

Jesse E. Purdy • Michael R. Markham • Bennett L. Schwartz • William C. Gordon

Learning and Memory

Second Edition





Learning and Memory

Second Edition

JESSE E. PURDY

Southwestern University

MICHAEL R. MARKHAM

Florida International University

BENNETT L. SCHWARTZ

Florida International University

WILLIAM C. GORDON

University of New Mexico

WADSWORTH

THOMSON LEARNING

Australia • Canada • Mexico • Singapore • Spain • United Kingdom • United States

Executive Editor: Vicki Knight
Senior Editor: Marianne Taflinger
Assistant Editor: Jennifer Wilkinson
Signing Representative: Miguel Ortiz
Project Editor: Pam Suwinsky
Print Buyer: Mary Noel
Permissions Editor: Bob Kauser

Production Service: Proof Positive/Farrowlyne Associates, Inc.
Art Editor: Roberta Broyer
Cover Designer: Jennifer Dunn
Cover Images: PhotoDisc
Cover Printer: R. R. Donnelley & Sons
Compositor: Black Dot Group
Printer: R. R. Donnelley & Sons

COPYRIGHT © 2001 Wadsworth, a division of Thomson Learning, Inc. Thomson Learning™ is a trademark used herein under license.

ALL RIGHTS RESERVED. No part of this work covered by copyright hereon may be reproduced or used in any form or by any means—graphic, electronic, or mechanical, including photocopying, recording, taping, Web distribution, or information storage and retrieval systems—without the written permission of the publisher.

Printed in the United States of America

1 2 3 4 5 6 7 04 03 02 01 00

For permission to use material from this text, contact us
by Web: <http://www.thomsonrights.com>
Fax: 1-800-730-2215
Phone: 1-800-730-2214

Library of Congress Cataloging-in-Publication Data

Learning and memory.—2nd ed. / Jesse E. Purdy . . . [et al].
p. cm.

Rev. ed. of: Learning and memory / William C. Gordon, c1989.
Includes bibliographical references (p.) and indexes.
ISBN 0-534-16914-7

1. Learning, Psychology of. 2. Memory. 3. Conditioned response. I. Purdy, Jesse E. II. Gordon, William C. Learning and memory.

BF318.G67 2000
153.1—dc21

00-034043

For more information, contact:
Wadsworth/Thomson Learning
10 Davis Drive
Belmont, CA 94002-3098
USA
<http://www.wadsworth.com>

International Headquarters
Thomson Learning
International Division
290 Harbor Drive, 2nd Floor
Stamford, CT 06902-7477
USA

UK/Europe/Middle East/South Africa
Thomson Learning
Berkshire House
168-173 High Holborn
London WC1V 7AA
United Kingdom

Asia
Thomson Learning
60 Albert Street, #15-01
Albert Complex
Singapore 189969

Canada
Nelson Thomson Learning
1120 Birchmont Road
Toronto, Ontario M1K 5G4
Canada



This book is printed
on acid-free
recycled paper.



Preface

We live in an age of information overload. We have driven the information highway, and it is clear that the accumulation of information is growing exponentially. As a consequence it is becoming more and more difficult to keep current. The days of the Renaissance person may be ending; it may no longer be possible to be an expert and excel in multiple fields of investigation. Psychology is no exception. Indeed, the U.S. Congress declared the 1990s to be the “Decade of the Brain,” and it appears that the first decade of the new millennium will be named the “Decade of Behavior.” These designations have had and will have an enormous impact on psychological science. The result will be an even greater increase in the number of psychological journals and the number of published papers in psychology. As the amount of information increases, our ability to access, then filter this information becomes critical. There are now ways to access information that were not available 10 years ago. We have instant access to vast sources of information through the Internet, but easy access to information is causing problems. How are we to discriminate between good information and bad? How do we sift through vast amounts of information and make sense of what we see? The answers lie in our ability to critically read and make informed decisions about the quality of the evidence and the methods by which that evidence was obtained.

