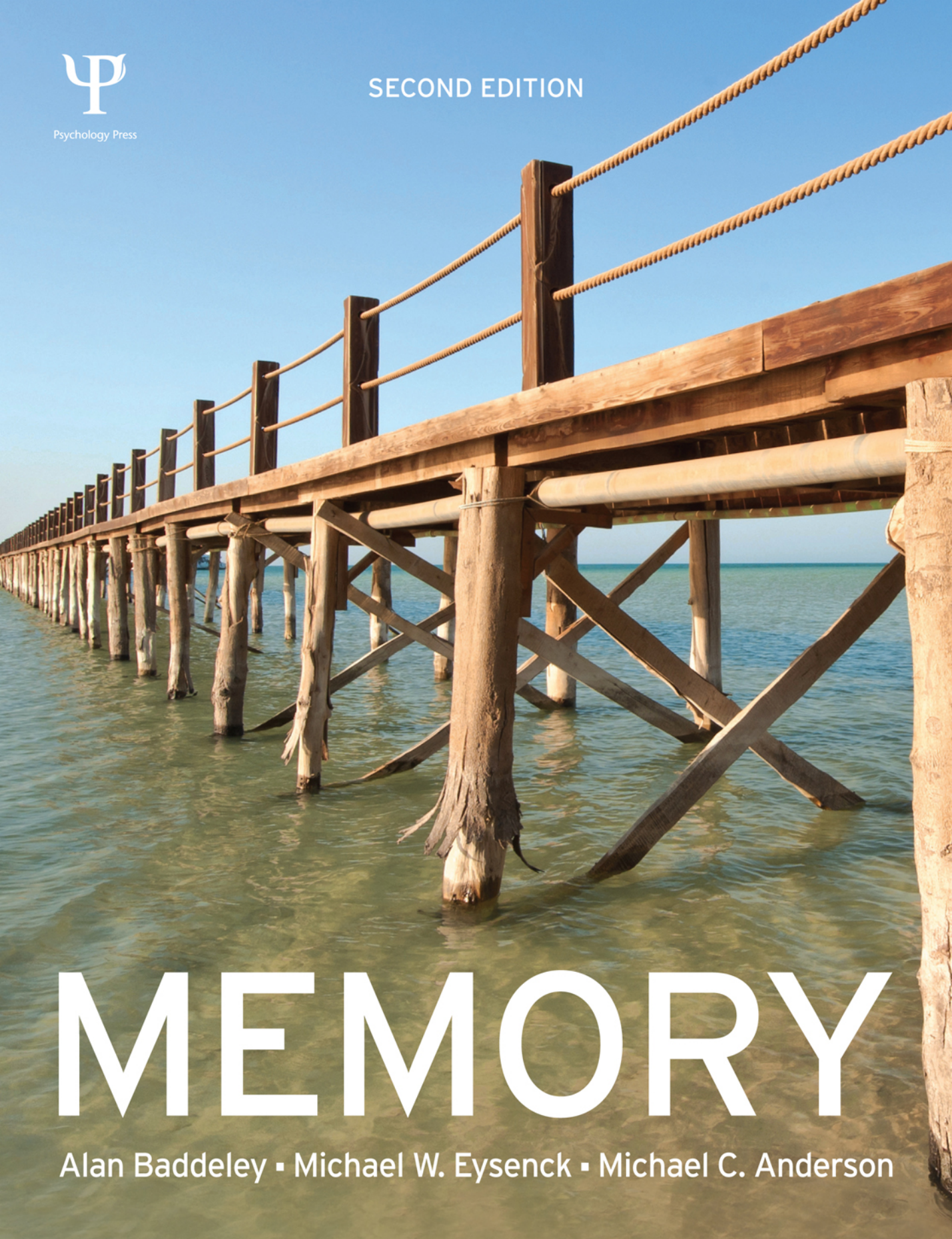
Psychology Press
SECOND EDITION
MEMORY
Alan Baddeley ▪ Michael W. Eysenck ▪ Michael C. Anderson

MEMORY

This best-selling textbook presents a comprehensive and accessible overview of the study of memory. Written by three of the world's leading researchers in the field, it contains everything the student needs to know about the scientific approach to memory and its applications.

Each chapter of the book is written by one of the three authors, an approach which takes full advantage of their individual expertise and style, creating a more personal and accessible text. This enhances students' enjoyment of the book, allowing them to share the authors' own fascination with human memory. The book also draws on a wealth of real-world examples throughout, showing students exactly how they can relate science to their everyday experiences of memory.

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- thoroughly revised throughout to include the latest research and updated coverage of key ideas and models;
- a brand new chapter on "Memory and the Brain," designed to give students a solid understanding of methods being used to study the relationship between memory and the brain, as well as the neurobiological basis of memory;
- additional pedagogical features to help students engage with the material, including many "try this" demonstrations, points for discussion, and bullet-pointed chapter summaries.

The book is supported by a Companion Website featuring extensive online resources for students and lecturers.

Alan Baddeley is Professor of Psychology at York University, UK.

Michael W. Eysenck is Professor of Psychology at Royal Holloway, University of London, UK.

Michael C. Anderson is Senior Scientist and Programme Leader at the MRC Cognition and Brain Sciences Unit in Cambridge, UK.

"For Hilary" — Alan Baddeley

"To Christine with love" — Michael W. Eysenck

"In memory of my father, Albin F. Anderson, a model of creativity and vision" — Michael C. Anderson

MEMORY

SECOND EDITION

ALAN BADDELEY,

MICHAEL W. EYSENCK,

AND MICHAEL C. ANDERSON

Psychology Press
Taylor & Francis Group
LONDON AND NEW YORK

Second edition published 2015
by Psychology Press
27 Church Road, Hove, East Sussex BN3 2FA

and by Psychology Press
711 Third Avenue, New York, NY 10017

Psychology Press is an imprint of the Taylor & Francis Group, an informa business

First edition published by Psychology Press 2009

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

Library of Congress Cataloging in Publication Data
Baddeley, Alan D., 1934-
Memory / Alan Baddeley, Michael W. Eysenck, and Michael Anderson. — 2nd ed.
pages cm
Includes bibliographical references and index.
1. Memory. I. Eysenck, Michael W. II. Anderson, Michael C. (Michael Christopher)
III. Title.
[DNLM: 1. Memory.]
BF371.B227 2015
153.1'2—dc23
2014016167

ISBN: 978-1-84872-183-8 (hbk)
ISBN: 978-1-84872-184-5 (pbk)
ISBN: 978-1-315-74986-0 (ebk)

Typeset in Sabon and Gill Sans
by Book Now Ltd, London

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ABOUT THE AUTHORS

Having graduated in Psychology from University College London, Alan Baddeley spent the following year at Princeton, the first of five such stays in the US. He returned to a post at the Medical Research Council Applied Psychology Unit (APU) in Cambridge, completing a Ph.D. concerned with the design of postal codes. He continued to combine applied research, for example on deep-sea diving, with theoretical issues such as the distinction between long- and short-term memory. After moving to the University of Sussex, he and Graham Hitch proposed a multicomponent model of working memory. He also began working with amnesic patients, continuing both these lines of research when he moved, first to a chair at the University of Stirling, then returning to the APU in Cambridge. After 20 years as its Director, he moved first to the University of Bristol, then to his current position in York where he has resumed his collaboration with Graham Hitch. He was awarded a CBE for his contributions to the study of memory, is a Fellow of the Royal Society, of the British Academy and of the Academy of Medical Sciences.

