

*Domjan and
Burkhard's*


 RD
EDITION

THE
PRINCIPLES
OF
LEARNING
AND
BEHAVIOR

*Revised by
Michael Domjan*



3RD
EDITION

Domjan and Burkhard's

The Principles of Learning and Behavior

Revised by Michael Domjan

University of Texas at Austin



*Brooks/Cole Publishing Company
Pacific Grove, California*



ITP™
The trademark ITP is used under license.

Brooks/Cole Publishing Company
A Division of Wadsworth, Inc.

© 1993, 1986, 1982 by Wadsworth, Inc., Belmont, California 94002.
All rights reserved. No part of this book may be reproduced, stored in a retrieval system, or transcribed, in any form or by any means—electronic, mechanical, photocopying, recording, or otherwise—without the prior written permission of the publisher, Brooks/Cole Publishing Company, Pacific Grove, California 93950, a division of Wadsworth, Inc.

Printed in the United States of America

10 9 8 7 6 5 4

Library of Congress Cataloging in Publication Data
Domjan, Michael, [date]

The principles of learning and behavior / Michael Domjan. — 3rd ed.
p. cm.

Includes bibliographical references and index.

ISBN 0-534-18912-1

1. Learning, Psychology of. 2. Conditioned response.
3. Behaviorism (Psychology) I. Title.

BF319.D65 1992

150.19'43—dc20

92-10828
CIP

Sponsoring Editor: *Vicki Knight*
Editorial Assistant: *Heather Graeve*
Production Editor: *Linda Loba*
Manuscript Editor: *Ann Mirels*
Permissions Editor: *Karen Wootten*
Interior Design: *E. Kelly Shoemaker*
Cover Design: *Katherine Minerva*
Art Coordinator: *Lisa Torri*
Photo Researcher: *Gail Meese*
Photo Coordinator: *Larry Molmud*
Typesetting: *Graphic World*
Cover printing: *Phoenix Color Corporation*
Printing and Binding: *R.R. Donnelley and Sons, Crawfordsville*

3RD
EDITION

Domjan and Burkhard's

*The Principles of
Learning and Behavior*

To Alice, Katherine, and Paul

Preface

Investigations of learning and behavior have been an integral part of the study of psychology throughout much of the twentieth century. In addition to providing important insights into the ways in which experience can lead to long-lasting changes in behavior, investigations of learning and behavior provide the behavioral technology for many allied fields, including behavioral neuroscience, developmental psychobiology, psychopharmacology, behavioral medicine, and behavioral toxicology. Studies of basic associative learning phenomena also provide the building blocks for some prominent theories of cognitive function. Thus, the study of learning is at the crossroads of many different approaches to investigating behavior.

The aim of the third edition of this book is the same as the aim of previous editions—to provide a lucid introduction to contemporary phenomena and theories about learning and behavior. The book strives to present a balanced perspective of the contemporary state of the field, rather than advocating a particular point of view. We attempt to point out the strengths and weaknesses of ideas in an even-handed fashion. As before, we have tried to emphasize the development of ideas instead of simply listing major findings. Although some contemporary ideas and phenomena cannot yet be fully integrated with previous findings, we have tried to provide an integrated approach wherever possible.

The order of chapters in the third edition is the same as it was in the second edition. Information is presented in increasing order of complexity, both within chapters and across chapters. The basic ideas presented at the beginning of each chapter serve as a foundation for material presented in subsequent chapters, with critical concepts repeated as they are needed. Technical terms are identified by bold-faced type the first time they appear, and definitions for them are provided in the Glossary.

Much has happened in the field of learning and behavior since 1985, when the previous edition of this book was prepared. The third edition presents new perspectives on old phenomena, as well as new phenomena and ideas that have become important in recent years. Numerous new examples of learning are provided in the revised text, many involving human subjects. In addition, we made a greater effort to use actual rather than hypothetical data in the illustrations.

