

Cognitive Psychology

Third Edition

Douglas L. Medin • Brian H. Ross • Arthur B. Markman

Cognitive Psychology

Third Edition

Douglas L. Medin

Northwestern University

Brian H. Ross

University of Illinois

Arthur B. Markman

University of Texas

Harcourt College Publishers

Fort Worth

Philadelphia
Toronto

San Diego
Montreal

New York
London

Orlando
Sydney

Austin
Tokyo

San Antonio

To Linda and Liberty, in that order. —Douglas Medin
In memory of my father, Martin. —Brian Ross
To my parents, Ed and Sondra Markman, for teaching me the power of thinking. —Arthur Markman

Publisher	Earl McPeck
Acquisitions Editor	Bradley J. Potthoff
Market Strategist	Katie Matthews
Developmental Editor	Peggy Howell
Project Editor	Elaine Richards
Art Director	David A. Day
Production Manager	Linda McMillan

Cover credit: © Digital Vision Ltd.

ISBN: 0-15-508057-1

Library of Congress Catalog Card Number: 00-102762

Copyright © 2001, 1997, 1992 by Harcourt, Inc.

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

Requests for permission to make copies of any part of the work should be mailed to the following address:
Permissions Department, Harcourt, Inc., 6277 Sea Harbor Drive, Orlando, FL 32887-6777.

Copyrights and Acknowledgments appear on page 613, which constitutes a continuation of the copyright page.

Address for Domestic Orders
Harcourt College Publishers, 6277 Sea Harbor Drive, Orlando, FL 32887-6777
800-782-4479

Address for International Orders
International Customer Service
Harcourt, Inc., 6277 Sea Harbor Drive, Orlando, FL 32887-6777
407-345-3800
(fax) 407-345-4060
(e-mail) hbintl@harcourt.com

Address for Editorial Correspondence
Harcourt College Publishers, 301 Commerce Street, Suite 3700, Fort Worth, TX 76102

Web Site Address
<http://www.harcourtcollege.com>

Harcourt College Publishers will provide complimentary supplements or supplement packages to those adopters qualified under our adoption policy. Please contact your sales representative to learn how you qualify. If as an adopter or potential user you receive supplements you do not need, please return them to your sales representative or send them to: Attn: Returns Department, Troy Warehouse, 465 South Lincoln Drive, Troy, MO 63379

Printed in the United States of America

1 2 3 4 5 6 7 8 9 0 3 9 9 8 7 6 5 4 3 2
Harcourt College Publishers

PREFACE

What are the most interesting questions that the human mind can ever pose and hope to answer? How the mind works is certainly one of them. How is it that the billions of neurons in our brains are organized such that we can move around the world, pursue goals, and interact with others? What gives rise to conscious experience? How is knowledge stored in the brain? Cognitive psychology is the study of the human mind; its domain includes questions concerning how people perceive the world, remember information, access and use knowledge, understand language, reason, learn, solve problems, and make decisions.

For most of us, our everyday experience seems quite unremarkable. We have the subjective experience of seeing the world as it is. We normally have no difficulty making sense of our world, and we don't have to worry about how to think, form sentences, and act; we just do them. When we look beneath the surface of everyday experience, however, we see that what our cognitive system accomplishes is nothing short of amazing. In this book we will examine the what, why, and how of these accomplishments.

What exactly is so amazing? As we shall see, the world continually confronts us with situations that offer too little information about what is going on and too many possibilities about what to do. For example, as we shall see in the chapter on perception, any visual input is consistent with an unlimited number of interpretations. The challenging question is how the perceptual system functions such that we normally are unaware of any ambiguity. Our experience is simply that of seeing things the way they are. The reason for this is that, instead of considering all the logical possibilities, our conceptual system comes prepared with expectations that greatly influence what we consider and how we act. We do not experience uncertainty and ambiguity because we typically do not consider alternative possibilities. These sorts of expectations or "constraints" occur in all facets of cognition. Constraints represent an adaptation to our world and therefore should be thought of as guiding principles rather than limitations.

It is as if the conceptual systems make bold guesses about the way things are, guesses that are accurate enough often enough that we can act intelligently. Perhaps the most important characteristic of the mind is that it is exquisitely adapted, "tuned" to life on earth.

