

BRAIN & BEHAVIOR

An Introduction to Biological Psychology

SECOND EDITION



Bob Garrett

BRAIN & BEHAVIOR

An Introduction to Biological Psychology

SECOND EDITION

Bob Garrett

Visiting Research Scholar
California Polytechnic State University, San Luis Obispo



Los Angeles • London • New Delhi • Singapore

Copyright © 2009 by SAGE Publications, Inc.

All rights reserved. No part of this book may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher.

For information:



SAGE Publications, Inc.
2455 Teller Road
Thousand Oaks, California 91320
E-mail: order@sagepub.com

SAGE Publications Ltd.
1 Oliver's Yard
55 City Road
London EC1Y 1SP
United Kingdom

SAGE Publications India Pvt. Ltd.
B 1/1 Mohan Cooperative Industrial Area
Mathura Road, New Delhi 110 044
India

SAGE Publications Asia-Pacific Pte. Ltd.
33 Pekin Street #02-01
Far East Square
Singapore 048763

Printed in Canada

Library of Congress Cataloging-in-Publication Data

Garrett, Bob.
Brain and behavior : an introduction to biopsychology / Bob Garrett. — 2nd ed.
p. cm.
Includes bibliographical references and index.
ISBN 978-1-4129-6100-4 (pbk.)
1. Psychobiology—Textbooks. I. Title.

QP360.G375 2008

612.8—dc22

2007044492

Printed on acid-free paper

08 09 10 11 12 10 9 8 7 6 5 4 3 2 1

<i>Acquiring Editor:</i>	Vicki Knight
<i>Associate Editor:</i>	Deya Saoud
<i>Editorial Assistant:</i>	Lara Grambling
<i>Production Editor:</i>	Sarah K. Quesenberry
<i>Copy Editor:</i>	QuADS Prepress (P) Ltd.
<i>Typesetter:</i>	C&M Digitals (P) Ltd.
<i>Illustrator:</i>	Barry Burns
<i>Cover Designer:</i>	Gail A. Buschman
<i>Production Artist:</i>	Janet E. Foulger
<i>Marketing Manager:</i>	Stephanie Adams

Preface

A Message From the Author

A benefit of growing up poor was that I learned the value of an education. And it did not take long to discover that the real value of education is not just a ticket to a better job but all the learning along the way about life and the world and what makes both of them work. That is what led me, after trying one major after another, to discover psychology.

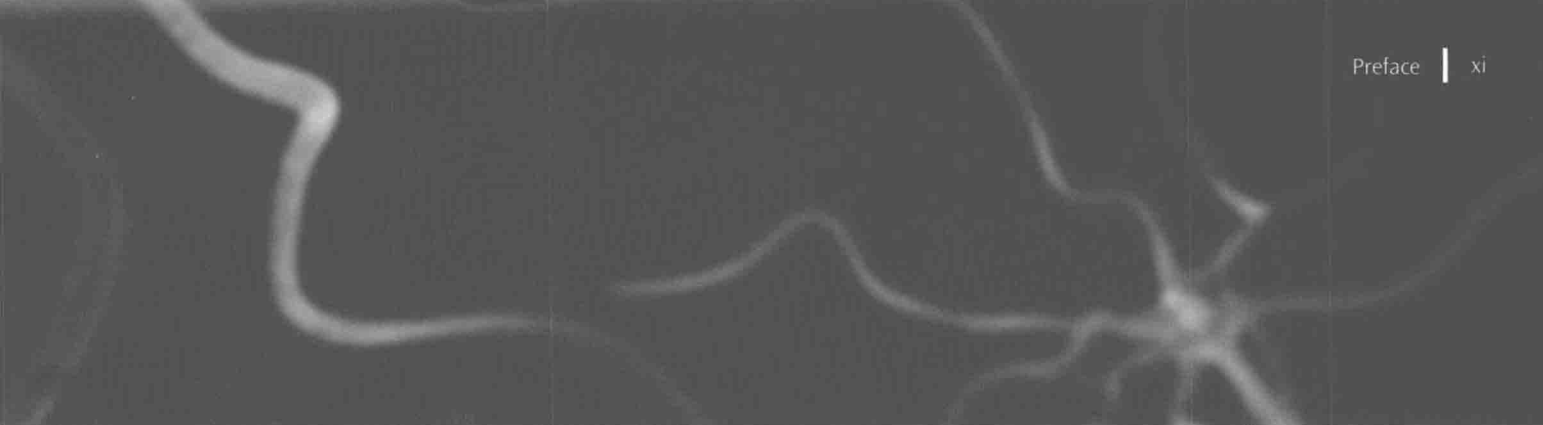
A child of Sputnik and enamored with science, I was especially attracted by the young and promising discipline of biological psychology. And as I pursued that promise, I was attracted to another—sharing my enthusiasm through teaching. For many years, I taught at DePauw University, where practically every student does two or three internships and the value of research is judged by what students learn from working alongside their mentors; similarly, the guiding principle at my current university, Cal Poly, San Luis Obispo, is that students should “learn by doing.” I believe in knowledge for its own sake, but I value knowledge that is useful even more. Perhaps that is why I needed to write *Brain and Behavior*; it is my testimonial to the usefulness of scientific knowledge.