CRITICAL READING, CRITICAL THINKING

This text is designed to help the student critically read and understand theoretical positions and to assess and interpret data in light of their theoretical implications. My colleagues and I have taken a subtle approach. We will present both sides of an issue, and we will consider the evidence for each position. We will approach issues from a historical perspective, and we will examine how the evidence has changed the questions that are asked and how theoretical positions are changed in light of new evidence. Often in this book the students may express concern because we will spend a fair amount of time considering a position only to conclude that a new theory is needed or that a new theory needs to be tested more thoroughly. Students may ask or demand that they simply be given the answer. The problem, of course, is that there may not be simple answers. Science moves forward, but its progress is not always evident. Thus, it is important for students to know that the study of learning and memory in psychological science is a work in progress. We have learned much, but we have much to learn. This text is designed to inform students about what we know and how we know it. But the text is also written with the goal that the student finishes the course knowing that it is only through the continued application of the scientific method that further progress can be made.

HOW BIOLOGY CONSTRAINS LEARNING

It would have been possible for my colleagues and I to write a book of this length with no reference earlier than 1990, but that would have been a mistake. Many of the important discoveries concerning the role of reinforcement in determining behavior were made 40 or more years ago, and much of the current literature builds on the foundation of those earlier studies. Indeed, many of today's theories rest on earlier theoretical positions, and these theories are often best understood in historical light. For example, to understand the current emphasis on biological constraints on learning and the adaptive role that learning plays in the life of an organism, it is important to remember that in the 1940s and 1950s learning was studied more or less as an end in and of itself. Most researchers in the 1940s and 1950s were not concerned with the role of evolutionary history in what an organism learned or remembered. Many of the apparatuses and most of the stimuli used in the study of learning and memory were designed to reduce the influence of evolutionary and ecological variables. This made sense because the current theme at the time was the belief that the general laws of learning transcended evolutionary history. As a result of this perception, working with a large number of species and worrying about the effects of the animal's evolutionary history and its ecological niche was viewed as nonproductive. However, with the finding that some animals can associate certain stimuli more easily than others and that in other

species the opposite is true, there was renewed interest in understanding learned behavior in the context of the organism's evolutionary and ecological background.

COMPREHENSIVE AND APPLIED

In writing this book, my colleagues and I faced difficult problems. We wanted the book to be comprehensive. We wanted to present discoveries and theoretical positions in a historical light and show how they changed as a result of more and better data. We wanted to provide students with a solid foundation of terminology and theory upon which they could begin to appreciate the depth of understanding already achieved, as well as an appreciation for the direction of future research. Finally, we wanted to provide a foundation for students to continue their study of learning and memory and to enhance their appreciation for the role that learning and memory play in all aspects of psychology. This latter goal was critical: Knowledge of learning and memory can help practicing clinicians devise effective therapy strategies. It also can inform educational psychologists of the means by which material is acquired and retained and provide insight into the best ways to present material. Knowledge of learning and memory can help the social psychologist understand how changes in attraction, prejudice, and attitude can occur, and it can help human factors engineers understand how to build safer and more efficient machines.

BLENDS ANIMAL AND HUMAN RESEARCH IN A WAY THAT'S BASIC AND APPLIED

In light of these emphases, this edition of *Learning and Memory* is a comprehensive text that combines current with classic research and includes a unique chapter 7 that bridges learning and memory by discussing the roles that stimulus generalization and discrimination learning play in concept formation in human and nonhuman animals. The text offers also an innovative blend of animal and human research that is both basic and applied. For example, basic research with animals includes comprehensive discussion of the observing response literature and sign tracking as well as extensive treatment of recent theories of classical conditioning by Wagner and others. Basic research with humans is considered in the discussions on concept formation as well as discussion of short-term and long-term memory. Applications of basic research in learning are considered in discussions of the role of classical conditioning in drug abuse and aversion therapies as well as the role of operant techniques in treating autism. Applications of basic research in memory are considered in discussions of false and repressed memories, amnesia, eyewitness memory, and memory practice and mnemonic improvement. My colleagues and I also made the text student friendly by providing examples and stories that introduce topics in ways that are easy to grasp and that are relevant and appropriate

for students. Chapter 7 opens with a scenario in which a researcher, having been awarded a federal grant to observe vervet monkeys in the wild, discovers the communication abilities of vervets as they encounter different predatory threats. In addition, the text includes many examples and figures, which not only serve as visual counterpoint but also help make the text easier to read and comprehend.