Goals

Ambiguity and adaptive responses to it provide some broad themes that serve to organize this book. We hope to provide the framework *to allow students to better appreciate not just a series of interesting phenomena in different areas of research but some basic commonalities that cut across these areas.*

A second, closely related goal is *to encourage the student to gain an appreciation for methods by which researchers study the mind.* Although we can gain some insight by thinking about how we think, this understanding is very limited. Much of cognition occurs so quickly that we are not able to reflect on it; for example, how do people read words, understand speech, or decide something is a bird? Even for slower processes, such as solving a math problem or deciding where to go to college, an examination of what people are thinking often leads to many possible interpretations. *Cognitive Psychology* examines a wide variety of activities and tries to provide an understanding that captures many of them.

A third goal of the book is *to convey challenges and open questions associated with the field of cognition*. Research on cognition has led to some striking and counterintuitive findings that have important practical implications. Nonetheless, we will be disappointed if students focus only on answers and conclusions and ignore the many deep puzzles that remain.

Features/Organization

In each chapter we have included three boxes: “An Enigma,” “A Debate,” and “An Application.” An Enigma highlights a strange or unexplained result in an area; A Debate focuses on an ongoing research debate; and An Application points to the ways in which research in an area has been applied either outside the lab or in another area of science.

To further help in giving some structure to the research area, the book, following a general introduction to the themes and methods of cognitive psychology, is organized into five parts. Part I is an overview; Part II (chapters 2, 3, and 4) examines how information is acquired, including basic learning processes, perception, and attention. Part III (chapters 5, 6, 7, and 8) addresses fundamental issues of memory and representation of knowledge, including how it is used in real-world cases and for imagery. Parts IV and V (chapters 9 through 14) begin with an examination of language and then address thinking, with a discussion of concepts, reasoning, problem solving, expertise, creativity, and decision-making.

This book is intended for a one-semester course in cognitive psychology. We have attempted to place the chapters in a logical sequence, but other orderings are possible. Your instructor may choose not to cover a chapter or two for reasons of interest, overlap with other courses, or shortage of time. Nonetheless you will get a lot of exposure to the important themes that provide the framework for this book.

It is probably important that the opening chapter outlining the themes be read first. Other than that it would probably be best to read chapter 5 before the other memory chapters and chapter 12 before 13. Although we tie together material across chapters, the overall themes permit an instructor to skip certain early chapters (e.g., Learning, Perception) without too much loss of continuity.

New to This Edition

This third edition of *Cognitive Psychology* represents a substantial revision. The single most important change is that Arthur Markman has joined the team of authors. It was important to this edition of the text to add new energy without sacrificing the conceptual framework that makes this book unique. Markman has known Medin and Ross and has collaborated with them for many years; he shares their vision of cognitive psychology as a field. His contributions are compatible, and his enthusiasm for cognitive psychology is reflected in every chapter in the new edition.

How has the current edition been changed? Each of the three authors has worked on each of the chapters and we think there is a visible improvement in clarity, even though we have not shied away from presenting technical details in many sections. Every chapter has been systematically updated and new material has been added, especially concerning new developments in cognitive neuroscience. In addition, based on extensive reviews, we have made a number of major changes from the second edition. Most notably, we have greatly reorganized the four memory chapters to make the presentation

more coherent, and we have deleted the chapter on language acquisition to enable us to expand coverage in other areas.

We have also carefully developed a new test bank for instructors to use. Authored by Wendy Domjan, the new test bank provides 50% more questions and identifies them by type: factual, application and conceptual. *Computerized test banks are available for Windows and Macintosh.*

Acknowledgments

We have received much help in writing this book. For this third edition we wish particularly to acknowledge the help of our developmental editor at Harcourt, Peggy Howell. She helped us overcome a variety of obstacles and brought us to the finish line in excellent time. We also thank art director David A. Day, project editor Elaine Richards, production manager Linda McMillan, copyeditor Beth Alvarez and proofreader Steven Baker, all of whom helped move this edition smoothly through production.

We also wish to thank the thoughtful and constructive comments of those who reviewed this edition of the book: James I. Chumbley, University of Massachusetts; Kenneth D. Kallio, SUNY–Geneseo; Steven M. Smith, Texas A & M University; Jerry Hauselt, Southern Connecticut State University; W. Daniel Phillips, The College of New Jersey; Tom Alley, Clemson University; Pamela Tsang, Wright State University; Kevin B. F. Thomas, University of Arizona–Sierra Vista; Patricia E. O’Neill, University of Mississippi; M. John Lutz, East Carolina University; and Thomas Sanocki, University of South Florida. Thanks also to earlier reviewers Woo-Kyoung Ahn, Neal Cohen, Gary Dell, Stephanie Doane, Evan Heit, Phillip Johnson-Laird, Gordon Logan, Harold Pashler, Javier Sainz, and David Swinney. A special thanks goes to Caryn Carlson, Bill Geisler, and Todd Maddox for helpful suggestions in their areas of expertise. We would also like to thank people who may not have helped directly with this book but who have had large influences on our thinking about cognition: James Anderson, John Anderson, Scott Atran, Larry Barsalou, Gordon Bower, William K. Estes, Dedre Gentner, Thomas Landauer, Gregory Murphy, Elissa Newport, Edward Smith, Edward Wisniewski, (and each other). Special thanks are due to Greg Hand, who helped in all phases of manuscript preparation. Greg, you are amazing.