Chapter 1 has been largely rewritten to include discussion of the roots of learning studies in questions dealing with comparative cognition, functional neurology, and animal models of human behavior. Chapter 1 also includes a more detailed discussion of methodological issues in the study of learning, as well as discussions of the use of animals in research and alternatives to animal research. Chapter 2 introduces the concept of a "modal action pattern" in place of "fixed action pattern" and includes numerous new human examples of habituation and sensitization. Chapter 3 includes new information about the origins of classical conditioning and a revised discussion of control procedures in classical conditioning. In Chapter 4, the discussion of the Rescorla/Wagner model has been expanded and its shortcomings better described. In addition, a number of new theories have been added to the chapter, including scalar expectancy theory, the comparator hypothesis, SOP, and AESOP. Chapter 5 includes an expanded discussion of response shaping and an expanded discussion of reinterpretations of the learned helplessness effect in terms other than learned helplessness theory. In Chapter 6, discussions of the matching law and of concurrent-chain schedules have been updated and expanded. Chapter 7 now includes a critical appraisal of the behavioral bliss point approach and an expanded discussion of optimal foraging within the context of behavioral regulation. In Chapter 8, much new information has been added about configural conditioning, contextual conditioning, and control of behavior by hierarchical relations among stimuli. In Chapter 9, the concept of predatory imminence, and related ideas, has been added. Chapter 10 includes a new section on contemporary studies of the associative structure of instrumental conditioning. In Chapter 11, the discussion of memory mechanisms is now organized around the concepts of acquisition and stimulus coding, retention and rehearsal, retrieval, and forgetting. In Chapter 12, new information has been added on serial pattern learning in simultaneous chains, perceptual concept learning, and language learning by nonhuman animals.*

I am grateful for the assistance of a number of individuals including Dr. Robert H. I. Dale, Butler University; Dr. Michael S. Fanselow, University of California, Los Angeles; Dr. Robert Ferguson, Buena Vista College; Dr. Nelson Freedman, Queen's University; Dr. Lewis R. Gollub, University of Maryland at College Park; Dr. Harry Strub, University of

*As before, the book is accompanied by a test bank.

Winnipeg; and Dr. Michael Zeiler, Emory University, who provided thoughtful reviews of the revision, and numerous others who also provided information and suggestions. I am also grateful to Vicki Knight for her editorial guidance and to Linda Loba for coordinating the production of the book.

Michael Domjan

Brief Contents

- 1** *Introduction* 1
- 2** *Elicited Behavior, Habituation, and Sensitization* 25
- 3** *Classical Conditioning: Foundations* 53
- 4** *Classical Conditioning: Mechanisms* 85
- 5** *Instrumental Conditioning: Foundations* 123
- 6** *Schedules of Reinforcement and Choice Behavior* 162
- 7** *Reinforcement: Theories and Experimental Analysis* 192
- 8** *Stimulus Control of Behavior* 221
- 9** *Aversive Control: Avoidance and Punishment* 260
- 10** *Classical-Instrumental Interactions and the Associative Structure of Instrumental Conditioning* 295
- 11** *Animal Cognition: Memory Mechanisms* 322
- 12** *Complex Animal Cognition* 358

Contents

1

Introduction

1

Historical Antecedents 3

Historical Developments in the Study of the Mind 4

Historical Developments in the Study of Reflexes 6

The Dawn of the Modern Era 7

Comparative Cognition and the Evolution of Intelligence 8

Functional Neurology 9

Animal Models of Human Behavior 10

The Definition of Learning 12

The Learning-Performance Distinction 13

Distinction Between Learning and Other Sources of
Behavior Change 14

Methodological Aspects of the Study of Learning 15

Learning as an Experimental Science 15

The General-Process Approach to the Study of Learning 16

The Use of Animals in Research on Learning 19

Rationale for the Use of Animals in Research on Learning 19

Laboratory Animals and Normal Behavior 20

Public Debate About Animal Research 21

2

Elicited Behavior, Habituation, and Sensitization

25

The Nature of Elicited Behavior 26

The Concept of the Reflex 26

The Modal Action Pattern 29

The Nature of Response-Eliciting Stimuli 30

The Role of Feedback in Elicited Behavior 31

Effects of Repeated Stimulation: Two Examples 34

Visual Attention in Human Infants 35

Startle Response in Rats 36

The Concepts of Habituation and Sensitization 37

Adaptiveness and Pervasiveness of Habituation and Sensitization	37
Distinctions Between Habituation, Sensory Adaptation, and Response Fatigue	38
A Dual-Process Theory of Habituation and Sensitization	39
<i>Characteristics of Habituation and Sensitization</i>	42
Time Course of Habituation and Sensitization	42
Stimulus Specificity of Habituation and Sensitization	44
Effects of Strong Extraneous Stimuli	46
Effects of Stimulus Intensity and Frequency	46
<i>Changes in Complex Emotional Responses</i>	47
The Opponent-Process Theory of Motivation	47
Mechanisms of the Opponent-Process Theory	48
Examples of Opponent Processes	50
<i>Concluding Comments</i>	52