RESOURCES FOR TEACHERS AND STUDENTS

Wadsworth Publishing Company has made available several resources for the instructor and the student. These resources supplement the text, bring the material to life for the student, assist the student in the course, and reduce the instructor's teaching load by providing a test bank that contains numerous questions of varying formats. In addition, the test bank provides a description of Wadsworth's popular software package "Sniffy, the Virtual Rat." This interactive software program allows students enrolled in institutions with or without operant conditioning labs to learn in a hands-on manner how to shape an animal to perform an operant task and the basics of classical conditioning. Depending on the package you choose, the program supports 16 to 40 separate exercises that teach the student the basics of operant and classical conditioning. Students learn to shape a virtual rat to press a bar for virtual cheese. They learn about cumulative records, schedules of reinforcement, and more complex behavioral phenomena including generalization and discrimination learning, extinction, and spontaneous recovery. In the exercises on classical conditioning, students learn about basic acquisition and extinction of a conditioned response, the effects of varying the strength of the CS and US, pre-exposure effects, blocking and overshadowing, and others.

Students enjoy training Sniffy to perform in an operant and classical conditioning setting, and they learn from the various exercises. We do not propose that Sniffy should be substituted for actual experience with live animals. However, in many institutions there is no other option. For these schools, Sniffy is a must to bring to life the material in this book. For programs that have an animal laboratory component associated with this course, Sniffy provides a good starting place for teaching students about conditioning animals. The instructor's manual that accompanies this text outlines the various exercises available from the Sniffy programs and shows where the material is covered in the text. Through Sniffy, students are able to see and experience what they have read, and they obtain a better sense of what life in a learning laboratory might be like. For more ideas about how to use Sniffy in courses, call the Wadsworth Marketing Department at 1-877-999-2350 to request a six-minute video.

Another resource offered by Wadsworth is Info Trac College Edition. Info Trac is a fully searchable online university library that includes the full text of articles from hundreds of scholarly and popular publications. Hot linked, expertly indexed, and ready to use, Info Trac College Edition is updated daily

with articles going back as far as four years. You can give your students four months' access—24 hours a day, 7 days a week—to this online library if you choose to package Info Trac College Edition with this book. Included among the large number of journals available to the student and that would be of interest to students enrolled in a course in learning and memory are the *American Journal of Psychology*, *American Scientist*, *Annual Review of Psychology*, *British Journal of Psychology*, *Ecological Monographs*, *Ecology*, *Journal of Cognitive Neuroscience*, *Journal of Experimental Education*, *Journal of General Psychology*, *Journal of Neuroscience*, *Journal of Social Psychology*, *Psychological Record*, *Quarterly Review of Biology*, and *Science*.

SUMMARY STATEMENTS

The second edition of *Learning and Memory* was written by authors who are experts in the areas of learning and memory and whose experience teaching undergraduate courses in learning and memory total more than 50 years. The text has been updated and expanded. It offers many more references and new topics including a section on punishment and behavioral systems theory. The text also includes a new chapter on the interaction of classical and operant conditioning and the chapter on verbal learning has been omitted. Finally, the text is much more biologically oriented and attempts to couch the topics of learning and memory within the total ecological and evolutionary history of the animal. In this vein we include sections that address which areas of the brain underlie the various components of learning and memory.

We have enjoyed writing this book, and we believe students will enjoy reading it.



About the Authors

Dr. Jesse E. Purdy received his B.S. in psychology in 1974, his M.S. in general-experimental psychology in 1976, and his Ph.D. in 1978 from Colorado State University. He graduated with an emphasis in comparative psychology. He currently holds the title Brown Distinguished Research Professor and chairs the Department of Psychology at Southwestern University, where he has been since 1978.

Dr. Purdy has an active research program that extensively involves undergraduate students. With his students he has authored and co-authored more than 30 articles and made more than 40 conference presentations. His work is primarily carried out at Southwestern University's Aquatic Animal Research Laboratory, a facility that houses both fresh water and salt water organisms. The focus of his work is on basic animal learning processes in aquatic animals, where he continues to explore the mechanisms of learning involved in sign tracking in goldfish and cuttlefish. He is also interested in questions relating to optimal foraging, defensive behaviors, and predator-prey interactions in aquatic animals. His work with cuttlefish has been highlighted on the Discovery Channel's *World of Wonder*.