Michael W. Eysenck graduated from University College London. He then moved immediately to Birkbeck University of London as a lecturer, where he completed his Ph.D. on the von Restorff and "release" memory effects. His research for several years focused on various topics within memory research (e.g. levels of processing; distinctiveness). However, for many years his research has focused mainly on anxiety and cognition (including memory). Most of this research has involved healthy populations but some has dealt with cognitive biases (including

memory ones) in anxious patients. This research has been carried out at Birkbeck University of London and at Royal Holloway University of London, where he has been Professor of Psychology since 1987 (Head of Department, 1987–2005). However, it was started during his time as Visiting Professor at the University of South Florida. He has published 40 books in psychology (many relating to human memory), including two research monographs on anxiety and cognition. He has been in 'Who's Who' since 1989.

Michael C. Anderson received his Ph.D. in Cognitive Psychology from the University of California, Los Angeles in 1994. After completing a post-doctoral fellowship in cognitive neuroscience at the University of California, Berkeley, he joined the psychology faculty at the University of Oregon, where he was director of the Memory Control Laboratory through 2007. Anderson is now Senior Scientist and Programme Leader at the MRC Cognition and Brain Sciences Unit in Cambridge England. His research investigates the roles of inhibitory processes as a cause of forgetting in long-term memory. Anderson's recent work has focused on executive control as a model of motivated forgetting, and has established the existence of cognitive and neurobiological mechanisms by which we can willfully forget past experiences. This work begins to specify the mechanisms by which people adapt the functioning of their memories in the aftermath of traumatic experience.

PREFACE TO THE FIRST EDITION

Some years ago, one of us (ADB) accepted an invitation to write a memory book for the general public. The result, *Your Memory: A User's Guide*, took the basic structure of an introductory memory course, but illustrated its points from personal observation and research on everyday memory. Although not designed as a text book, it began to be used, in both its initial and in a somewhat modified form, for introductory memory courses, proving popular with students who liked its more relaxed approach. There have, however, been substantial developments in the study of memory since it was first written. This has included a much more extensive body of research on everyday memory, leading to the suggestion of producing a new book that attempts to keep the virtues of the original, while presenting an updated and extended account of human memory, explicitly designed as a memory text. The three of us jointly agreed to take on this task. In order to keep the personal tone, we agreed that each of us would undertake a number of chapters according with our interests, rather than attempt a more corporate style. Each chapter is therefore identified with one of the three authors.

One issue in writing a memory book is the question of how it should be structured. After a good deal of thought we have opted for the standard approach of following information through the memory system, beginning with sensory memory going on to discuss short-term and working memory, followed by episodic memory which in turn leads to semantic memory and the accumulation of knowledge. There is, of course, substantial work that depends upon this basic framework but goes beyond it, with topics such as autobiographical memory, prospective memory, memory development and aging, amnesia; and applied issues such as eyewitness testimony and improving your memory. We have chosen to treat such topics separately, while at the same time referring back to earlier chapters. This means that a given topic may be described more than once, often by more than one author. We regard this as a form of distributed practice and hence an advantage rather than a drawback.

A more serious problem is presented by the limitations of the simple information flow structure. First of all, it has become increasingly clear that information flows in both directions, with memory reflecting an alliance of *interactive* systems. For example, working memory plays an important role in long-term learning, but is itself influenced by existing knowledge. We try to make this clear without unduly complicating the picture.

A second problem concerns the different levels of development of research and theory in different areas. In tackling a given area, we tend to approach it from a historical viewpoint, both because of the importance of the early work for subsequent development, and also because earlier work is usually conceptually simpler, providing a clear route into subsequent more complex theory. However, while this might work

well *within* chapters, it does not always work for the between-chapter structure. The chapters on short-term and working memory for instance, describe an area that has developed hugely since the 1960s, in the depth and complexity of theoretical development, in the degree of involvement of neuropsychology and neuroimaging, and in breadth of application. Other areas of equal importance are easier to understand. The role of organization in long-term learning for instance is a topic where the basic phenomena and ground rules had been established by the 1970s, with little further development necessary. Many newer applications such as the study of autobiographical memory and prospective memory are still at a relatively early stage of theoretical development, and as a result probably present less of a challenge to the student than some of the earlier chapters. We have therefore tried to structure the book in such a way as to allow the user to pick a different route through the book, if preferred.

In the twenty-first century, no memory book can be complete without taking into account the implications of recent exciting developments in neuroscience. Two of us (MCA and ADB) are currently involved in neuroimaging studies, and two of us (MWE and ADB) in studies involving patients with neuropsychological or emotional difficulties. However, while taking such advances into account where appropriate, our focus is on the *psychology* of human memory, which we believe will provide a sound foundation for developments in the neuroscience of memory, as well as continuing to offer a solid basis for applying knowledge gained in the laboratory to the many problems of memory in everyday life.

This project has depended crucially on the patience, help and support of our colleagues at Psychology Press including Lucy Kennedy who played an important role in planning the book, and Rebekah Edmondson, Veronica Lyons, and Tara Stebnicky who ensured that the plans became a reality. We are also grateful to Michael Forster who proposed the book and provided sustained enthusiasm for it through its long gestation. ADB's contribution owes a great deal to Lindsey Bowes, who not only typed his rambling dictations, but also provided invaluable help with finding references and overcoming the many IT glitches experienced by those of us whose semantic memory comes principally from a pre-computer age. Finally, I am grateful to my wife Hilary, for her support and tolerance of my excuses for not doing the manly chores expected of a husband, initially because I was writing a book on working memory, duly followed by my embarking on the present book. Ah well, back to the chores!

MCA is very grateful to Justin Hulbert, who made useful comments on his chapters; preparing all figures and their captions, key terms, supplementary PowerPoints, and biographies with dizzying efficiency.

MWE is also extremely grateful to his wife, Christine, for her unflagging support. She has become used to the fact that I have been involved almost continuously in book writing for the past 25 years or so. I don't have anyone to thank for typing up my chapters because (ill-advisedly or not) I have always done my own word processing!

Alan Baddeley

PREFACE TO THE SECOND EDITION

We were happy with the reception of the first edition of *Memory*, and given that the basic foundations of our understanding of memory have not changed dramatically in the last five years, have retained most of the original structure and content. The major change has been in the growing impact of neuroscience on the study of memory, something that is reflected throughout the book. Given its importance, we have added a further chapter describing the range of methods used to study memory and the brain with the aim that this will both provide an introductory overview, and a point of reference for the repeated use of such methods in studies throughout the rest of the book. In terms of general content, the degree of change varies across chapters depending on our view of the extent to which interesting and important new developments have taken place. In my own case for example, while the short-term and working memory chapters reflect several new developments, resulting in a degree of restructuring, others such as the introductory chapter and the chapter on organization and memory have fewer changes. There is also some reordering of the later chapters to form what we think is a more logical structure, together with a substantial rewrite of the chapter on amnesia using a more patient-centered approach, and discussing what happens "when memory systems fail."

Michael Forster, the publisher whose enthusiasm led to the first edition, tells me that second editions of textbooks are usually the best. While we would not like to discount the possibility of even better editions in the future we ourselves trust, following the helpful comments of our reviewers, that our efforts have been worthwhile.

Once again we are grateful for the efficiency and good humour of the staff at Psychology Press, and in particular to Mandy Collison and Ceri Griffiths, and to Richard Cook at Book Now who oversaw the production stage to a very tight schedule. My own contribution has again depended crucially on the skills of Lindsey Bowes in coping with my rambling dictation, helping locate references and coping with the many IT glitches that seem to conspire against me. Finally, I am again very grateful to my wife Hilary for her support and encouragement during what has proved to be a surprisingly extensive revision. I shall now have to find another reason avoiding domestic chores!