3

Classical Conditioning: Foundations

53

<i>Pavlov and the Early Years of Classical Conditioning</i>	54
<i>The Classical Conditioning Paradigm</i>	57
<i>Experimental Situations</i>	57
Sign Tracking	57
Fear Conditioning	59
Eyeblink Conditioning of Rabbits	61
Taste-Aversion Learning	62
<i>Excitatory Pavlovian Conditioning</i>	64
Excitatory Conditioning Procedures	64
Measurement of the Conditioned Response	65
Control Procedures in Classical Conditioning	66
Effectiveness of Excitatory Conditioning Procedures	67
<i>Contiguity and Signal Relations Between Conditioned and Unconditioned Stimuli</i>	69
Examples of Signal Relations	69
<i>Inhibitory Pavlovian Conditioning</i>	70
Procedures for Inhibitory Conditioning	71
Measuring Conditioned Inhibition	73
<i>Extinction</i>	76
Extinction and Habituation	76
The Learning Involved in Extinction	77
<i>Applications of Classical Conditioning</i>	78
Digestion	78
Control of Pain Sensitivity	79
Control of Disease Resistance	79
Acquired Food Preferences and Aversions in People	80
Alcohol-Aversion Therapy	81
Infant and Maternal Responses Involved in Nursing	82
Conditioning of Sexual Behavior	82
<i>Concluding Comments</i>	83

4	<p><i>Classical Conditioning: Mechanisms</i> 85</p> <p><i>What Makes Effective Conditioned and Unconditioned Stimuli?</i> 86</p> <p style="padding-left: 2em;">Initial Response to the Stimuli 86</p> <p style="padding-left: 2em;">The Novelty of Conditioned and Unconditioned Stimuli 86</p> <p style="padding-left: 2em;">CS and US Intensity 87</p> <p style="padding-left: 2em;">CS-US Relevance, or Belongingness 88</p> <p style="padding-left: 2em;">The Concept of Biological Strength 91</p> <p><i>What Determines the Nature of the Conditioned Response?</i> 94</p> <p style="padding-left: 2em;">The Stimulus-Substitution Model 94</p> <p style="padding-left: 2em;">The Compensatory-Response Model 99</p> <p style="padding-left: 2em;">The CS as a Determinant of the Form of the CR 103</p> <p style="padding-left: 2em;">The Behavior Systems Approach 104</p> <p style="padding-left: 2em;">A Functional/Adaptive Approach to the CR 106</p> <p><i>How Do Conditioned and Unconditioned Stimuli Become Associated?</i> 107</p> <p style="padding-left: 2em;">The Blocking Effect 108</p> <p style="padding-left: 2em;">The Rescorla-Wagner Model 109</p> <p style="padding-left: 2em;">Other Models of Classical Conditioning 115</p> <p><i>Concluding Comments</i> 121</p>
5	<p><i>Instrumental Conditioning: Foundations</i> 123</p> <p><i>Early Investigations of Instrumental Conditioning</i> 125</p> <p><i>Modern Approaches to the Study of Instrumental Conditioning</i> 126</p> <p style="padding-left: 2em;">Discrete-Trial Methods 126</p> <p style="padding-left: 2em;">Free-Operant Methods 128</p> <p><i>Instrumental Conditioning Procedures</i> 136</p> <p style="padding-left: 2em;">Positive Reinforcement 136</p> <p style="padding-left: 2em;">Punishment 137</p> <p style="padding-left: 2em;">Negative Reinforcement 137</p> <p style="padding-left: 2em;">Omission Training 138</p> <p style="padding-left: 2em;">A Final Note on Terminology 138</p> <p><i>Fundamental Elements of Instrumental Conditioning</i> 139</p> <p style="padding-left: 2em;">The Instrumental Response 139</p> <p style="padding-left: 2em;">The Instrumental Reinforcer 145</p> <p style="padding-left: 2em;">The Response-Reinforcer Relation 148</p> <p><i>Concluding Comments</i> 161</p>
6	<p><i>Schedules of Reinforcement and Choice Behavior</i> 162</p> <p><i>Simple Schedules of Intermittent Reinforcement</i> 164</p> <p style="padding-left: 2em;">Ratio Schedules 164</p> <p style="padding-left: 2em;">Interval Schedules 165</p> <p style="padding-left: 2em;">Comparison of Ratio and Interval Schedules 167</p> <p><i>Response-Rate Schedules of Reinforcement</i> 170</p> <p><i>Extinction</i> 172</p> <p style="padding-left: 2em;">Effects of Extinction Procedures 172</p> <p style="padding-left: 2em;">Determinants of Extinction Effects 173</p>

Mechanisms of the Partial-Reinforcement Extinction Effect 174
Concurrent Schedules: The Study of Choice 176
 Measures of Choice Behavior 177
 The Matching Law 178
 Mechanisms of the Matching Law 181
Concurrent-Chain Schedules: The Study of Complex Choice 186
Concluding Comments 191