Dr. Purdy has been active in several professional organizations, including the Southwestern Comparative Psychology Association, the Southwestern Psychological Association, and Psi Chi. He served on the board of directors for SCPA and he served as president of SWPA. He is currently president-elect of Psi Chi, the national honor society in psychology.

Dr. Michael R. Markham is Assistant Professor of Psychology at Florida International University. He received his B.A. from the University of New Mexico in 1990 and his Ph.D. in psychology from the University of New Mexico in 1994. His courses include Introduction to the Experimental Analysis of Behavior, Biological Psychology, and Theories of Learning. His research interests focus on interactions of Pavlovian conditioning and stimulus classes in humans and nonhuman animals.

Bennett L. Schwartz is an Associate Professor of Psychology at Florida International University in Miami, Florida. He received his Ph.D. in psychology from Dartmouth College in 1993. He has published papers on memory, metacognition, and the tip-of-the-tongue phenomenon in journals such as *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *Memory & Cognition*, and *Memory*. He has taught Memory and Cognitive Psychology at FIU since 1993. He recently became the proud father of an infant daughter, Sarina.



Contents

Preface	xvii
1 An Introduction to Learning and Memory	1
Chapter Overview	2
✓ Varieties of Learning and Memory	3
✓ <i>Habituation and Sensitization</i>	3
✓ <i>Classical Conditioning</i>	4
✓ <i>Instrumental Conditioning</i>	4
✓ <i>Short-Term Memory</i>	5
✓ <i>Long-Term Memory</i>	5
✓ <i>Encoding, Storage, Representation, and Retrieval</i>	6
Theme 1: Learning and Memory Are Basic Processes That Result in Diverse Phenomena.	7
✓ <i>Defining Learning and Memory</i>	7
✓ <i>Defining Learning</i>	7
✓ <i>Defining Memory</i>	9
Theme 2: Learning and Memory Are Interrelated but Separable Domains.	10

	Theme 3: Learning and Memory Are Adaptive Processes.	10
	Learning and Memory in Biological Organisms	12
	✓ <i>A Biological Basis of Learning and Memory</i>	13
	✓ <i>Biological Constraints on Learning and Memory</i>	17
	Theme 4: Learning and Memory Occur in a Biological Context.	17
	✓ Differences and Similarities in the Study of Learning and Memory	17
	✓ Summary Statements	19
2	Classical Conditioning: Basic Principles	21
	Chapter Overview	22
	Pavlov's Original Experiments	23
	Examples of Classical Conditioning	24
	The Concept of Contingency	28
	Methods for Studying Classical Excitatory Conditioning	29
	<i>Human Conditioning Paradigms</i>	29
	<i>Conditioning Paradigms Used with Animals</i>	31
	Variables That Affect Excitatory Conditioning	33
	<i>The Relationship Between the CS and US</i>	33
	<i>The Temporal Order of the CS and US</i>	34
	<i>The CS-US Interval</i>	35
	<i>The Correlation of CS and US Occurrence</i>	37
	<i>The Number of CS-US Pairings</i>	38
	Characteristics of the CS and the US	39
	<i>CS and US Intensity</i>	39
	<i>Prior Experience with CS or US</i>	40
	<i>CS-US Relevance</i>	40
	<i>The Presence of Other Stimuli During Conditioning</i>	42
	Conditioning Without an Explicit US	46
	<i>Higher Order Conditioning</i>	46
	<i>Sensory Preconditioning</i>	47
	The Biological Basis of Classical Conditioning	48
	Classical Inhibitory Conditioning	50
	<i>Problems in Measuring the Inhibitory CR</i>	50
	<i>Conditionings That Promote Inhibitory Conditioning</i>	51