I (Michael Eysenck) would like to echo my two co-authors by expressing my heartfelt thanks to the staff at Psychology Press for their cheerful and efficient approach to the production of this book. I agree that special thanks are due to Mandy Collison, Ceri Griffiths, and Richard Book for their outstanding efforts. I am indebted to my wife Christine in every way for her continued support for my time-consuming book-writing efforts. When I have finished the book on which I am currently working for Psychology Press, I look forward to having more time available to spend with our delightful grandchildren Sebastian and Clementine.

MCA would like to express his gratitude to his partner, Nami, for her support and patience in the process of preparing this revised edition. She is very pleased that the new edition is now complete, and especially that nowhere in the text are there any stories of embarrassing memory failures involving her (but plenty involving me, about which she feels knowingly bemused).

Alan Baddeley
York, 2014

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Contents

CHAPTER 1

WHAT IS MEMORY?

Alan Baddeley

Memory is something we complain about. Why? Why are we quite happy to claim "I have a terrible memory!" but not to assert that "I am amazingly stupid"? Of course, we do forget; we do sometimes forget appointments and fail to recognize people we have met in the past, and rather more frequently we forget their names. We do not, however, often forget important events; if the bridegroom failed to turn up for his wedding he would not be believed if he claimed to have forgotten. Consequently, failing to recognize an old acquaintance suggests that the person was perhaps not of great importance to us. The obvious excuse is to blame one's terrible memory.

In the chapters that follow, we will try to convince you that your memory is in fact remarkably good, although fallible. We agree with Schacter (2001) who, having described what he refers to as the seven sins of memory, accepts that the sins are in fact the necessary consequences of the virtues that make our memories so rich and flexible. Our memories might be less reliable than those of the average computer but they are just as capacious, much more flexible, and a good deal more user friendly. Let us begin by considering the case of Clive Wearing who has the misfortune to have had much of his memory capacity destroyed by disease (Wilson, Baddeley, & Kapur, 1995).

WHY DO WE NEED MEMORY?

Clive is an extremely talented musician, an expert on early music who was master of a major London choir. He himself sang and was asked to perform before the Pope during a papal visit to London. In 1985, he had the misfortune to suffer a brain infection from the herpes simplex virus, a virus that exists in a large proportion of the population, typically leading to nothing worse than cold sores but very occasionally breaking through the blood–brain barrier to cause encephalitis, an inflammation of the brain that can prove fatal. In recent years, treatment has improved, with the result that patients are more likely to survive, although often having suffered from extensive brain damage, typically in areas responsible for memory.

When he eventually recovered consciousness, Clive was densely amnesic and appeared to be unable to store information for periods longer than seconds. His interpretation of his plight was to assume that he had just recovered consciousness, something that he would announce to any visitor, and something that he repeatedly recorded in a notebook, each time crossing out the previous line and writing "I have now recovered consciousness" or "consciousness has now finally been recovered," an activity that continued for many, many years.

Clive knew who he was and could talk about the broad outlines of his early life, although the detail was very sparse. He knew he had spent 4 years at Cambridge University, but could not recognize a photograph of his college. He could remember, although somewhat vaguely, important events in his life such as directing and conducting the first modern performance of Handel's *Messiah* using original instruments in an appropriate period setting, and could talk intelligently about the historical development of the role of the musical conductor. However, even this selected knowledge was sketchy; he had written a book on the early composer Lassus, but could not recall any of the content. Asked who had written *Romeo and Juliet*, Clive did not know. He had remarried, but could not remember this. However, he did greet his new wife with enormous enthusiasm every time she appeared, even though she might only have been out of the room for a few minutes; every time he declared that he had just recovered consciousness.

Clive was totally incapacitated by his amnesia. He could not read a book or follow a television program because he immediately forgot what had gone before. If he left his hospital room, he was immediately lost. He was locked into a permanent present, something he described as "hell on earth." "It's like being dead—all the bloody time!"

However, there was one aspect of Clive's memory that appeared to be unimpaired, that part concerned with music. When his choir visited him, he found that he could conduct them just as before. He was able to read the score of a song and accompany himself on the keyboard while singing it. For a brief moment he appeared to return to his old self, only to feel wretched when he stopped playing. Over 20 years later, Clive is still just as densely amnesic but now appears to have come to terms with his terrible affliction and is calmer and less distressed.

ONE MEMORY OR MANY?

Although Clive's case makes the point that memory is crucial for daily life, it does not tell us much about the nature of memory. Clive was unfortunate in having damage to a range of brain areas, with the result that he has problems that extend beyond his amnesia. Furthermore, the fact that Clive's musical memory and skills are unimpaired suggests that memory is not a single simple system. Other studies have shown that densely amnesic patients can repeat back a telephone number, suggesting preserved immediate memory, and that they can learn motor skills at a normal rate. As we will see later, amnesic patients are capable of a number of types of learning, demonstrating this by improved performance, even though they do not remember the learning experience and typically deny having encountered the situation before. The evidence suggests, therefore, that rather than having a single global memory system, the picture is more complex. The first few chapters of this book will try to unpack some of this complexity, providing a basis for later chapters that are concerned with the way in which these systems influence our lives, how memory changes as we move through childhood to adulthood and old age, and what happens when our memory systems break down.

In giving our account of memory, we are of course presenting a range of psychological theories. Theories develop and change, and different people will hold different theories to explain the same data. As a glance at any current memory journal will indicate, this is certainly the case for the study of memory. Fortunately, there is a great deal of general agreement between different groups studying the psychology of memory, even though they tend to use somewhat different terminology. At this point, it might be useful to say a little bit about the concept of theory that underpins our own approach.

THEORIES, MAPS, AND MODELS

What should a psychological theory look like? In the 1950s, many people thought they should look like theories from physics. Clark Hull studied the learning behavior of white rats and attempted to use his results to build a rather grand general theory of learning in which the

learning behavior of both rats and people was predicted using a series of postulates and equations that were explicitly modeled on the example set by Isaac Newton (Hull, 1943).

By contrast, Hull's great rival, Edward Tolman (1948), thought of rats as forming "cognitive maps," internal representations of their environment that were acquired as a result of active exploration. The controversy rumbled on from the 1930s to the 1950s, and then was abandoned quite suddenly. Both sides found that they had to assume some kind of representation that went beyond the simple association between stimuli impinging on the rat and its learned behavior, but neither seemed to have a solution to the problem of how these could be investigated.

The broad view of theory that we shall take is that theories are essentially like maps. They summarize our knowledge in a simple and structured way that helps us to understand what is known. A good theory will help us to ask new questions and that in turn will help us find out more about the topic we are mapping. The nature of the theory will depend on the questions we want to answer, just as in the case of maps of a city. The map that will help you travel by underground around London or New York looks very different from the sort of map that you would need if you wanted to walk, with neither being a direct representation of what you would see if you stood at a given location. That does not of course mean that they are bad maps, quite the opposite, because each map is designed to serve a different purpose.

In the case of psychological theories, different theories will operate at different levels of explanation and focus on different issues. An argument between a shopkeeper and customer, for example, would be explained in very different ways by a sociologist, who might emphasize the economic and social pressures, a social psychologist interested in interpersonal relationships, a cognitive psychologist interested in language and a physiological psychologist who might be interested in the emotional responses of the two disputants and how these are reflected in the brain. All of these explanations are relevant and in principle should be relatable to each other, but none is the single "correct" interpretation.

This is a view that contrasts with what is sometimes called **reductionism**. This assumes that the aim of science is to reduce each explanation to the level below: Social psychology to cognitive psychology, which in turn should be explained physiologically, with the physiology then being interpreted biochemically and ultimately in terms of physics. Although it is clearly valuable to be able to explain phenomena at different but related levels, this is ultimately no more sensible than for a physicist to demand that we should attempt to design bridges on the basis of subatomic particle physics, rather than Newtonian mechanics.