Now that the second edition is done, I can look forward to more leisurely ways of spending my time: beach walks and tennis with my wife, hiking the hillsides near our home, and watching our grandchildren grow. But you can be sure I’ll be watching out of the corner of my eye to see whether students are enjoying what I have written and whether they are experiencing the same thrill of discovery I had when I was their age.

To the Instructor

When I first wrote *Brain and Behavior*, I had one goal, to entice students into the adventure of biological psychology. There are other good texts out there, but they read like they were written for serious junior and senior psychology majors who appreciate the importance of biological psychology in its own right. This book is for them, too, but I wrote it so any student who is interested in behavior, including the newly declared sophomore major or the curious student who has wandered over from the history department, could have the deeper understanding that comes from a biological perspective as they take other courses in psychology.

It is not enough to draw students in with lively writing or by piquing their interest with case studies and telling an occasional story along the way; unless they feel they are learning something significant, they won’t stay—they’ll look for excitement in more traditional places. As I wrote, I remembered the text I struggled with in my first biopsychology class; it wasn’t very interesting because we knew much less about the biological underpinnings of behavior than we do now. Since that time, we have learned how the brain changes during learning, we have discovered some of the genes and brain deficiencies that cause schizophrenia, and we are beginning to understand how intricate networks of brain cells produce language, make us intelligent, and help us play the piano or find a mate. In other words, biopsychology has become a lot more interesting. So the material is there; now it is my job to communicate the excitement I have felt in discovering the secrets of the brain and to make a convincing case that biopsychology has the power to answer the questions *students* have about behavior.



A good textbook is all about teaching, but there is no teaching if there is no learning. Over the years, my students taught me a great deal about what they needed to help them learn. For one thing, I realized how important it is for students to build on their knowledge throughout the course, so I made several changes from the organization I saw in other texts. First, the chapter on neuronal physiology precedes the chapter on the nervous system, because I believe that you cannot understand how the brain works unless you know how its neurons work. And I reversed the usual order of the vision and audition chapters, because I came to understand that audition provides a friendlier context for introducing the basic principles of sensation and perception. The chapters on addiction, motivation, emotion, and sex follow the introduction to neurophysiology; this was done to build student motivation before tackling sensation and perception. Perhaps more significantly, some topics have been moved around among chapters so they can be developed in a more behaviorally meaningful context. So language is discussed along with audition, the body senses with the mechanisms of movement, the sense of taste in the context of feeding behavior, and olfaction in conjunction with sexual behavior. Most unique, though, is the inclusion of a chapter on the biology of intelligence and another on consciousness. The latter is a full treatment of recent developments in the field, rather than limited to the usual topics of sleep and split-brain behavior. These two chapters strongly reinforce the theme that biopsychology is personally relevant and capable of addressing important questions.

Brain and Behavior has several features that will motivate students to learn and encourage them to take an active role in their learning. It engages the student with interest-grabbing opening vignettes, illustrative case studies, and In the News items and Application boxes that take an intriguing step beyond the chapter content. Throughout each chapter, questions in the margins keep the student focused on key points, a Concept Check at the end of each section serves as a reminder of the important ideas, and On the Web icons point the way to related information on the Internet. At the end of the chapter, In Perspective emphasizes the importance and implications of what the student has just read, a summary helps organize that information, and Testing Your Understanding assesses the student's conceptual understanding as well as factual knowledge. Then, For Further Reading is a guide for students who want to explore the chapter's topics more fully. I have found over the years that students who use the study aids in a class are also the best performers in the course.

New in the Second Edition

As you would expect, the second edition of *Brain and Behavior* includes a number of changes. Foremost, and reflecting the rapid advances in biological psychology and neuroscience, this edition contains 500 new references. More than 60 illustrations have been added, and 25 others were significantly revised to increase their informational and educational value. In addition, new tables have been added where there was a need to organize or summarize complex material. In addition, most of the In the News and Application features have been either replaced or updated with more recent information. The material on research techniques that

was previously in the appendix has been expanded and combined with two topics from the first edition's introductory chapter, Science, Research, and Theory and Research Ethics, to form the new chapter "The Methods and Ethics of Research." This provides research methodology the emphasis it deserves while giving the introductory chapter a sharper focus.

The new edition continues its theme of showcasing our rapidly increasing understanding of genetic influences on behavior with discussions of numerous recent findings, particularly with regard to obesity, hostility and aggression, Parkinson's disease, Alzheimer's disease, autism, and schizophrenia. Another theme that has been strengthened is the broader societal relevance of biopsychology, from the ethical implications of stem cell research to the cost of addictions and disorders, to new strategies for treating brain and spinal cord damage.