Extinction	54
<i>Spontaneous Recovery</i>	55
<i>Variables That Affect Rate of Extinction</i>	55
<i>Treating Phobias Through Extinction</i>	56
Summary Statements	57
3 Classical Conditioning: Theoretical Issues	59
Chapter Overview	60
The Necessary and Sufficient Conditions	
for CR Development	63
<i>Contiguity Theory: Basic Assumptions</i>	63
<i>Contiguity Theory: The Evidence</i>	64
<i>Contingency Theory: Basic Assumptions</i>	66
<i>Contingency Theory: The Evidence</i>	67
<i>Conclusions About Contingency in Conditioning</i>	69
Modified Contiguity Theory: The Rescorla-Wagner	
Model	70
<i>The Formal Expression of the Rescorla-Wagner Model</i>	71
<i>Rescorla-Wagner Model: The Evidence</i>	73
Recent Theories of Classical Conditioning	75
<i>Wagner's Priming Theory</i>	75
<i>Behavior Systems Theory</i>	78
What Is Associated in Classical Conditioning?	83
<i>Stimulus-Response or Stimulus-Stimulus Learning?</i>	83
<i>Evidence Concerning the Elements in an Association</i>	83
<i>The Role of Context in Conditioning</i>	87
<i>Contextual Stimuli as CSs</i>	88
<i>Evidence for Contextual Stimuli as CSs</i>	88
<i>Contextual Stimuli as Cues for the CS-US Relationship</i>	89
<i>Conclusions About Contextual Stimuli</i>	89
Summary Statements	90
4 Instrumental/Operant Conditioning:	
Learning from the Consequences of Behavior	91
Chapter Overview	93
Early Experiments: Thorndike and Skinner	95
Behavior, Consequences, and Contingencies	96
<i>Reinforcement and Punishment</i>	96
<i>Operant Conditioning in the Treatment of Alcohol Abuse</i>	99

✓ Paradigms for Studying Instrumental and Operant	
Conditioning	100
<i>The Instrumental-Operant Distinction</i>	100
✓ <i>Instrumental-Conditioning Paradigms</i>	100
<i>Escape and Avoidance Paradigms</i>	101
Operant Procedures	103
<i>The Bar-Press Response in Rats</i>	103
<i>The Key-Peck Response in Pigeons</i>	104
<i>Operant Responses in Humans</i>	104
<i>Measuring the Operant Response</i>	104
<i>The Shaping Procedure</i>	106
✓ <i>Variables That Affect Instrumental and Operant</i>	
<i>Responding</i>	108
Positive Reinforcement Situations	108
✓ <i>Amount or Magnitude of Reinforcement</i>	108
<i>Delay of Reinforcement</i>	109
<i>Contrast Effects</i>	109
<i>Intermittent Reinforcement</i>	110
<i>Schedules of Reinforcement</i>	111
<i>More Complex Schedules of Reinforcement</i>	114
✓ Negative Reinforcement Situations: Escape Learning	
and Avoidance	116
<i>Amount of Reinforcement</i>	116
<i>Delay of Reinforcement</i>	117
<i>Negative Reinforcement Situations: Avoidance Learning</i>	117
<i>Punishment Situations</i>	118
The Biological Basis of Instrumental/Operant	
Conditioning	122
<i>Biological Constraints on Conditioning</i>	122
<i>Reinforcement Centers in the Brain</i>	124
The Discriminative Stimulus	126
Extinction	126
<i>Variables That Affect Extinction of Positively</i>	
<i>Reinforced Responses</i>	127
<i>Conditions Present During Extinction</i>	128
<i>Variables That Affect Extinction of Negatively Reinforced</i>	
<i>Responses</i>	129
Summary Statements	129

5	Instrumental and Operant Conditioning: Theoretical Issues	131
	Chapter Overview	132
	The Nature of Reinforcement	135
	<i>Primary and Secondary Reinforcers</i>	135
	<i>Theories of Primary Reinforcement</i>	136
	<i>Stimulus-Based Theories of Reinforcement</i>	136
	<i>Response-Based Theories of Reinforcement</i>	140
	<i>The Response-Disequilibrium Hypothesis</i>	142
	<i>Conclusions About Primary Reinforcement Theories</i>	146
	The Role of Reinforcement in Instrumental and Operant Conditioning	146
	<i>The Thorndike-Hull Hypothesis</i>	147
	<i>The Spence-Hull Hypothesis</i>	149
	<i>Response-Outcome Theories</i>	153
	Theories of Extinction	154
	<i>Amsel's Frustration Theory: A Competing-Response Hypothesis</i>	154
	<i>The Discrimination Hypothesis of Extinction</i>	156
	<i>Capaldi's Generalization Decrement Hypothesis</i>	157
	<i>Capaldi's Sequential Theory</i>	157
	<i>Conclusions Concerning Extinction Theories</i>	158
	Punishment: Theoretical Issues	159
	<i>Should We Use Punishment?</i>	162
	<i>Response Disequilibrium and Punishment</i>	163
	Summary Statements	164
6	The Interaction of Classical and Operant Conditioning	165
	Chapter Overview	166
	Classical Conditioning and Instrumental Conditioning in Avoidance Learning	168
	<i>Mowrer's Two-Factor Theory</i>	168
	<i>Support for Two-Factor Theory</i>	170
	<i>Contradictory Evidence for Two-Factor Theory</i>	171
	<i>The Role of Discriminative Stimuli and Instinctive Drift</i>	172
	The Observing Response: The Power of Conditioned Reinforcement	174
	<i>Theoretical Explanations of the Observing Response</i>	176
	<i>Generality of the Observing Response</i>	177

