2.01 Introduction and Overview

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2.01.1 The Cognitive Psychology of Memory: Introduction

The main problem in the scientific study of memory is that it proceeds on many different fronts. Neurochemical and neurobiological approaches propel some researchers; systems neuroscientists examine changes in larger pathways in the nervous system; animal behaviorists examine learning and memory as reflected in behavior of (mostly) infrahuman animals, such as birds finding caches of seed; cognitive psychologists study human memory through behavioral means using measures such as recall and recognition; computer scientists endorse computational approaches to memory that sometimes pay little attention to behavioral or neuroscience constraints; and, of course, the study of memory has been the topic of discourse by philosophers for over 2000 years. This four-volume series covers a huge selection of topics that are central to the scientific study of memory. In a different edited volume, Roediger et al. (2007) considered 16 critical concepts in the science of memory from the various viewpoints described above.

2.01.2 Cognitive Approaches to Memory

Practitioners of what is today called cognitive psychology have a long tradition of the experimental study of various aspects of memory. Experimental psychology is often dated from the founding of Wilhelm Wundt's laboratory in Leipzig in 1879. Coincidentally, that same year marks the year that Hermann Ebbinghaus (1850–1909) began his painstaking research that led to his great book, *Über das Gedächtnis (On Memory)* in 1885 (Ebbinghaus, 1885). Ebbinghaus conducted meticulous experiments that asked many fundamental questions about learning and memory, and virtually all his results have stood the test of time in that they have been widely replicated. His work dates the start of the cognitive/behavioral study of learning and memory in humans, although of course centuries of speculation and theorizing (particularly by the British empiricist philosophers) preceded and informed his first experimental efforts. Bower (2000) provides a brief historical overview of this approach to studying learning and memory.

Cognitive psychologists approach the problem of memory through careful experimentation to examine theories that vary in their levels of specification. Some theories (say, transfer-appropriate processing) are broad and seek to capture a wide range of performance across many situations, whereas other approaches (such as mathematical models of performance in specific tasks) are more formal and often attempt to capture memory performance only in tightly structured paradigms.

Traditionally, up until perhaps 30 years ago, cognitive psychologists paid little attention to neuroscience discoveries, and likewise, neuroscientists paid little attention to the experimental work of the cognitive psychologists. Although this division of labor is honored to some degree in the separate volumes of this work, the interests of scientists are clearly broader today. Unlike the case 30 years ago, cognitive psychologists today follow advances in neuroscience with great interest, and many of the concepts and tasks used by neuroscientists were originally developed by psychologists (either those studying animal learning and memory or those applying cognitive methods to these topics in humans). Although this volume is largely devoted to the cognitive/behavioral study of memory, many chapters lean heavily on neuroscience findings. The authors were given leeway to cover their particular topic from

the vantage they deemed most appropriate, bringing in the types of evidence they considered most relevant. Some chapters rely heavily on neuroscience evidence, whereas others refer to purely behavioral experimentation. I see this as perfectly appropriate for the various topics covered in this volume.

2.01.3 Organization of the Volume

One time-honored procedure in the study of cognitive processes is sorting (e.g., Mandler, 1967). An experimenter can give a subject a set of concepts and ask him or her to sort them into groups. The hope is to discover something about how the subject's mind organizes experiences into concepts or categories. The titles of chapters for this volume were originally listed alphabetically, but then the editors of each volume were asked to organize them in some meaningful way, which corresponds reasonably well to a sorting task. I took several trials to reach criterion on this task and can still quibble with myself on various decisions. Luckily, the editors were not asked to create sections of the volume and to label our categories. Here I provide some rationale for the ordering of the chapters and, at the same time, outline the contents of the volume.

The volume begins with a chapter on attention and memory by Neil Mulligan (*See* Chapter 2.02). After all, events in the world that are not attended will not be encoded well and cannot be remembered later, so this seemed a logical starting point. Nelson Cowan's chapter on sensory memory (*See* Chapter 2.03) follows this one. Sensory memory (iconic storage, echoic storage, and similar processes in other modalities) lies at the borderline between perceiving and remembering. No one has ever proposed a good solution to the question of where perceiving ends and remembering begins, and ideas about sensory storage bridge this gap. Susan Gathercole's chapter on working memory comes next (*See* Chapter 2.04). The topic of how people hold information in mind while manipulating it in reasoning and solving problems represents a huge topic in cognitive psychology over the past 40 years. The next chapter is on serial learning by Alice Healy and William Bonk (*See* Chapter 2.05). Most research on serial learning uses paradigms requiring short-term recall (such as digit span and similar procedures), so placing it after the working memory chapter seems reasonable. However, the chapter also covers long-term processes in serial organization.