The aim of the present book is to outline what we know of the *psychology* of memory. We believe that an account at the psychological level will prove valuable in throwing light on accounts of human behavior at the interpersonal and social level, and will play an important role in our capacity to understand the neurobiological factors that underpin the various types of memory. We suggest that the psychology of memory is sufficiently understood to begin to interface very fruitfully with questions at both of these levels, and hope to illustrate this over the subsequent chapters.

HOW CAN WE STUDY MEMORY?

The case of Clive Wearing demonstrates how important memory is, and how complex, but leaves open the question of how it can best be studied. The attempt to understand human memory extends at least as far back as Aristotle, and forms one of the classic questions within the philosophy of mind, although without reaching any firm conclusions. This was vividly illustrated by a lecture on memory by the eminent philosopher

KEY TERM

Reductionism: The view that all scientific explanations should aim to be based on a lower level of analysis: psychology in terms of physiology, physiology in terms of chemistry, and chemistry in terms of physics.

A. J. Ayer that I attended as a student. He began, rather unpromisingly, by declaring that memory was not a very interesting philosophical question. He seems to have demonstrated this pretty effectively as I can remember none of the lecture, apart from his statement that his memory was totally devoid of imagery, prompting a skeptical questioner to ask "If I tell you that the band of the grenadier guards is marching past the end of the street, banners flying and trumpets sounding, do you not hear or see anything?" "No" replied the philosopher; "I don't believe you!" said the questioner and sat down crossly.

This point illustrates a limitation of a purely philosophical approach to the understanding of memory in particular, and to mind in general, namely its reliance on introspection, the capacity to reflect and report our on-going thoughts. These are not unimportant, but are not a reliable indication of the way our minds work for two principal reasons. The first of these, as our example shows, is that, people differ in what they appear to experience in a given situation; does memory depend on visual imagery, and if not, why do some of us experience it? Second, and even more importantly, we are only consciously aware of a relatively small proportion of the mechanisms underpinning our mental life, and as we will see, the tip of the mental iceberg that is available to conscious awareness is not necessarily a good guide to what lies beneath.

While there are still important issues addressed by the philosophy of mind, it is now generally acknowledged these can best be pursued in collaboration with a scientific approach based on empirical evidence. To return to the question of imagery, as I suspect Ayer knew, in the late nineteenth century, Sir Francis Galton had asked a number of "eminent men" to reflect on their breakfast table from that morning and describe the vividness of the resulting memory, finding a huge range of responses. What was not known by Galton is that these huge differences are not reflected in how accurate our memories are, suggesting that accuracy depends on some nonconscious process. Could it be that different people have the same experience but just describe it differently? Or do they have different memory systems? Or perhaps they have the same basic system but have a different strategy for using it? Hence, although they are interesting, subjective reports do not provide a very solid basis for understanding how our memory works.

So how can we move beyond introspection?

An answer to this started to develop in Germany in the latter half of the nineteenth century. It was concerned initially with the discipline of *psychophysics*, an attempt to systematically map the relationship between physical stimuli such as brightness and loudness onto their perceived magnitude. Despite success in linking physical stimuli to the psychological experience of participants, capacities such as learning and memory were initially regarded as unsuitable for experimental study. This view was dramatically overturned by a German philosopher, Herman Ebbinghaus, who conducted an intensive series of experiments on himself over a 2-year period, showing that it was indeed possible to plot systematic relationships between the conditions of learning and the amount learned. Having published this, the first classic book on the science of memory (Ebbinghaus, 1885), he moved on to

Ebbinghaus (1850–1909) was the first person to demonstrate that it was possible to study memory experimentally.

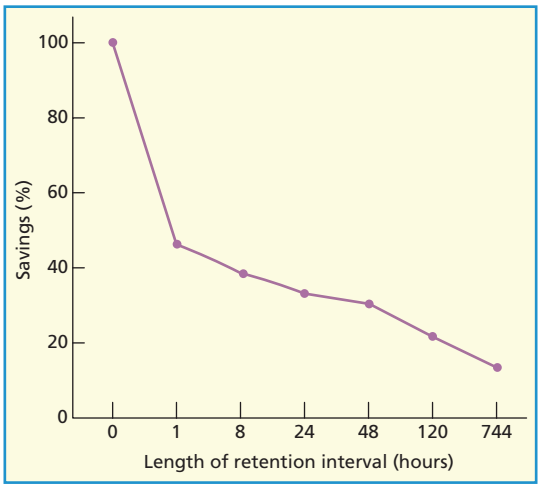

Figure 1.1 Forgetting over time as indexed by reduced savings during relearning. Data from Ebbinghaus (1885/1913).

study color vision, intelligence and a range of other questions in the newly developing field of experimental psychology.

So what did Ebbinghaus do? He began by simplifying the experimental situation, attempting to develop material that was devoid of meaning but was verbally learnable and reportable, inventing what has become known as the nonsense syllable, consonant–vowel–consonant items such as *zug*, *pij*, and *tev*. He served as his own subject, always holding constant the room in which he learned, the time of day and the rate of presentation, which was rapid, so as to avoid any temptation to attempt to find meaning in the stimuli. Ebbinghaus established some of the basic principles of learning that will discussed in Chapter 5 and the classic forgetting curve shown in Figure 1.1 that forms the basis of all subsequent work in this area (see Chapter 9).

The Ebbinghaus tradition was subsequently most strongly developed in the US, focusing particularly on the factors and conditions surrounding the important question of how new learning interacted with what was already known. Results were interpreted in terms of associations that were assumed to be formed between stimuli and responses, using a limited range of methods that typically involved remembering lists of nonsense syllables or words (McGeoch & Irion, 1952). This is often referred to as the verbal learning approach. It developed from the 1930s to the 1960s, particularly in mid-Western laboratories, and emphasized the careful mapping of phenomena rather than the ambitious building of grand theories such as that proposed by Clark Hull. When the grand theories appeared to collapse, however, the more staid approach that had previously been disparagingly discounted by its critics as "dust bowl empiricism" began to attract a broader range of investigators interested in studying learning and memory. This led to the founding of a new journal *The Journal of Verbal Learning and Verbal Behavior*, which, when the term "verbal learning" later became unfashionable, became *The Journal of Memory and Language*.

A second development that occurred at this point had its roots in both Europe and North America. In the 1930s, a German approach known as Gestalt psychology began attempting to apply ideas developed in the study of perception to the understanding of human memory. Unlike the behaviorist approaches, *Gestalt* psychologists tended to emphasize the importance of internal representations rather than observable stimuli and responses, and to stress the active role of the rememberer. Gestalt psychology suffered badly from Nazi persecution, but enough Gestalt psychologists moved to North America to sow the seeds of an alternative approach to verbal learning; an approach that placed much more emphasis on the activity of the learner in organizing material. This approach was typified by two investigators who had grown up in Europe but had then emigrated and been trained in North America: George Mandler and Endel Tulving.

KEY TERM

Verbal learning: A term applied to an approach to memory that relies principally on the learning of lists of words and nonsense syllables.

Gestalt psychology: An approach to psychology that was strong in Germany in the 1930s and that attempted to use perceptual principles to understand memory and reasoning.

In Britain, a third approach to memory developed, based on Frederick Bartlett's (1932) book *Remembering*. Bartlett explicitly rejected the learning of meaningless material as an appropriate way to study memory, using instead complex material such as folk tales from other cultures, reflecting his interest in social psychology and stressing the importance of the rememberer's "effort after meaning." This approach emphasized the study of the memory errors that people made, explaining them in terms of the participants' cultural assumptions about the world. Bartlett proposed that these depended on internal representations that he referred to as **schemas**. His approach differed radically from the Ebbinghaus tradition, relying on quite complex tasks but, as was the case with the later followers of Tolman and Hull, Bartlett was left with the problem of how to study these elusive inner representations of the world.