Autoshaping and Sign Tracking	177
<i>Autoshaping: The Role of the Discriminative Stimulus as a Conditioned Stimulus</i>	177
<i>Sign Tracking Studies</i>	181
<i>What Is Learned in Sign Tracking and Goal Tracking?</i>	185
Situations in Which Instrumental Conditioning	
Influences the Classically Conditioned Response	188
<i>The Conditioned Response May Make the US More Reinforcing</i>	188
<i>The CR May Be Reinforced by the US</i>	189
Classical and Operant Conditioning: One Process or Two?	189
<i>A Mathematical Model of Operant Conditioning</i>	190
Summary Statements	191
7 Generalization, Discrimination, and Concept Learning	193
Chapter Overview	194
Stimulus Generalization	198
<i>Methods for Studying Generalization in the Laboratory</i>	198
<i>Variables That Affect Stimulus Generalization</i>	200
<i>The Basis for Generalization Gradients</i>	204
<i>Traditional Explanations for Generalization</i>	204
<i>The Role of "Incidental Stimuli" in Generalization</i>	205
<i>Two Recent Theoretical Interpretations of Stimulus Generalization</i>	205
<i>Generalizations Mediated by Internal Responses</i>	207
Discrimination Learning	208
<i>Apparatus, Methods of Training, and Types of Discriminations</i>	209
<i>Theories of Discrimination Learning</i>	212
<i>Attacks on the Continuity Position</i>	217
<i>Additional Attacks on Continuity Theory</i>	218
<i>Conclusions</i>	222
Concepts Learning	222
<i>Representation of Concepts</i>	223
<i>Theories of Concept Representation</i>	223
<i>Concepts in Nonhuman Species</i>	227
Summary Statements	229

8	Sensory and Short-Term or Working Memory	231
	Chapter Overview	232
	Information Processing	233
	<i>Encoding</i>	233
	<i>Storage</i>	233
	<i>Retrieval</i>	233
	<i>Memory Systems</i>	234
	The Atkinson-Shiffrin Model	235
	Sensory Memory	237
	<i>The Adaptive Value of Sensory Memory</i>	243
	Short-Term Memory	244
	<i>The Characteristics of Short-Term Memory</i>	245
	<i>Control Processes in Short-Term Memory</i>	246
	<i>Codes Used in Short-Term Memory</i>	247
	<i>Forgetting from Short-Term Memory</i>	249
	<i>Evidence Pertinent to the Decay and Interference Theories</i>	251
	Working Memory	256
	<i>Evidence for Subsystems</i>	257
	<i>Phonological Loop</i>	258
	<i>Visuo-Spatial Sketch Pad</i>	259
	<i>Central Executive</i>	259
	The Neuropsychology of Short-Term Memory	259
	Summary Statements	261
9	Encoding in Long-Term Memory	263
	Chapter Overview	264
	The Levels-of-Processing Approach	267
	<i>Intentional vs. Incidental Learning</i>	267
	<i>Evidence Supporting the Levels-of-Processing Approach</i>	269
	<i>The Status of the Levels-of-Processing Approach</i>	271
	<i>Distinctiveness</i>	272
	<i>Effort of Processing</i>	273
	<i>Elaborative Processing</i>	275
	<i>Retrieval Conditions Matter</i>	275
	Dimensions of Encoding	276
	<i>Historical Antecedents</i>	277
	<i>Learning and Practice</i>	277
	<i>The Spacing Effect</i>	278