Robert Greene provides a chapter on the fundamental topic of repetition and spacing effects (*See* Chapter 2.06). Perhaps the first principle of learning and memory is that repeated experiences are (almost) always better remembered than single experiences; further, having two experiences distributed in time (up to some limit that differs for various tasks and retention intervals) leads to greater performance. Another fundamental principle, dating at least to George Miller's (1956) pioneering work on recoding in memory, is that events are not remembered as they are presented in the outside world (events do not somehow leap into the brain as veridical copies of experience), but, rather, events are coded (or recoded) as they are filtered through an individual's personal experiences (or apperceptive mass, to bring back a useful term from early in psychology). Events are remembered as they are coded and not as they necessarily 'are' in the environment. Reed Hunt's chapter on coding processes brings out this important point and shows how recoding can improve retention in some cases but in other cases can lead to errors (*See* Chapter 2.07). Mental imagery is one type of code that has received great attention in the literature, and Cesare Cornoldi, Rossana DeBeni, and Irene Mammarella review this literature in the next chapter (*See* Chapter 2.08).

An event that differs dramatically from many other events that are themselves similar is usually well remembered, which constitutes a distinctiveness effect. For example, a picture of a horse embedded in the middle of a 99-word list of other concrete nouns is much better remembered than if the word 'horse' is presented in a uniform list of 100 words (with 'horse' embedded in the analogous position in the list). This outcome occurs even if the mode of recall is verbal (i.e., people must recall the word 'horse' both when it is presented as a picture and as a word). Distinctiveness effects are ubiquitous in memory research, and Stephen Schmidt provides a review of what is known about this topic in his chapter 'A Theoretical and Empirical Review of the Concept of Distinctiveness in Memory Research' (*See* Chapter 2.09). The next chapter, 'Mnemonic Devices: Underlying Processes and Practical Applications,' by James Worthen and Reed Hunt, brings together the chapters on recoding, imagery, and distinctiveness by reviewing techniques for memory improvement that have been developed over the years (*See* Chapter 2.10). Some of these techniques date back to the ancient Greeks, but modern research has helped to uncover the reasons for their effectiveness. Many of these techniques depend on

imagery, and some (such as the method of loci) rely on humans' ability to remember routes and spatial layouts well, especially ones experienced repeatedly. Timothy McNamara, Julia Sluzenski, and Bjorn Rump review the interesting topic of human spatial memory and navigation (*See* Chapter 2.11).

The next chapters in the volume have to do with memory losses and errors. Forgetting refers to the loss of information over time, and James Nairne and Josefa Pandeirada review the topic in their chapter by that name (*See* Chapter 2.12). A complementary topic is on inhibitory processes, a chapter by Karl-Heinz Bauml (*See* Chapter 2.13). Inhibitory processes are concerned with another set of phenomena that have to do with forgetting. The basic idea is that forgetting may result from an active process of memories being inhibited and therefore forgotten, at least temporarily. Forgetting is often considered an error of omission – information does not come to mind when we try to retrieve it – but errors of commission are of great interest, too. False memories arise when we retrieve information differently from the way it was experienced or, in the most dramatic cases, when we retrieve confident memories of events that never happened at all. Elizabeth Marsh, Andrea Eslick, and Lisa Fazio review this topic in their chapter titled 'False Memories' (*See* Chapter 2.14). Eric Eich, Elke Geraerts, Jonathan Schooler, and Joseph Forgas provide a chapter on mood and emotion in memory, titled 'Memory in and About Affect' (*See* Chapter 2.15). When people are in different moods when they experience events and then try to retrieve them later, they often remember more poorly than if the moods are the same between encoding and retrieval (the phenomenon of mood-congruent memory). However, when people experience greater emotional states during encoding (e.g., strong fear), they often remember events well.

The next few chapters have to do with retrieval of information from memory, as well as associated states of consciousness and processes during this process. Suparna Rajaram and Sarah Barber provide an overview of retrieval processes in memory (*See* Chapter 2.16). John Gardiner writes on the distinction between remembering and knowing, which are responses representing two states of conscious awareness during retrieval (*See* Chapter 2.17). Asher Koriat, Morris Goldsmith, and Vered Halamish discuss control processes in voluntary remembering, dealing with issues such as the criterion people use when deciding that recovered information should be reported as a memory and the factors affecting memory reports (*See* Chapter 2.18). Stephen Lindsay writes on the related topic of source monitoring, or the issue of how people recollect the source of information they report as a memory – did I read the fact in the newspaper, did a friend tell me, or was it learned from television (*See* Chapter 2.19)? Janet Metcalfe and John Dunlosky write on the issue of metamemory, or what people know about their own memories and the strategic processes used in regulating encoding and retrieval of information (*See* Chapter 2.20). Alan S. Brown has provided two chapters on puzzling phenomena of memory retrieval, the experience of déjà vu (when a person has the strange sensation that an event or scene has been experienced previously), and the tip-of-the-tongue phenomenon (the annoying experience when a desired bit of information can almost, but not quite, be retrieved) (*See* Chapters 2.21, 2.22).