To the Student

Brain and Behavior is my attempt to reach out to students, to open a door and beckon them inside to experience the fascinating world of biological psychology. These are exceptionally exciting times, comparable in many ways to the renaissance that thrust Europe from the Middle Ages into the modern world. In Chapter 1, I quote Kay Jamison's comparison of neuroscience, which includes biopsychology, to a "romantic, moon-walk sense of exploration." I know of no scientific discipline with greater potential to answer the burning questions about ourselves than neuroscience in general and biopsychology in particular. I hope this textbook will convey that kind of excitement as you read about discoveries that will revolutionize our understanding of what it means to be human.

I want you to succeed in this course, but, more than that, I want you to learn more than you ever imagined you could and to go away with a new appreciation of the promise of biological psychology. So now I'm going to start sounding like a parent. I want you to sit near the front of the class, because those students usually get the best grades. That is probably because they stay more engaged and ask more questions; but to ask good questions you should *always* read the text assignment before you go to class. And so you'll know where you're going before you begin to read, take a look at "In this chapter you will learn," then skim the chapter subheadings, and read the summary. Use the questions in the margins as you go through, answer the Concept Check questions, and be sure to test yourself at the end. Computer icons like the one you see here will tell you which figures have been animated on the text's Web site to help sharpen your understanding, and numbered WWW icons in the margins will direct you to a wealth of additional information on the web. Then don't forget to look up some of the books and articles in For Further Reading. If you do all of these things you won't just do better in this course; you will leave saying, "I really got something out of that class!"

I wrote *Brain and Behavior* with you in mind, so I hope you will let me know where I have done things right and, especially, where I have not (bgarrett@calpoly.edu.) I wish you the satisfaction of discovery and knowledge as you read what I have written *for you*.



Supplemental Material

Student Study Guide

This affordable student study guide and workbook to accompany Bob Garrett's *Brain and Behavior, Second Edition* will help students get the added review and practice they need to improve their skills and master their course. Each part of the study guide corresponds to the appropriate chapter in the text and includes the following: chapter outline, chapter summary, study quiz, and a chapter posttest.

Student Study Site

This free student study site provides additional support to students using *Brain and Behavior, Second Edition*. The Web site includes e-flashcards, study quizzes (students can receive their score immediately), relevant SAGE journal articles with critical thinking questions, and relevant Internet resources. Also included are animations of key figures in the text. Visit the study site at www.sagepub.com/garrettbb2study.

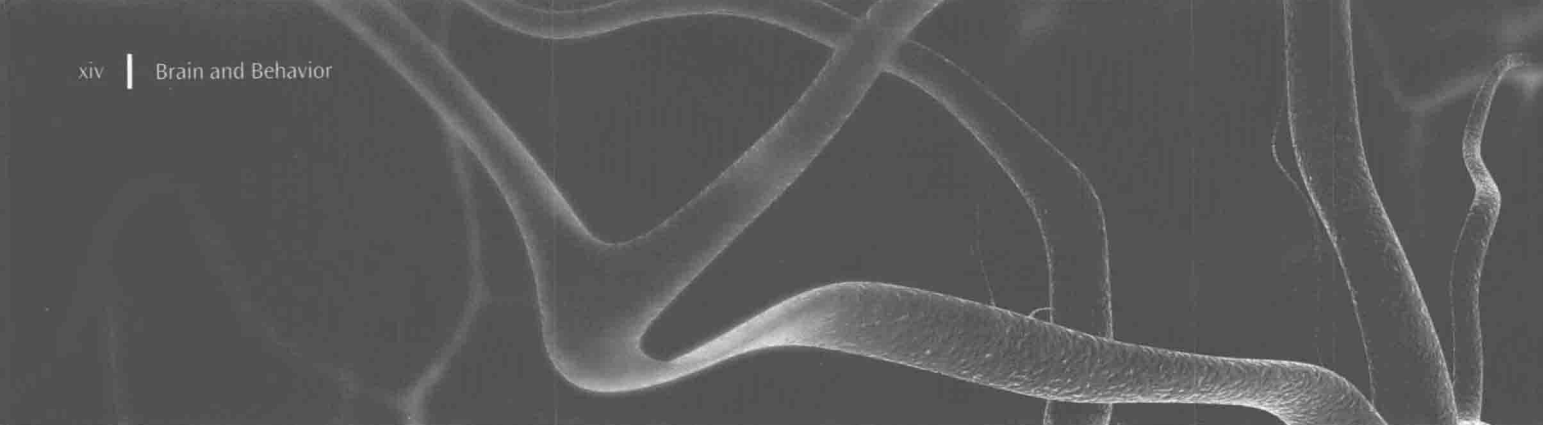
Instructor's Resources on CD-ROM

This set of instructor's resources provides a number of helpful teaching aids for professors new to teaching biological psychology and to using *Brain and Behavior, Second Edition*. Included on the CD-ROM are PowerPoint slides, a computerized test bank to allow for easy creation of exams, lecture outlines, suggested class activities and critical thinking questions, and video and Internet resources for each chapter of the text.