7

Reinforcement: Theories and Experimental Analysis 192

Fundamental Issues in Reinforcement Theory 193
Reinforcement as Stimulus Presentation 194
 Physiological Homeostasis and Drive Reduction 195
 Primary Motivation and Incentive Motivation 195
 Sensory Reinforcement 196
 Brain-Stimulation Reinforcement and Motivation 196
Reinforcement as Behavioral Regulation 197
 The Precursors of Behavioral Regulation Theories 198
 Premack's Theory of Reinforcement 198
 The Response-Deprivation Hypothesis 203
 Behavioral Bliss Points and Behavioral Regulation 204
 Economic Concepts and Response Allocation 210
 Optimal Foraging Theory and Behavioral Regulation 214
Concluding Comments 219

8

Stimulus Control of Behavior 221

Differential Responding and Stimulus Discrimination 223
 Stimulus Generalization 225
 Stimulus Generalization Gradients as a Measure of
 Stimulus Control 225
 Effects of Sensory Capacity and Orientation on
 Stimulus Control 226
 Effects of Experience on Stimulus Control 227
What Is Learned in Discrimination Training? 236
 Spence's Theory of Discrimination Learning 237
 Errorless Discrimination Training 239
 Effects of Intradimensional Discrimination Training 240
Control of Behavior by Compound Stimuli 245
 Relative Effectiveness of Stimulus Elements as Signals
 for Reinforcement 246
 Effects of Type of Reinforcement on Stimulus Control 247
 Effects of Type of Instrumental Response on Stimulus Control 249
 Effects of Relative Ease of Conditioning Various Stimuli 250
 Theoretical Approaches to the Control of Behavior by
 Compound Stimuli 251
Control of Instrumental Behavior by Contextual Cues 253

<i>Control of Behavior by Conditional, or Hierarchical, Relations</i>	254
<i>Concluding Comments</i>	259

9 *Aversive Control: Avoidance and Punishment* 260

<i>Avoidance Behavior</i>	261
Origins of the Study of Avoidance Behavior	262
The Discriminated Avoidance Procedure	263
The Two-Process Theory of Avoidance	264
Experimental Analysis of Avoidance Behavior	266
Alternative Theoretical Accounts of Avoidance Behavior	275
The Avoidance Puzzle: Concluding Comments	282
<i>Punishment</i>	282
Experimental Analysis of Punishment	283
Theories of Punishment	290
Punishment Outside the Laboratory	294

10 *Classical–Instrumental Interactions and the Associative Structure of Instrumental Conditioning* 295

<i>The Role of Instrumental Reinforcement in Classical Conditioning Procedures</i>	296
The Omission Control Procedure	297
Conditioned Response Modifications of the US	299
<i>The Role of Classical Conditioning in Instrumental Conditioning Procedures</i>	300
The r_g - s_g Mechanism	301
Concurrent Measurement of Instrumental Behavior and Classically Conditioned Responses	303
Modern Two-Process Theory	305
Response Interactions in the Effects of Classically Conditioned Stimuli on Instrumental Behavior	309
Discriminative Stimulus Properties of Classically Conditioned States	310
Conditioned Central Emotional States or Reward-Specific Expectancies?	314
<i>The Associative Structure of Instrumental Conditioning</i>	315
A Summary of Two-Process Approaches	315
Contemporary Approaches to the Associative Structure of Instrumental Conditioning	316
<i>Concluding Comments</i>	320

11 *Animal Cognition: Memory Mechanisms* 322

<i>What is Animal Cognition?</i>	323
<i>Animal Memory Paradigms</i>	324

Working and Reference Memory 326
 Delayed Matching to Sample 327
 Spatial Memory in a Radial Maze 334
 Spatial Memory in Food-Storing Birds 337
Memory Mechanisms 340
 Acquisition and the Problem of Stimulus Coding 340
 Retention and the Problem of Rehearsal 344
 Retrieval 346
Forgetting 350
 Proactive and Retroactive Interference 351
 Retrograde Amnesia 353
Concluding Comments 357