A possible answer to this problem evolved gradually during the Second World War with the development of computers. Mathematicians such as Weiner (1950) in the US, and physiologists such as Gray Walter (1953) in the UK described machines that were able to demonstrate a degree of control that resembled purposive behavior. During the 1940s, a Scottish psychologist, Kenneth Craik (1943), working with Bartlett in Cambridge produced a brief but influential book entitled *The Nature of Explanation*. Here he proposed the idea of representing theories as **models**, and using the computer to develop such models. He carried out what were probably the first psychological experiments based on this idea, using analog computers (digital computers were still being invented) and applying his computer-based theoretical model to the practical problem of gun-aiming in tanks.

KEY TERM

Schema: Proposed by Bartlett to explain how our knowledge of the world is structured and influences the way in which new information is stored and subsequently recalled.

Model: A method of expressing a theory more precisely, allowing predictions to made and tested.

Tragically, in 1945 he was killed in a traffic accident while still a young man.

Fortunately, the new approach to psychology, based on the computer metaphor, was being taken up by a range of young investigators, and in the years following the war, this information-processing approach to psychology became increasingly influential. Two books were particularly important. Donald Broadbent's *Perception and Communication* (1958) developed and applied Craik's seminal ideas to a range of work carried out at the Medical Research Council Applied Psychology Unit in Cambridge, England, much of it stimulated by practical problems originating during the war. Some 9 years later, this growing field was then brilliantly synthesized and summarized by Ulric Neisser (1967) in a book whose title provided a name for this burgeoning field: *Cognitive Psychology*.

Using the digital computer as an analogy, human memory could be regarded as comprising one or more storage systems. Any memory system—whether physical, electronic, or human—requires three things, the capacity to *encode*, or enter information into the system, the capacity to *store* it, and—subsequently—the capacity to find and *retrieve* it. However, although these three stages serve different functions, they interact: The method of registering material or encoding determines what and how the information is stored, which in turn will limit what can subsequently be retrieved. Consider a simple physical memory device, a shopping list. If it is to work, you need to write legibly in a language the recipient shopper understands. If it were to get wet, the ink would blur (impaired storage) making it less distinct and harder to read (retrieval). Retrieval would be harder if your handwriting was poor (an encoding–retrieval interaction), and if the writing was smudged (a storage–retrieval interaction). The situation is further complicated by the discovery that our memories comprise not one, but several interrelated memory systems.

HOW MANY KINDS OF MEMORY?

As the influence of the cognitive approach to psychology grew, the balance of opinion moved

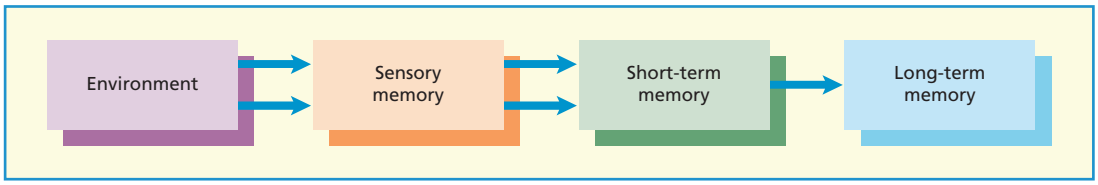

Figure 1.2 An information-processing approach to memory. Information flows from the environment through sensory storage and short-term storage to long-term memory.

from the assumption of a single memory system based on stimulus–response associations towards the idea that two, three or perhaps more memory systems were involved. Figure 1.2 shows the broad view that came to be widely accepted during the 1960s. It assumed that information comes in from the environment and is first processed by a series of sensory memory systems, which could be best regarded as providing an interface between perception and memory. Information is then assumed to be passed on to a temporary short-term memory system, before being registered in long-term memory (LTM). A particularly influential version of this model was proposed by Atkinson and Shiffrin (1968). It was dubbed the **modal model** because it was representative of many similar models of the operation of human memory that were proposed at the time. As we shall see, a number of the assumptions underlying this model were subsequently questioned, causing it to be further elaborated.

The question of how many kinds of memory remains controversial, some theorists object to the very concept of a memory *store* as too static, arguing instead that we should concerned with *processes* (e.g. Nairne, 1990, 2002; Neath & Surprenant, 2003). They point to similarities across a range of very different memory tasks and suggest that these imply common processes, and hence a unitary memory system. Our own view is that we need to think in terms of both structures such as stores and the processes that operate on them, just as an analysis of the brain requires the contribution of both static anatomical features and a more dynamic concern with physiology. We should certainly look for similarities across domains in the way that these systems perform, but the presence of common features should not encourage us to ignore the differences.

Fortunately, regardless of the question of whether one emphasizes similarities or differences, the broad picture remains the same. In what follows, we ourselves use the distinctions between types of memory as a way of organizing and structuring our knowledge of human memory. As discussed below, we assume separate sensory, short-term and long-term memory systems, each of which can be subdivided into separate components. We do not, however, assume the simple flow of information from the environment into long-term memory that is suggested in Figure 1.2, as there is abundant evidence that information flows in both directions. For example, our knowledge of the world, stored in long-term memory, can influence our focus of attention, which will then determine what is fed into the sensory memory systems, how it is processed and whether it is subsequently remembered. Thus a keen football fan watching a game will see and remember particular plays that her less enthusiastic companion will miss.

We begin with a brief account of **sensory memory**. This was an area of considerable activity during the 1960s and provides a good illustration of the general principles of encoding, storage, and retrieval. However, given that it relates more to perception than memory, it will not be covered in the remainder of the book. Our outline continues with introductory accounts of short-term and working memory, before moving to a brief preliminary survey of long-term memory.

KEY TERM

Modal model: A term applied to the model of memory developed by Atkinson and Shiffrin (1968).

SENSORY MEMORY

If you wave your hand while holding a sparkler in a dark room, it leaves a trail, which rapidly fades. The fact that the image persists long enough to draw an apparent line suggests that it is being stored in some way, and the fact that the line rapidly fades implies some simple form of forgetting. This phenomenon forms the basis for movies; a sequence of static images is presented rapidly, with blank intervals in between, but is perceived as a continuous moving image. This occurs because the perceptual system stores the visual information long enough to bridge the gap between the static images, integrating each one with the next, very slightly different, image.

Neisser (1967) referred to this brief visual memory system as **iconic memory**, referring to its auditory counterpart as "echoic memory." In the early 1960s, a number of investigators at Bell Laboratories in the US used the new information-processing approach to analyze this fleeting visual memory system (Sperling, 1960, 1963; Averbach & Sperling, 1961).Sperling (1960) briefly presented a visual array of twelve letters in three rows of four, and then asked for recall (Figure 1.3). People could typically remember four or five items correctly. If you try this task, however, you will have the sensation that you have seen more than four or five, but that they have gone before you can report them. One way of avoiding the problem of forgetting during reporting is to present the same array and reduce the number of items to be reported, but not tell the participant in advance which ones will be selected for recall. Sperling therefore required only one of the three lines to be reported, signaling the line to be recalled by presenting a tone; a high tone for the top line, a medium tone for line two, and a low tone for line three. As he did not tell the participant in advance which line would be cued, the report could be treated as representative of the whole array; multiplying the score by three will thus give an estimate of the total number of letters stored. However, as shown in Figure 1.4, this depends on when the recall tone is presented. When recall is tested immediately, it should provide an estimate of the total capacity of the memory store, with the fall-off in performance as the tone is delayed representing the loss of information. Note that Figure 1.4 shows two curves, one with a bright field before and after the letters, and the other with the letters preceded and followed by a dark visual field. A subsequent experiment (Sperling, 1963) found that the brighter the light during the interval, the poorer the performance, suggesting that the light is interfering with the memory trace in some way, a process known as **masking**.