Acknowledgments

I have had a number of mentors along the way, to whom I am forever grateful. A few of those special people are Wayne Kilgore, who taught the joys of science along with high school chemistry and physics; Garvin McCain, who introduced me to the satisfactions of research; Roger Kirk, who taught me that anything worth doing is worth doing over and over until it's right; and Ellen Royce and Ouida Piner, who shared their love of language. These dedicated teachers showed me that learning was my responsibility, and they shaped my life with their unique gifts and quiet enthusiasm.

My most important supporter has been my wife, Duejean; love and thanks to her for her patient understanding and her appreciation of how important this project is to me. And then, applause all around for Cheri Delello, Stephanie Adams, Deya Saoud, Lara Grambling, and Ravi Balasuriya, whose competence and professionalism convinced me that Sage is "the natural home for authors"; and a special thanks to Sarah Quesenberry for her patient and tireless work as project editor, to Kate Barnes for her exemplary developmental editing, to Marcy Lunetta and Sara van Valkenburg for their work on permissions and photos, to Eric Shrader for photo research, to Robert Stufflebeam for animations, and to Barry Burns for artwork.



But most of all, thanks to Vicki Knight, editor for both editions and the guiding force behind *Brain and Behavior*. Then, my gratitude to DePauw University for the sabbatical leave that started this whole project and to Cal Poly for all the resources it has so generously provided.

I would like to extend heartfelt kudos to the talented and forbearing supplement authors: Susan Fortenbury, University of Missouri-St. Louis: PowerPoint slides; Heather Patisaul, North Carolina State University: Instructor's Resources; Brady Phelps, South Dakota State University: Test Bank and Study Quizzes; and Sheila Steiner, Jamestown College: Student Study Guide.

In addition, the following reviewers gave generously of their time and expertise throughout the development of this text, and contributed immensely to the quality of *Brain and Behavior*:

First Edition: Susan Anderson, University of South Alabama; Patrizia Curran, University of Massachusetts–Dartmouth; Lloyd Dawe, Cameron University; Tami Eggleston, McKendree College; James Hunsicker, Southwestern Oklahoma State University; Eric Laws, Longwood College; Margaret Letterman, Eastern Connecticut State University; Doug Matthews, University of Memphis; Grant McLaren, Edinboro University of Pennsylvania; Rob Mowrer, Angelo State University; Anna Napoli, University of Redlands; Robert Patterson, Washington State University; Joseph Porter, Virginia Commonwealth University; Jeffrey Stern, University of Michigan–Dearborn; Aurora Torres, University of Alabama in Huntsville; Michael Woodruff, East Tennessee State University; and Phil Zeigler, Hunter College.

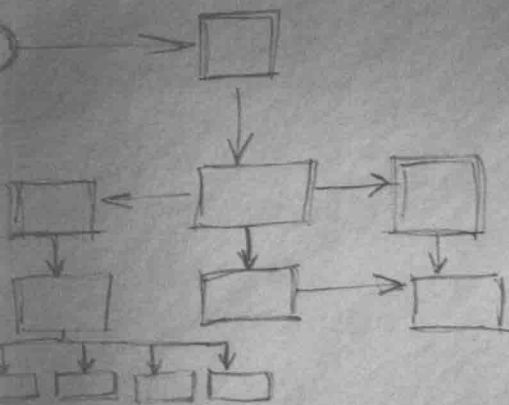
Second Edition: M. Todd Allen, University of Northern Colorado; Patricia A. Bach, Illinois Institute of Technology; Wayne Brake, UC Santa Barbara; Steven I. Dworkin, University of North Carolina; Sean Laraway, San Jose State University; Mindy J. Miserendino, Sacred Heart University; Brady Phelps, South Dakota State University; Susan A. Todd, Bridgewater State College; and Elizabeth Walter, University of Oregon.

