewhere between a necessary evil and a wave of the future" (Neisser, 1988, p.545).

However, despite the increasing flow of ecologically relevant

research, it is still far from easy to present an overall view that is not based on the laboratory. It is so much easier to carry out theoretically cogent studies under controlled conditions, that this is likely to remain the major source of theoretical development, although not necessarily of initial theoretical insights into human memory. There will, however, remain a constant need to check laboratory findings against everyday life, and of course to check our theoretical interpretations of everyday phenomena within the more tightly controlled arena of the laboratory.

There is also, of course, a need to bear both the laboratory and the world in mind in teaching the psychology of memory. Since most theoretically cogent work has been done in the laboratory, the temptation is to present a traditional laboratory-based approach, with occasional illustrations and nods in the direction of real-world application. The present book makes a conscious attempt to break away from this. Instead of listing the areas that have been explored, and then attempting to justify such research, I shall try to begin with some basic questions about memory. Questions that an intelligent Martian landing on earth might ask, based particularly on the question of what function or functions memory serves. I shall try to illustrate the importance of these various functions by describing patients who, usually as a result of brain damage have had a given function destroyed or impaired.

WHAT IS MEMORY?

The use of a single term might seem to suggest that memory is a unitary system, albeit a complicated one such as the heart or the liver. As will become obvious, it is not one system but many. The systems range in storage duration from fractions of a second up to a lifetime, and in storage capacity from tiny buffer stores to the long-term memory system that appears to far exceed in capacity and flexibility the largest available computer.

One way of gaining some appreciation of the importance of memory is to study the plight of patients whose memory has been impaired as a result of brain damage. Consider for example the case of Clive Wearing, a very intelligent and highly talented professional musician and broadcaster who in his 40s was afflicted by encephalitis, a virus that caused inflammation, and subsequently damage to his brain. He was unconscious for many weeks from an attack that would, up to recently, have been sufficient to kill him. However, drugs for treating encephalitis have improved, and his health recovered, leaving him with substantial brain damage and a very dense amnesia.

Amnesia is not an all-or-none condition, and most amnesics can appear to be relatively normal on initial meeting. Not so in the case of Clive, since his amnesia was so dense that he could remember nothing from more than a few minutes before, a state that he attributed to having just recovered consciousness. Left to his own devices, he would often be found writing down a time, for example

3.10, and the note "I have just recovered consciousness", only to cross out the 3.10 and add 3.15, followed by 3.20, etc. If his wife left the room for a few minutes, when she returned he would greet her with great joy declaring that he had not seen her for months and asking how long he had been unconscious. Experienced once, such an event could be intriguing and touching, but when it happens repeatedly day in, day out, it rapidly loses its charm.

Clive was not capable of showing new learning of people or events, rapidly becoming frustrated in a learning situation and fulminating against anyone so stupid as to waste his time on silly tests when he had only recovered consciousness a few moments before. In some patients, new learning may be impaired, while their recollection of earlier learning is normal. Not so, alas, in the case of Clive, whose capacity to recall his earlier life was patchy in the extreme. He could still remember general features, such as where he had been to school and what college he had attended at Cambridge, together with highlights such as singing for the Pope on his visit to London, and some particularly dramatic musical events he had organized. In all cases, however, his capacity to recall detail was extremely poor.

What of his semantic memory, his general knowledge of the world? Here again considerable impairment had occurred. He had written a book on Lassus, an early composer, and could still recall just a few salient features of the composer's life, but with no richness or detail. When shown pictures of Cambridge, a city in which he had spent four years of his life and subsequently visited frequently, the only scene he recognized was King's College Chapel, the best known and most distinctive Cambridge building; he did not recognize a photograph of his own college. More general knowledge was also markedly impaired for someone of his level of culture and intelligence. He could not for example remember who had written *Romeo and Juliet*, and when shown a picture of the Queen and Duke of Edinburgh identified them as singers he had known from a Catholic church.

One aspect of Clive's skills did however, appear to be remarkably well-preserved, namely his musical ability. His wife describes returning on one occasion to find that the choir that Clive had directed was visiting him, and to observe him conducting them through a complex piece of music showing all his skills and capacity to spot when someone was making a mistake. Similarly, he could play the piano or harpsichord extremely well, although initially he did encounter one particular problem. Many pieces have a point at which a return sign means that that section has to be played once again before continuing. Initially Clive ran into difficulties at this point, becoming stuck in an apparently eternal loop. Subsequently, however, he appears to have solved the problem of how to cope with this, although it is far from clear how.

The effect of Clive's memory loss on his life is, of course, devastating. If he goes out alone, he is lost and has no idea how to find his way back. He can not tell anyone who finds him where he

has come from or where he is going. He has only the haziest access to his own past, and no apparent capacity to learn anything new. In his own words, his life is "Hell on earth—It's like being dead—all the bloody time".

The desperate plight of Clive and densely amnesic patients like him clearly demonstrates that memory is important, but does not tell us how we should go about investigating it. What are the important questions? Let us suppose that by some miracle of science, alas still far beyond our capabilities, that we could give Clive a new memory, working well in hot and cold weather, immersible under water and capable of withstanding the sorts of forces encountered by American football players in collision—in short, something that has most of the characteristics of a normal human memory system. What questions should we ask of such a system in order to decide whether it really was as good as Clive's old memory?

Component Processes

I might perhaps begin by asking my brand new memory box one question that is of great importance to me, if not the rest of the world, namely "Who am I?" In order to answer this, the memory box would need to have some form of ***autobiographical memory***, a record of the experiences of a lifetime that go together to create myself as a person. In the case of psychologists studying normal memory, this was a topic initially raised by Galton in 1883, but largely neglected since, until a resurgence of interest in the last few years. We shall be discussing this in Chapter 12.

A second question that would interest me about my box concerns the issue of "What do I know?" Clive would find it very necessary to have a system that contained a great deal of information, not only facts about composers and choirs, but also general information about the world, how to order food, to travel on buses and carry out the wide range of skills that are essential to functioning as a normal participant in any complex society such as our own. The study of this topic, *semantic memory* was also somewhat neglected until attempts to provide a knowledge-base for computer systems stimulated an interest in the way in which this enormously important but complex facility operates in people. We shall be exploring this in Chapter 13.

A third crucial question I might want to ask my new system is "How will it learn?" Evolution has come up with two broad strategies for solving the problem of allowing complex behavior. One is to pre-program the organism so that everything that is necessary for efficient functioning is built into the genes of the organism, with a minimum of modification necessary. This occurs in the case of many insects and so-called "lower organisms". While such a solution is very rigid, organisms adopting it have been successful for far longer than man has been on the planet, and may well outlive him by a similar margin. The other strategy is to