Later work by Michael Turvey (1973) investigated two separate types of masking operating at different stages. The first of these involves *brightness masking*, with the degree of masking increasing when the mask becomes brighter, or is presented closer in time to the stimulus. This effect only occurs if the mask and the stimulus are presented to the same eye, suggesting that it is operating at a peripheral retinal level. If you were a subject in such an experiment, this type of masking would give rise to experiencing a composite of target and mask, with the brighter the mask the less distinct the target. This is distinct from *pattern masking*, the second type studied, which occurs when targets are followed by a mask comprising broadly similar features to the target, for example jumbled fragments of letters. This type of mask operates even when the target is presented to one eye and the mask to the other. This suggests that it influences a later stage of visual processing that occurs

KEY TERM

Sensory memory: A term applied to the brief storage of information within a specific modality.

Iconic memory: A term applied to the brief storage of visual information.

Masking: A process by which the perception and/or storage of a stimulus is influenced by events occurring immediately before presentation (forward masking) or more commonly after (backward masking).

B C X Y
N F R W
T Z K D

Figure 1.3 Stimulus array used by Sperling. Although twelve letters were presented, participants only had to recall one row, that cued by a high, medium, or low tone.

after information from the two eyes has been combined into a single percept. It is relatively insensitive to brightness and subjectively feels as if a clear image has been disrupted before the information could adequately be read off from it.

What function does iconic memory serve other that of keeping psychologists busy, or as Haber concluded in desperation, reading at night in a thunderstorm? The answer is that its function is probably indirect, forming part of the process of perceiving the world. As we scan the visual world, stimuli of huge complexity will fall on our retina, comprising far more information than it is useful for us to process and store. It seems likely that iconic memory represents two early stages of a process whereby information is read off from the retina, and some of it then fed through to a more durable short-term visual store. It is this that allows us to build up a coherent representation of the visual world and that allows a movie to be perceived, not as a series of static frames with gaps in between, but as a continuous and realistic visual experience. The early stages of iconic memory are probably best regarded as aspects of perception; the subsequent more stable stage will be discussed in the chapter on short-term memory.

The auditory system also involves a brief sensory memory component that Neisser named **echoic memory**. If you are asked to remember a long telephone number, then your pattern of errors will differ depending on whether the number is heard or read. With visual presentation, the likelihood of an error increases systematically from the beginning to the end of the sequence, whereas, as shown

KEY TERM

Echoic memory: A term sometimes applied to auditory sensory memory.

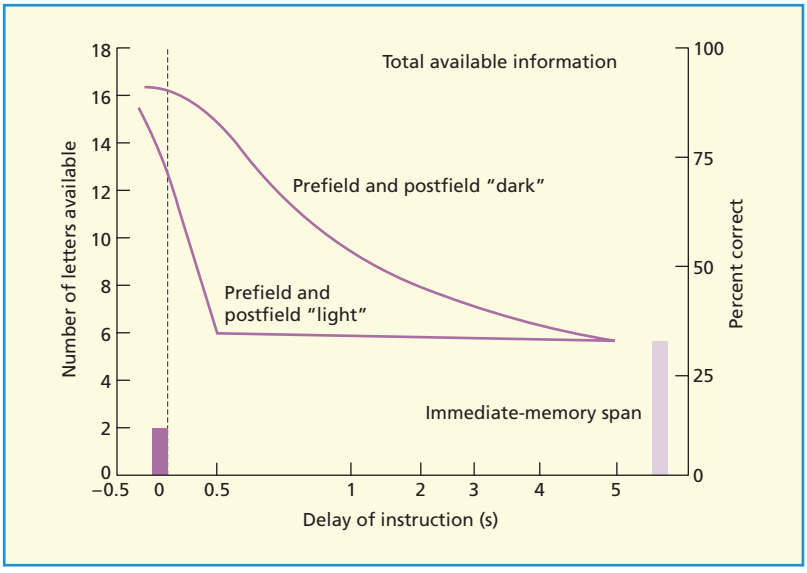

Figure 1.4 Estimated number of letters available using the partial report method, as a function of recall delay. From Sperling (1963). Copyright © 1963 by The Human Factors Society and Ergonomics Society Inc. Reprinted by permission of Sage Publications.

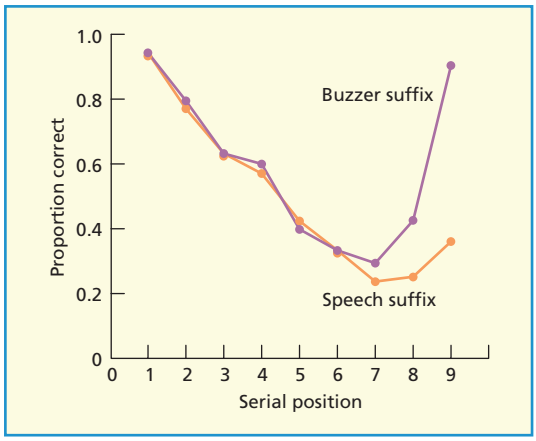

Figure 1.5 Serial recall of a nine-item list when an additional item, the suffix, is either the spoken word *zero* or a sound made by a buzzer. From Crowder (1972). Copyright © 1972 Massachusetts Institute of Technology, by permission of the MIT Press.

in Figure 1.5, with auditory presentation the last one or two items are much more likely to be correct than are items in the middle of the list (Murdock, 1967). This recency advantage can be removed by interposing another spoken item between presentation and recall, even when this item itself does not need to be processed, and is always the same, for example, the instruction "recall." In an extensive series of experiments, Crowder and Morton (1969; Crowder & Raeburn, 1970; Crowder, 1971) showed that the nature of this suffix is critical. A visual or nonspeech-like auditory suffix, such as a buzzer, does not disrupt performance, whereas a spoken suffix does, regardless of its meaning.

Crowder and Morton postulated what they term a precategorical acoustic store as the basis for the auditory recency effect. However, the question of whether the process responsible for the enhanced auditory recency effect is better regarded as a form of memory or an aspect of perception remains controversial (Jones, Hughes, & Macken, 2006; but see also Baddeley & Larsen, 2007). Regardless of its interpretation, the auditory recency component is sufficiently large and robust to play a potentially significant role in studies of verbal short-term memory, and has even been proposed as an alternative to more conventional views of performance on short-term verbal memory tasks (Jones et al., 2006). We will return to this issue when discussing short-term memory. In the meantime, it seems likely that an adequate explanation of echoic memory will need to be fully integrated with a broader theory of speech perception.

SHORT-TERM AND WORKING MEMORY

As this topic, and that of long-term memory, forms a major part of the book, for present purposes we will limit ourselves to a very brief outline. We use the term **short-term memory (STM)** in a theory-neutral way to refer to the temporary storage of small amounts of material over brief delays. This leaves open the question of how this storage is achieved. In most, if not all situations, there is likely to be a contribution to performance from long-term memory that will need to be taken into account in evaluating the role of any more temporary storage systems. Much of the work in this area has used verbal material, and there is no doubt that even when the stimuli are not verbal, people will often use verbal rehearsal to help maintain their level of performance over a brief delay (see Chapter 3). It is important to bear in mind, however, that STM is not limited to verbal material, and has been studied extensively for visual and spatial information, though much less extensively for smell and touch.

The concept of **working memory** is based on the assumption that a system exists for the temporary maintenance and manipulation of information, and that this is helpful in

KEY TERM

Short-term memory (STM): A term applied to the retention of small amounts of material over periods of a few seconds.