—Bob Garrett

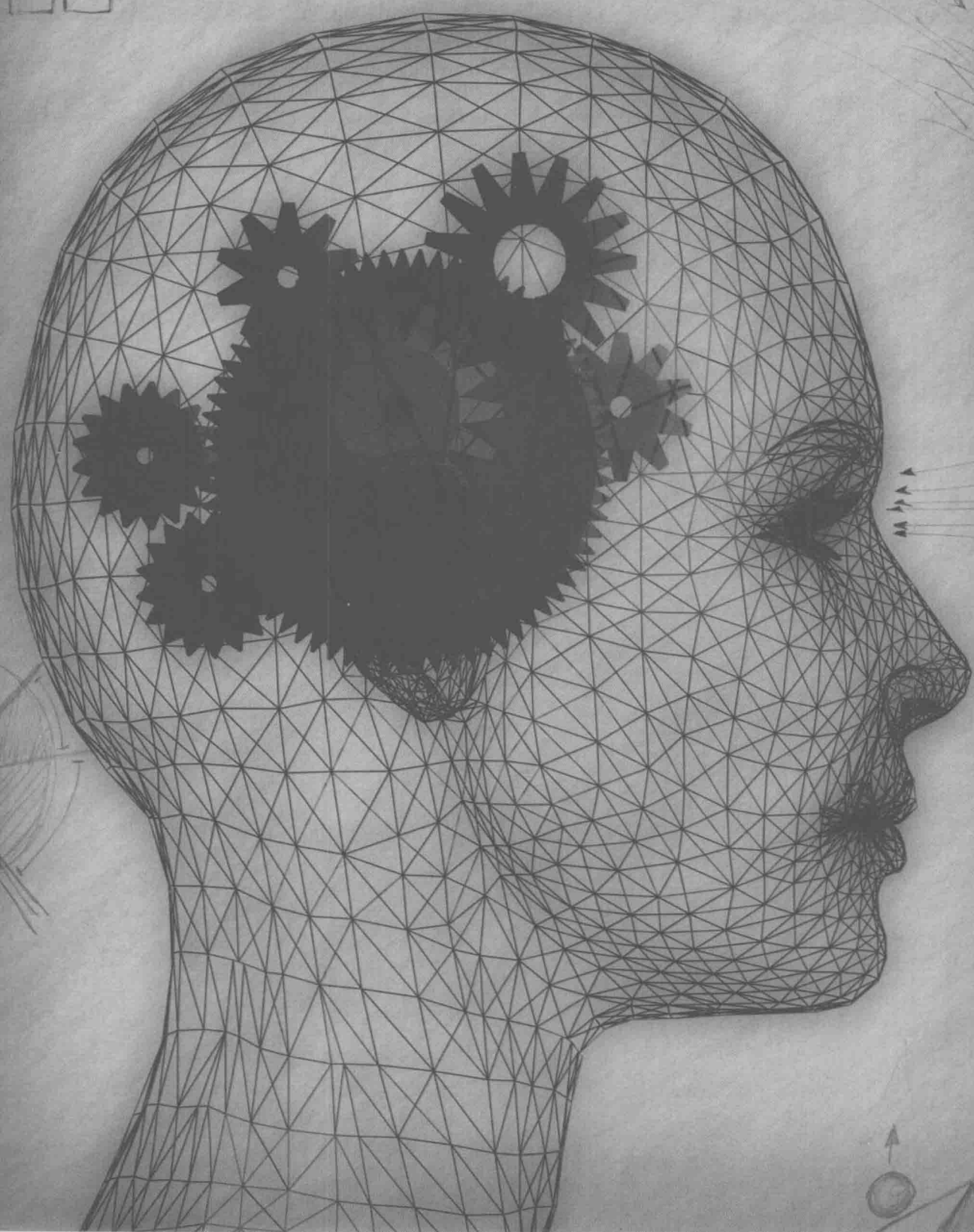
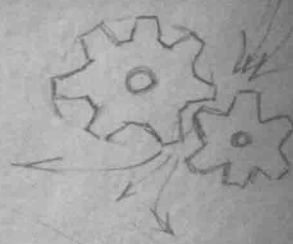
About the Author



Bob Garrett is currently a visiting research scholar at California Polytechnic State University, San Luis Obispo. He was Professor of Psychology at DePauw University in Greencastle, Indiana, and held several positions there, including Chairperson of the Department of Psychology, Faculty Development Coordinator, and Interim Dean of Academic Affairs. He received his BA from the University of Texas at Arlington and his MA and PhD from Baylor University.



philosophy





Brief Contents

Chapter 1. What Is Biopsychology? 1

PART I.

NEURAL FOUNDATIONS OF BEHAVIOR: THE BASIC EQUIPMENT

Chapter 2. Communication Within the Nervous System 23

Chapter 3. The Functions of the Nervous System 51

Chapter 4. The Methods and Ethics of Research 87

PART II.

MOTIVATION AND EMOTION: WHAT MAKES US GO

Chapter 5. Drugs, Addiction, and Reward 123

Chapter 6. Motivation and the Regulation of Internal States 155

Chapter 7. The Biology of Sex and Gender 189

Chapter 8. Emotion and Health 225

PART III.

INTERACTING WITH THE WORLD

Chapter 9. Hearing and Language 255

Chapter 10. Vision and Visual Perception 293

Chapter 11. The Body Senses and Movement 329

PART IV.