12

Complex Animal Cognition

358

Timing and Counting 359
 Techniques for the Measurement of Timing Behavior 359
 Characteristics of the Internal Clock 361
 A Model of Timing 362
 The Relation Between Timing and Counting 364
Serial Pattern Learning 364
 Possible Bases of Serial Pattern Behavior 365
 Serial Pattern Behavior with Simultaneous Stimulus Arrays 366
 Effects of the Structure of Serial Patterns 368
Perceptual Concept Learning 370
 Generalization to Novel Exemplars 371
 Concept Training and Pseudoconcept Training Compared 372
 Discrimination Between Perceptual Categories 373
 Development of Conceptual Errors 374
 Mechanisms of Perceptual Concept Learning 376
Inferential and Analogical Reasoning 377
 Transitive Inferential Reasoning 378
 Analogical Reasoning 379
Teaching Language to Chimpanzees 382
 A Comparison of Training Procedures 385
 Features of Language Competence in Chimpanzees 387

Glossary 392
References 406
Name Index 447
Subject Index 455

1

Introduction

Historical Antecedents

- Historical Developments in the Study of the Mind
- Historical Developments in the Study of Reflexes

The Dawn of the Modern Era

- Comparative Cognition and the Evolution of Intelligence
- Functional Neurology
- Animal Models of Human Behavior

The Definition of Learning

- The Learning–Performance Distinction
- Distinction Between Learning and Other Sources of Behavior Change

Methodological Aspects of the Study of Learning

- Learning as an Experimental Science
- The General-Process Approach to the Study of Learning

The Use of Animals in Research on Learning

- Rationale for the Use of Animals in Research on Learning
- Laboratory Animals and Normal Behavior
- Public Debate About Animal Research

The goal of this chapter is to introduce the reader to the study of learning and behavior. We begin by discussing key concepts in the study of learning from a historical standpoint, including a description of the origins of experimental research in the area. These origins lie in studies of the evolution of intelligence, functional neurology, and animal models of human behavior. The defining characteristics of learning will be described next, followed by a discussion of methodological approaches to the study of learning. Because numerous experiments on learning have been performed with animal subjects, we will conclude the chapter by considering the pros and cons of using animals in research.

People have always been interested in understanding behavior, be it their own or the behavior of others. This interest is more than idle curiosity. How we live our lives is largely governed by our own actions and the actions of others. Whether you were admitted to the college of your choice depended mainly on your prior scholastic record and the decisions of an admissions officer. Whether you get along well with your roommates depends on how accommodating you are and on what they do that you find irritating. Whether you get to school on time depends on how crowded the roads are and how well you manage to navigate the traffic.

Any systematic effort to understand behavior must include consideration of what we learn and how we learn it. Numerous aspects of both human and animal behavior are the products of learning. We learn to read, to write, and to count. We learn how to walk down stairs without falling, how to open doors, how to ride bicycles, and how to swim. We also learn when to relax and when to become anxious. We learn what foods are good for us and what will make us sick. We learn who will be fun to visit with and whose company to avoid. We learn how to tell when someone is unhappy and when that person feels fine. We learn when to carry an umbrella and when to take an extra scarf. Life is filled with activities and experiences that are shaped by what we have learned.

Learning is one of the biological processes that are crucial for the survival of many forms of animal life. The integrity of life depends on a variety of biological functions. Animals have to take in nutrients, eliminate metabolic wastes, and otherwise maintain proper balance in internal functions. Through evolution, a variety of biological systems have emerged to accomplish these tasks. Many of these systems are primarily physiological, such as the respiratory, digestive, and excretory systems. However, finely tuned internal physiological processes are often not enough to maintain the integrity of life. Animals and

people live in environments that are constantly changing because of climatic changes, changes in food resources, the coming and going of predators, and other external factors. Adverse effects of environmental change often have to be minimized by behavioral adjustments. Animals have to know, for example, how to find and obtain food as food sources change, avoid predators as new ones enter their territory, and find new shelter when storms destroy their old homes. Accomplishing these tasks obviously requires motor movements, such as walking and manipulating objects. These tasks also require the ability to predict important events in the environment, such as the availability of food in a particular location and at a particular time. Acquisition of new motor behavior and new anticipatory reactions involves learning. Thus, animals learn to go to a new water hole when the old one dries up and learn new anticipatory reactions when new sources of danger appear. These learned adjustments to the environment are no less important for survival than internal physiological processes such as respiration and digestion.

Most people automatically associate learning with the acquisition of new behavior. That is, they identify learning by the gradual appearance of a new response in the organism's repertoire. This is the case when people learn to read, ride a bicycle, or play a musical instrument. However, the behavior change involved in learning can just as well consist of the decrease or loss of some behavior in the organism's repertoire. A child, for example, may learn not to cross the street when the traffic light is red, not to grab food from someone else's plate, and not to yell and scream when someone is trying to take a nap. Learning to withhold responses is just as important as learning to make responses, if not more so.

When considering learning, people commonly focus on the kinds of learning that require special training—the kinds of learning that take place in public schools and colleges,