Working memory: A memory system that underpins our capacity to "keep things in mind" when performing complex tasks.

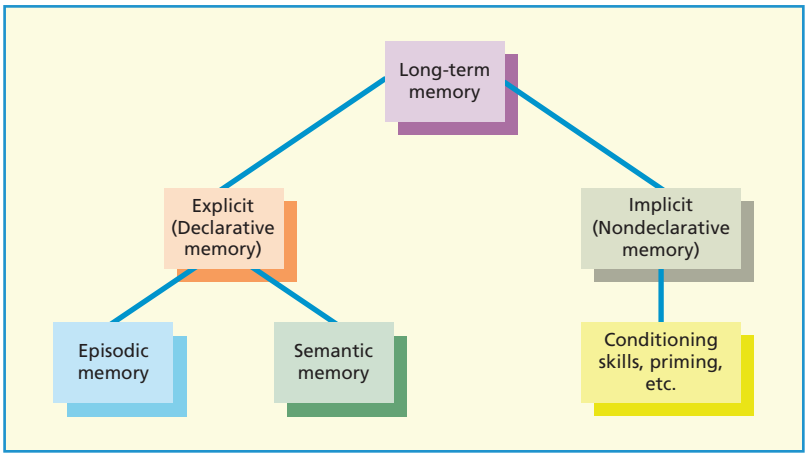

Figure 1.6 Components of long-term memory as proposed by Squire (1992).

performing many complex tasks. A number of different models of working memory have been proposed, with the nature and emphasis of each model tending to depend on the particular area of interest of the theorist, and their theoretical style. However, most assume that working memory acts as a form of mental workspace, providing a basis for thought. It is usually assumed to be linked to attention, and to be able to draw on other resources within short-term and long-term memory (Miyake & Shah, 1999). By no means all approaches, however, emphasize the role of memory rather than attention. One approach that does so is the multicomponent model proposed originally by Baddeley and Hitch in 1974 as a means of linking research on the psychology and neuropsychology of STM to its functional role in performing important cognitive activities such as reasoning, comprehension and learning. This approach has continued to prove productive for over 40 years (Baddeley, 2007) and is the principal focus of Chapter 4, on working memory.

LONG-TERM MEMORY

We shall use the classification of long-term memory proposed by Squire (1992). As shown in Figure 1.6, this classification makes a broad distinction between explicit or declarative memory and implicit or nondeclarative memory. Explicit memory refers to situations that we would generally think of as involving memory, both for specific *events*, such as meeting a friend unexpectedly on holiday last year, and remembering *facts* or information about the world, for example the meaning of the word *testify* or the color of a ripe banana. Implicit memory refers to situations in which some form of learning has occurred, but which is reflected in *performance* rather than through overt remembering, riding a bicycle for example or reading a friend's handwriting more easily because we have encountered it frequently in the past. We will briefly discuss these in turn, leaving a full exploration to subsequent chapters.

KEY TERM

Long-term memory: A system or systems assumed to underpin the capacity to store information over long periods of time.

Explicit/declarative memory: Memory that is open to intentional retrieval, whether based on recollecting personal events (episodic memory) or facts (semantic memory).

Implicit/nondeclarative memory: Retrieval of information from long-term memory through performance rather than explicit conscious recall or recognition.

Explicit memory

As Figure 1.6 shows, this can be divided into two categories, **semantic** and **episodic memory**. During the 1960s, computer scientists attempting to achieve automatic language processing discovered that their computer programs needed to have built into them some kind of knowledge of the world, which could represent the meaning of the words being processed. This led psychologists to attempt to study the way in which humans store such semantic information. At a conference convened to discuss these new developments, a Canadian psychologist, Endel Tulving (1972), proposed a distinction that was immediately adopted and has been used extensively ever since, that between *semantic* and *episodic* memory. Semantic memory refers to knowledge of the world. It goes beyond simply knowing the meaning of words and extends to sensory attributes such as the color of a lemon or the taste of an apple. It also includes general knowledge of how society works, what to do when you enter a restaurant or how to book a theatre seat. It is inherently general in nature, although it can in principle be acquired on a single occasion. If you heard that an old friend had died, this would be likely to become part of your general knowledge of that person, hence part of your semantic memory, although you might well forget where or when you had heard this.

If you subsequently recall the particular occasion when and where you had learned this sad news, then this would be an instance of *episodic memory*, which underpins the capacity to remember specific single episodes or events. Hence, a given event can be registered in both types of memory. Tulving himself (2002) now limits the use of the term "episodic memory" to situations in which you actually re-experience some aspect of the original episode, for example remembering how surprised you were that your informant knew your old friend. Tulving refers to this capacity as **mental time travel** and emphasizes its value, both in allowing us to recollect and "relive" individual events, and to use that information for planning a future action, for example sending a letter of condolence. It is this capacity to acquire and retrieve memories for particular events that tends to be most severely disrupted in amnesic patients, and it is this deficit that has made Clive Wearing's life so unbearably difficult.

How are semantic and episodic memory related? One possibility is that semantic memory is simply the residue of many episodes. For example, I know that Madrid is the capital of Spain, not only because I was told it at school but also because I have encountered this fact in countless news-reels and had it reinforced by visiting Madrid. Consistent with this assumed role of episodic memory in forming semantic memory is the fact that most amnesic patients have difficulty in building up new semantic knowledge. They typically would not know

Semantic memory goes beyond the meaning of words, and extends to sensory attributes such as taste and color; and to general knowledge of how society works, such as how to behave in a supermarket.

KEY TERM

Semantic memory: A system that is assumed to store accumulative knowledge of the world.

Episodic memory: A system that is assumed to underpin the capacity to remember specific events.

Mental time travel: A term coined by Tulving to emphasize the way in which episodic memory allows us to relive the past and use this information to imagine the future.

the name of the current President of the United States of America, or what year it is, or which teams were doing well in their favorite sport. This suggests that although semantic and episodic memory might possibly involve separate systems, they clearly interact (Tulving, 2002).

Implicit memory

Amnesic patients thus tend to show not only grossly disturbed episodic memory, but also a greatly impaired capacity to add to their store of knowledge of the world. There are, however, a number of situations in which they do appear to learn at a normal rate, and the study of these preserved capacities has had an important influence on the development of the concept of implicit or nondeclarative memory.

One preserved form of learning is simple **classical conditioning**. If a tone is followed by a brief puff of air to the eye, amnesic patients will learn to blink in anticipation (Weiskrantz & Warrington, 1979). Despite learning at a normal rate, they do not remember the experience and cannot explain the function of the nozzle that delivers the air puff to their eye. Amnesic patients can also learn motor skills, such as improving with practice the capacity to keep a stylus in contact with a moving spot of light (Brooks & Baddeley, 1976). Warrington and Weiskrantz (1968) demonstrated that word learning was also preserved in densely amnesic patients under certain conditions. They presented their patients with a list of unrelated words and then tested for retention in a number of different ways. When asked to recall the words or recognize which of the subsequent sequence of words had already been presented, the patients performed very poorly. However, when the nature of the test was changed to one in which the task was to "guess" a word when given the first few letters, both patients and normal participants were likely to "guess" a word that had been seen earlier. For example, a patient who had been shown the word "bring" and was later given the letters "BR– – –" would be just as likely as control participants to guess "bring" rather than "bread," but would not remember having just seen that word.. Patients could take full advantage of their prior experience, despite failing to remember that they had even been shown any words earlier, indicating that *something* had been stored. As we shall see, this phenomenon, known as **priming**, is found in a range of perceptual tasks, both visual and auditory, and can also be found in the progressive improvement in more complex activities such as reading mirror writing (Cohen & Squire, 1980) or assembling a jigsaw puzzle (Brooks & Baddeley, 1976).