COMPLEX BEHAVIOR

Chapter 12. Learning and Memory 363

Chapter 13. Intelligence and Cognitive Functioning 393

Chapter 14. Psychological Disorders 427

Chapter 15. Sleep and Consciousness 465

Glossary 504

References 513

Chapter-Opening Photo Credits 559

Author Index 560

Subject Index 584

Detailed Contents

Preface x

About the Author xv

Chapter 1. What Is Biopsychology? 1

The Origins of Biopsychology 3

Prescientific Psychology and the

Mind-Brain Problem 3

Descartes and the Physical Model of Behavior 4

Helmholtz and the Electrical Brain 6

The Localization Issue 6

Nature and Nurture 9

The Genetic Code 9

IN THE NEWS: DNA'S ROLE IN COMPUTER EVOLUTION 11

Genes and Behavior 11

The Human Genome Project 12

Heredity: Destiny or Predisposition? 13

PART I. NEURAL FOUNDATIONS OF BEHAVIOR: THE BASIC EQUIPMENT

Chapter 2. Communication Within the Nervous System 23

The Cells That Make Us Who We Are 24

Neurons 24

APPLICATION: TARGETING ION CHANNELS 31

Glial Cells 32

How Neurons Communicate With Each Other 34

Chemical Transmission at the Synapse 34

Regulating Synaptic Activity 40

Neurotransmitters 41

APPLICATION: AGONISTS AND ANTAGONISTS IN THE REAL WORLD 43

Computer Models and Neural Networks 43

Chapter 3. The Functions of the Nervous System 51

The Central Nervous System 52

The Forebrain 53

APPLICATION: THE CASE OF PHINEAS GAGE 59

The Midbrain and Hindbrain 63

The Spinal Cord 65

Protecting the Central Nervous System 66

The Peripheral Nervous System 68

The Cranial Nerves 68

The Autonomic Nervous System 68

Development and Change in the Nervous System 71

The Stages of Development 71

How Experience Modifies the Nervous System 75

*Damage and Recovery in the Central Nervous
System 76*

IN THE NEWS: BRAIN PROSTHESIS PASSES LIVE TISSUE TEST 78

Chapter 4. The Methods and Ethics of Research 87

Science, Research, and Theory 88

Theory and Tentativeness in Science 89

Experiments Versus Correlational Studies 89

Research Techniques 91

Staining and Imaging Neurons 91

Light and Electron Microscopy 95

Measuring and Manipulating Brain Activity 96

APPLICATION: BRAIN IMPLANTS THAT MOVE 101

Brain Imaging Techniques 101

IN THE NEWS: SCANNING KING TUT 103

Investigating Heredity 105

Research Ethics 109

Plagiarism and Fabrication 109

Protecting the Welfare of Research Participants 110

Gene Therapy 112

Stem Cell Therapy 113

IN THE NEWS: GENE DOPING AND SPORTS 114

PART II. MOTIVATION AND EMOTION: WHAT MAKES US GO

Chapter 5. Drugs, Addiction, and Reward 123

Psychoactive Drugs 124

- Opiates* 125
- Depressants* 126
- Stimulants* 129
- Psychedelics* 133
- Marijuana* 134

IN THE NEWS: CONTROVERSY OVER MEDICAL MARIJUANA HEATS UP 136

Addiction 136

- The Neural Basis of Addiction* 137
- Dopamine and Reward* 137
- Other Roles for Dopamine* 139

APPLICATION: IS COMPULSIVE GAMBLING AN ADDICTION? 141

- Treating Drug Addiction* 142

The Role of Genes in Addiction 145

- Separating Genetic and Environmental Influences* 145
- What Is Inherited?* 146
- Implications of Alcoholism Research* 148

Chapter 6. Motivation and the Regulation of Internal States 155

Motivation and Homeostasis 156

- Theoretical Approaches to Motivation* 157
- Simple Homeostatic Drives* 158

Hunger: A Complex Drive 161

- The Role of Taste* 161

APPLICATION: PREDATOR CONTROL THROUGH LEARNED TASTE AVERSION 164

- Digestion and the Two Phases of Metabolism* 164
- Signals That Start a Meal* 167

IN THE NEWS: YOU ARE WHAT YOUR MOTHER ATE 169

- Signals That End a Meal* 170
- Long-Term Controls* 171

Obesity 173

- The Myths of Obesity* 175
- The Contribution of Heredity* 175

Obesity and Reduced Metabolism 176

- Treating Obesity* 178

Anorexia and Bulimia 180

- Environmental and Genetic Contributions* 181

IN THE NEWS: THE TRAGEDY OF BULIMIA 182

- The Role of Serotonin* 182

Chapter 7. The Biology of Sex and Gender 189

Sex as a Form of Motivation 190

- Arousal and Satiation* 191
- The Role of Testosterone* 192
- Brain Structures and Neurotransmitters* 193
- Sensory Stimuli in Sexual Behavior* 197

APPLICATION: OLFACTORY RECEPTORS AREN'T JUST FOR SMELLING 198

The Biological Determination of Sex 200

- Chromosomes and Hormones* 200
- Prenatal Hormones and the Brain* 202

Gender-Related Behavioral and Cognitive Differences 203

- Some Demonstrated Male-Female Differences* 204
- Origins of Male-Female Differences* 204