Colleen Parks and Andrew Yonelinas provide the chapter 'Theories of Recognition Memory' (*See* Chapter 2.23), with particular emphasis on whether a single-factor or two-factor theory best accounts for the data. William Hockley writes about the related topic of memory search in various types of memory tests, including short-term recognition (S. Sternberg's (1966) item recognition test), long-term recognition, free recall, and other tasks (*See* Chapter 2.24). Both the chapter on recognition and the chapter on memory search involve considerations of mathematical modeling, and the next chapter by Jeroen Raaijmakers explicitly considers mathematical models of human memory (*See* Chapter 2.25). His chapter is followed by a related one by Michael Kahana, Marc Howard, and Sean Polyn on associative retrieval processes in episodic memory (*See* Chapter 2.26). Karl Szpunar and Kathleen McDermott provide an overview on the concept of episodic memory as it has developed since Tulving's seminal chapter in 1972 (Tulving, 1972) (*See* Chapter 2.27). They discuss how neural processes involved in episodic memory may also subserve a person's envisioning the future as well as recollecting the past.

The next series of chapters involves memory of a different kind from episodic memory. David Balota and Jennifer Coane's chapter on semantic memory concerns representation of well-learned information such as words and their meanings (*See* Chapter 2.28). Brian Ross, Eric Taylor, Erica Middleton, and Timothy Nokes survey the related field of how humans learn concepts and categories in 'Concept and Category Learning in Humans' (*See* Chapter 2.29). Gideon Deák and Anna Holt describe research on the critical issue of language learning and report how theories have advanced over the years (*See*

Chapter 2.30). Peter Frensch and Hilde Haider discuss research on the venerable topic of transfer and expertise (*See* Chapter 2.31), a topic that really runs throughout the book in many ways.

Pierre Perruchet reviews the evidence concerning implicit learning, which uses transfer designs as a major tool for understanding (*See* Chapter 2.32). Dale Stevens, Gagan Wig, and Daniel Schacter then review recent evidence on the related topic of implicit memory and priming (*See* Chapter 2.33). Timothy Lee and Richard Schmidt provide an overview on the topic of motor learning and memory, which is related to implicit learning in some ways (*See* Chapter 2.34). Much recent work has shown that procedural and motor skills (as well as some other forms of learning) consolidate while people sleep. Jessica Payne, Jeffrey Ellenbogen, Matthew Walker, and Robert Stickgold review this exciting frontier in memory research in 'The Role of Sleep in Memory Consolidation' (*See* Chapter 2.35).

The next group of chapters is concerned with development of memory across the lifespan, as well as individual differences among people in memory ability. Carolyn Rovee-Collier and Kimberly Cuevas review evidence about infant memory (*See* Chapter 2.36), and then Peter Ornstein, Catherine Haden, and Priscilla SanSouci consider the development of skilled remembering in children (*See* Chapter 2.37). Elena Grigorenko discusses developmental disorders of learning (*See* Chapter 2.38), and Michelle Dawson, Laurent Mottron, and Morton Gernsbacher describe learning in autism (*See* Chapter 2.39). Michael Kane and Tina Miyake write about individual differences in episodic memory among adults (*See* Chapter 2.40), and Moshe Naveh-Benjamin and Susan Old discuss aging and memory (*See* Chapter 2.41). Finally, Anders Ericsson describes research on superior memory of mnemonists and experts in various domains (*See* Chapter 2.42).

The next few chapters of the book focus on more applied aspects of learning and memory research. Mark McDaniel and Aimee Callendar discuss work on cognition, memory, and education, focusing on applying principles from learning and memory research to educational practice (*See* Chapter 2.43). Jeffrey Neuschatz and Brian Cutler discuss the important issue of eyewitness identification (*See* Chapter 2.44). Since the advent of DNA evidence, over 200 people convicted of crimes – often on the basis of eyewitness evidence - have been released from prison, exonerated by DNA evidence. This state of affairs has caused a searching examination of the typical methods used by police to conduct eyewitness identifications. Gilles Einstein, Mark McDaniel, Richard Marsh, and Robert West discuss another popular topic in recent research – how people remember to do things in the future, such as taking an antibiotic pill four times a day when fighting an infection. Their chapter, 'Prospective Memory: Processes, Lifespan Changes, and Neuroscience,' discusses this interesting line of research (*See* Chapter 2.45).

The last three chapters of the volume examine memory from a broader perspective. Most chapters previously described are based on laboratory tasks concerned with learning and memory. Martin Conway and Helen Williams write on the nature of autobiographical memory, which is concerned with how people recollect the events of their lives (*See* Chapter 2.46). Michael Ross, Craig Blatz, and Emily Schryer discuss social memory processes, which includes the issue of how people influence one another as they remember (as well as other topics) (*See* Chapter 2.47). Finally, James Wertsch discusses the emerging topic of collective memory (*See* Chapter 2.48), which is a representation of the past that is shared by members of a group. The group might be people in a nation recollecting an important historical event, such as how people in the United States remember the Revolutionary War. Different groups may see the past in different ways, as Wertsch brings out in his chapter. The empirical study of collective memory is an emerging topic but one that is sure to be more important in the future.

2.01.4 Conclusion

The 47 substantive chapters in this volume represent a marvelous, state-of-the art digest by leading scholars as they summarize what is known about many of the critical topics in the cognitive psychology of learning and memory. The entries range from topics that have a long history (e.g., transfer) to those that have emerged only recently (prospective memory, collective memory). Editing the volume has caused me to learn much, and I believe every reader of this volume will share this experience.

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