Given that these are all examples of implicit learning and memory, do they all reflect a single memory system? While attempts continue to be made to account for them all in terms of a single system (see Neath & Surprenant, 2003), our own view is that although they have features in common, they represent a range of different learning systems using different parts of the brain that have evolved for different purposes. They seem to represent a tendency for evolution to develop similar ways of addressing problems across different systems.

MEMORY: BEYOND THE LABORATORY

We have so far discussed the question of how to develop a theoretical understanding of human memory: how it encodes, stores, and retrieves information. However, if our theory is to be useful as well as informative, then it needs to be applicable beyond the confines of the laboratory, to tell about how our memories will work in the world. It must aim to extend beyond the student population, on which much of the research is based, and tell

KEY TERM

Classical conditioning: A learning procedure whereby a neutral stimulus (e.g. a bell) that is paired repeatedly with a response-evoking stimulus (e.g. meat powder), will come to evoke that response (salivation).

Priming: The process whereby presentation of an item influences the processing of a subsequent item, either making it easier to process (positive priming) or more difficult (negative priming).

us about how memory functions in children and the elderly, across different cultures and in health and disease.

It is of course much more difficult to run tightly controlled experiments outside the laboratory, with the result that most of the theoretically focused studies that inform the initial chapters are laboratory based. Some investigators argue that we should confine our research to the laboratory, extending it only when we have a thorough understanding of memory. Others have followed Bartlett in suggesting that this is likely to lead to the neglect of important aspects of memory. In response to this rather conservative view, a group of psychologists in South Wales enthusiastically convened an international conference concerned with practical aspects of memory. It was a great success, with people coming from all over the world to talk about their research on topics ranging from memory for medical information to sex differences in facial memory, and from expert calculators to brain-damaged patients (Gruneberg, Morris, & Sykes, 1978).

Ulric Neisser was invited to give the opening address. In it, he lamented the laboratory-based tradition declaring that "If X is an interesting or socially significant aspect of memory, then psychologists have hardly ever studied X!" (Neisser, 1978, p. 4). He was in fact preaching to an enthusiastic audience of the converted, whose work presented over the next few days was already refuting his claim. However, his address was less well received in other quarters, resulting in a paper complaining of "the bankruptcy of everyday memory" (Banaji & Crowder, 1989). This led to a lively, although rather unfruitful, controversy, given that it was based on the false assumption that psychologists should limit their research to *either* the laboratory *or* the world beyond. Both approaches are valuable. It is certainly easier to develop and test our theories under controlled laboratory conditions, but if they tell us little or nothing about the way in which memory works in the world outside, they are of distinctly limited value.

In general, attempts to generalize our theories have worked well, and have in turn enriched theory. One important application of theory is to the memory performance of particular groups such as children, the elderly, and patients with memory problems. As we will see, these not only demonstrate the robustness and usefulness of cognitive theory, but have also provided ways of testing and enriching theory. A good case in point is the study of

In Medieval times, accurate and precise articulation of the words of the church liturgy was more important than the sound of the music, with errors taken very seriously. The demon Titivillus was believed to take time off from his other task of inducing errors in written manuscripts to collect such omissions and slips of the tongue. Each day a thousand bags of such lapses would be conveyed to his master Satan, written in a book of errors and used against the unfortunate cleric on the Day of Judgement. It appears that in due course the level of accuracy improved to a point at which Titivillus was driven to filling his sack with idle gossip from the congregation, a rather menial task for a respectable demon (Zieman, 2008).

patients with a very dense but pure amnesia, which has told us about the everyday importance of episodic memory, has helped develop tests and rehabilitation techniques for clinical neuropsychologists, and has, at the same time, had a major impact on our theories of memory.

A second major benefit from moving beyond the laboratory comes from a realization that certain very important aspects of memory were not being directly covered by existing theories. Some of these have led to important new theoretical developments. This is the case with the study of semantic memory, which, as mentioned earlier, was initially prompted by the attempt of computer scientists to develop programs that could understand language (Collins & Quillian, 1969). Another area of very active research that was driven by a practical need is that of eyewitness testimony, where it became clear that the failures of the judiciary to understand the limitations of human memory were often leading to potentially very serious miscarriages of justice (Loftus, 1979). Other areas have developed as a result of identifying practical problems that have failed to be addressed by theory. A good example of this is prospective memory, remembering to do things. This use of memory is of great practical importance, but for many years was neglected because it reflects a complex interaction between attention and memory. These broader topics are covered in the latter part of the book, which will illustrate the now widely accepted view that theoretical and practical approaches to memory are allies and not rivals.

The contribution of neuroscience

Both the Ebbinghaus and Bartlett approaches to the study of memory were based on the psychological study of memory performance in normal individuals. In recent years, however, this approach has increasingly been enriched by data from neuroscience, looking at the contribution of the brain to our capacity to learn and remember. Throughout this book, you will come across cases in which the study of memory disorders in patients has thrown light on the normal functioning of human memory. In particular, the problems faced by patients with memory problems can often tell us about the function that our memories serve, and how they can be further investigated. Recent years have seen a rapid development of methods that allow the neuroscientist to observe and record the operation of the brain in healthy people both at rest and while performing complex activities, including those involved in learning and remembering. These will be discussed in the next chapter

SUMMARY

- Although we complain about our memories, they are remarkably efficient and flexible in storing the information we need and discarding what is less important.
- Many of our memory lapses result from this important need to forget nonessentials, if we are to remember efficiently.
- The study of memory began with Ebbinghaus, who greatly simplified the experimental situation, creating a carefully constrained approach that continued in North America into the twentieth century.
- Alternative traditions developed in Germany, where the study of perception influenced the way in which Gestalt psychologists thought about memory, and in Britain, where Bartlett used a richer and more open approach to memory.

(Continued)

(Continued)

- During the 1950s and 1960s, these ideas, influenced further by the development of the computer, resulted in an approach that became known as cognitive psychology.
- In the case of memory, this emphasized the need to distinguish between encoding or input into memory, memory storage, and memory retrieval, and to the proposal to divide memory into three broad types, sensory memory, short-term memory, and long-term memory.
- The information-processing model is very well illustrated in Sperling's model of visual sensory memory, in which the various stages were ingeniously separated and analyzed.
- These were assumed to lead into a temporary *short-term* or *working memory*. This was initially thought to be largely verbal in nature but other modalities were subsequently shown to be capable of temporary storage.
- The short-term memory system was assumed to feed information into and out of long-term memory.
- Long-term memory was further subdivided into *explicit* or declarative memory, and *implicit* or nondeclarative memory.
- Explicit memory was further divided into two types: The capacity to recollect individual experiences, allowing "mental time travel," became known as *episodic memory*, whereas our stored knowledge of the world was termed *semantic memory*.
- A range of implicit or nondeclarative learning and memory systems were identified, including classical conditioning, the acquisition of motor skills, and various types of priming
- An important development in recent years has been the increased interest in extending theory beyond the laboratory. Although this has led to controversy; it is clear that we need the laboratory to refine and develop our theories, but that we also need to move outside the laboratory to investigate their generality and practical importance.

POINTS FOR DISCUSSION

1. What are the strengths and weaknesses of the approach to memory taken by Ebbinghaus and Bartlett?
2. How did the cognitive approach to memory build on these foundations?
3. Do we need to assume more than one kind of memory? If so, why?

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POINTS FOR DISCUSSION

1 What are the advantages and disadvantages of the study of brain damaged patients as compared to the neuroimaging of healthy participants?

2 Neuroimaging studies often focus on brain localization; what are the strengths and weaknesses of this for a theoretical understanding of memory?

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