IN THE NEWS: HOW MOTHERHOOD CHANGES A RAT'S LIFE 205

Sexual Anomalies 206

- Male Pseudohermaphrodites* 206
- Female Pseudohermaphrodites* 207

APPLICATION: SEX AT THE OLYMPICS 208

- Sex Anomalies and the Brain* 208
- Ablatio Penis: A Natural Experiment* 209

Sexual Orientation 211

- The Social Influence Hypothesis* 212
- Genes and Sexual Orientation* 213
- Hormonal Influence* 214
- Brain Structures* 215
- The Challenge of Female Homosexuality* 217
- Social Implications of the Biological Model* 218



Chapter 8. Emotion and Health 225

Emotion and the Nervous System 226

Autonomic and Muscular Involvement in Emotion 226

APPLICATION: A CAMERA FOR SPOTTING LIARS 230

The Limbic System 231

The Prefrontal Cortex 233

The Amygdala 234

Hemispheric Specialization 235

Stress, Immunity, and Health 236

Stress as an Adaptive Response 236

Negative Effects of Stress 237

Social and Personality Variables 239

Pain as an Adaptive Emotion 240

Biological Origins of Aggression 242

Hormones and Aggression 243

The Brain's Role in Aggression 244

IN THE NEWS: SUPREME COURT ENDS DEATH PENALTY FOR MINORS 245

Serotonin and Aggression 245

Heredity and Environment 247

PART III. INTERACTING WITH THE WORLD

Chapter 9. Hearing and Language 255

Hearing 257

The Stimulus for Hearing 257

The Auditory Mechanism 258

Frequency Analysis 263

Locating Sounds With Binaural Cues 268

APPLICATION: COCHLEAR IMPLANTS FOR ARTIFICIAL HEARING 269

Language 272

Broca's Area 272

Wernicke's Area 274

The Wernicke-Geschwind Model 274

Reading, Writing, and Their Impairment 276

Mechanisms of Recovery From Aphasia 278

A Language-Generating Mechanism? 279

Language in Nonhumans 282

Neural and Genetic Antecedents 284

Chapter 10. Vision and Visual Perception 293

Light and the Visual Apparatus 294

The Visible Spectrum 294

The Eye and Its Receptors 295

Pathways to the Brain 298

APPLICATION: RESTORING LOST VISION 300

Color Vision 301

Trichromatic Theory 302

Opponent Process Theory 302

A Combined Theory 304

Color Blindness 307

Form Vision 308

Contrast Enhancement and Edge Detection 308

Hubel and Wiesel's Theory 311

Spatial Frequency Theory 312

The Perception of Objects, Color, and Movement 314

The Two Pathways of Visual Analysis 315

Disorders of Visual Perception 317

IN THE NEWS: WHEN THEY'RE ALL FACES IN THE CROWD 318

The Problem of Final Integration 322

Chapter 11. The Body Senses and Movement 329

The Body Senses 330

Proprioception 330

The Skin Senses 330

The Vestibular Sense 331

The Somatosensory Cortex and the Posterior Parietal Cortex 333

The Sensation of Pain 336

APPLICATION: TAPPING INTO THE PAIN RELIEF CIRCUIT 340

Movement 342

The Muscles 342

The Spinal Cord 343

The Brain and Movement 344

IN THE NEWS: CONTROLLING THE WORLD WITH THOUGHT 349

Disorders of Movement 351



PART IV. COMPLEX BEHAVIOR

Chapter 12. Learning and Memory 363

Learning as the Storage of Memories 364

Amnesia: The Failure of Storage and Retrieval 365

Mechanisms of Consolidation and Retrieval 366

Where Memories Are Stored 367

Two Kinds of Learning 369

Working Memory 370

Brain Changes in Learning 371

Long-Term Potentiation 371

Synaptic Changes 374

The Role of LTP in Learning 375

Consolidation Revisited 376

Changing Our Memories 377

Learning Deficiencies and Disorders 379

Effects of Aging on Memory 379

IN THE NEWS: A MEMORY PILL AT LAST? 380

Alzheimer's Disease 380

APPLICATION: GENETIC INTERVENTIONS FOR ALZHEIMER'S 386

Korsakoff's Syndrome 387

Chapter 13. Intelligence and Cognitive Functioning 393

The Nature of Intelligence 394

What Does "Intelligence" Mean? 394

The Structure of Intelligence 396

The Biological Origins of Intelligence 396

The Brain and Intelligence 397

Specific Abilities and the Brain 400

Heredity and Environment 402

APPLICATION: IS ANIMAL INTELLIGENCE RELEVANT TO HUMANS? 403

Deficiencies and Disorders of Intelligence 407

Effects of Aging on Intelligence 407

Retardation 410

Autism 412

Attention Deficit Hyperactivity Disorder 418

IN THE NEWS: THE GENE THAT WOULDN'T SIT STILL 421

Chapter 14. Psychological Disorders 427

Schizophrenia 429

Characteristics of the Disorder 429

Heredity 430

Two Kinds of Schizophrenia 433

The Dopamine Hypothesis 434

Beyond the Dopamine Hypothesis 434

Brain Anomalies in Schizophrenia 436

Affective Disorders 442

Heredity 443

The Monoamine Hypothesis of Depression 444

Electroconvulsive Therapy 446

APPLICATION: ELECTRICAL STIMULATION FOR DEPRESSION 447

Antidepressants, ECT, and Neural Plasticity 448

Rhythms and Affective Disorders 449

Bipolar Disorder 450

Brain Anomalies in Affective Disorder 451

Suicide 453

Anxiety Disorders 454

Generalized Anxiety, Panic Disorder, and Phobia 455

Obsessive-Compulsive Disorder 455

IN THE NEWS: GLUTAMATE: THE MASTER SWITCH? 456

Chapter 15. Sleep and Consciousness 465

Sleep and Dreaming 466

Circadian Rhythms 468

Rhythms During Waking and Sleeping 471

The Functions of REM and Non-REM Sleep 473

Sleep and Memory 474

Brain Structures of Sleep and Waking 476

Sleep Disorders 479

IN THE NEWS: WHY TEENS CAN'T WAKE UP IN THE MORNING 481

Sleep as a Form of Consciousness 483

The Neural Bases of Consciousness 484

Awareness 484

Attention 486

The Sense of Self 487

Theoretical Explanations of Consciousness 495

APPLICATION: DETERMINING CONSCIOUSNESS WHEN IT COUNTS 497

Glossary 504

References 513

Chapter-Opening Photo Credits 559

Author Index 560

Subject Index 584

What Is Biopsychology?

1

The Origins of Biopsychology

Prescientific Psychology and the Mind-Brain Problem

Descartes and the Physical Model of Behavior

Helmholtz and the Electrical Brain

The Localization Issue

CONCEPT CHECK

Nature and Nurture

The Genetic Code

IN THE NEWS: DNA'S ROLE IN COMPUTER EVOLUTION

Genes and Behavior

The Human Genome Project

Heredity: Destiny or Predisposition?

CONCEPT CHECK

In this chapter you will learn

- How biological psychology grew out of philosophy and physiology
- How brain scientists think about the mind-brain problem
- How behavior is inherited and the relationship between heredity and environment

“There is a wonderful kind of excitement in modern neuroscience, a romantic, moon-walk sense of exploration and setting out for new frontiers. The science is elegant . . . and the pace of discovery absolutely staggering.

—Kay R. Jamison,
An Unquiet Mind”

Neuroscience is the multidisciplinary study of the nervous system and its role in behavior. An interesting topic, surely, but *neuroscience is a romantic moonwalk*? To understand why Kay Jamison chose this analogy, you would need to have watched in astonishment from your backyard on an October night in 1957 as the faint glint of reflected light from Sputnik crossed the North American sky. The American people were stunned and fearful as the Russian space program left them far behind. But as the implications of this technological coup sank in, the United States set

about constructing its own space program and revamping education in science and technology. Less than 4 years later, President Kennedy made his startling commitment to put an American astronaut on the moon by the end of the decade. But the real excitement would come on the evening of July 20, 1969, as you sat glued to your television set watching the *Eagle* lander settle effortlessly on the moon and the first human step onto the surface of another world (Figure 1.1). For Kay Jamison and the rest of us involved in solving the mysteries of the brain, there is a very meaningful parallel between the excitement of Neil Armstrong's "giant leap for mankind" and the thrill of exploring the inner space of human thought and emotion.

There is also an inescapable parallel between Kennedy's commitment of the 1960s to space exploration and Congress's declaration 30 years later that the 1990s would be known as the Decade of the Brain: Understanding the brain demands the same incredible level of effort, ingenuity, and technological innovation as landing a human on the moon. There were important differences between those two decades, though. President Kennedy acknowledged that no one knew what benefits would arise from space exploration. But as the Decade of the Brain began, we understood that we would not only expand the horizons of human knowledge but also advance the treatment of neurological diseases, emotional disorders, and addictions that cost the United States an estimated trillion dollars a year for care, lost productivity, and crime (Uhl & Grow, 2004).

Another difference was that the moon-landing project was born out of desperation and a sense of failure, while the Decade of the Brain was a celebration of achievements, both past and current. In the past few years, we have developed new treatments for depression, identified key genes responsible for the devastation of Alzheimer's disease, discovered agents that block addiction to some drugs, learned ways to hold off the memory impairment associated with old age, and produced a map of the human genes.

Figure 1.1

The Original Romantic Moonwalk.

Space exploration and solving the mysteries of the brain offer similar challenges and excitement. Which do you think will have the greater impact on your life?

SOURCE: Courtesy of NASA.