Finally, we acknowledge a great deal of tangible and intangible support on the home front. For their love, support and patience Doug, Brian, and Art would like to thank Linda, Cheri, and Betsy, respectively.

—Douglas Medin, Brian Ross, and Arthur Markman

TABLE OF CONTENTS

Preface	v	Part II Acquiring Information	45
Part I Overview	1	Chapter 2 Learning	47
Chapter 1 Possibilities, Information, and Approaches to the Study of the Mind	3	Introduction	48
Introduction	4	The Challenge of Learning	48
Domain of Cognitive Psychology	4	The Biological Backdrop of Learning	49
Puzzles	5	Fixed-Action Patterns and Releasers	50
Possibilities	7	Critical Periods and Imprinting	52
A Framework	8	Constraints on Learning	57
A Closer Look	9	Basic Learning	59
Themes and Implications	11	Habituation	59
Knowledge and Experience	11	Classical Conditioning	60
Ways of Knowing	11	Trial-and-Error Learning or Instrumental Learning	66
Experimentation	15	Paired-Associate Learning	68
Cognitive Psychology and Experimentation	16	Implications	71
Roots of Cognitive Psychology	17	The Learning-Performance Distinction	71
Introspectionism	18	Contingency Learning and Illusory Correlation	72
Behaviorism	18	Content and Meaningful Learning	75
Critique of Behaviorism	19	Summary	78
Cognitive Psychology	22	Key Terms	79
The Emergence of Cognitive Science	24	Recommended Readings	79
Cognitive Neuroscience Techniques	26	Chapter 3 Perception	80
Event-Related Potentials	27	The Problem of Perception	81
Positron Emission Tomography	27	Visual Perception	82
Functional Magnetic Resonance Imaging	28	Low-Level Vision	83
Levels of Analysis	31	Localization	87
Marr's Three Levels	31	High-Level Vision	96
Recursive Decomposition	33	Feature Detection Theories	96
Diversity of Approaches	34	Structural Theories	99
Degree of Formalism	34	Template Matching and Alignment	104
Explicit Versus Implicit Structure	35	Face Recognition and Visual Subsystems	105
Connectionist Models	36	Levels and the Integration of Information in Perceptual Context Effects	108
Ecological Validity	40	The Word Superiority Effect	109
Summary	42	Summary	113
Key Terms	43	Key Terms	114
Recommended Readings	43	Recommended Readings	114

Chapter 4 Attention	115	Summary	194
Introduction	116	Key Terms	195
Initial Observations in Perceptual Attention	117	Recommended Readings	195
Sensory Stores	117		
Evidence for Capacity Limitations	118		
Focused Attention	121		
Capacity and Attention	123		
Bottleneck Theories	124		
Late Selection	126		
Capacity Theories	126		
Feature Integration Theory	130		
Attention in Complex Tasks	133		
Capacity and Automaticity	136		
Central Executive Functions	141		
Dual-Task Interference	141		
Attention and the Brain	144		
Summary	147		
Key Terms	147		
Recommended Readings	148		
 Part III Memory	 149		
 Chapter 5 Memory: Remembering New Information	 151		
Introduction	152		
Centrality of Memory	152		
Uses of Memory	152		
Short-Term Memory	154		
Introduction	154		
Characteristics of Short-Term Memory	155		
Working Memory	158		
Summary	164		
Long-Term Memory	164		
Introduction	164		
Encoding	166		
Retrieval	170		
Encoding-Retrieval Interactions	171		
Forgetting	181		
Summary	185		
Models of Memory for New Information	186		
General Approach	186		
Simple Association Models	187		
The SAM Model	189		
		Chapter 6 Memory Systems and Knowledge	196
		Introduction	197
		Semantic Knowledge	197
		Characteristics of Semantic Memory	197
		The Hierarchical Model	198
		Evaluation of the Hierarchical Model	200
		Episodic Memory	202
		Are Episodic and Semantic Memory Distinct Memory Systems	202
		Procedural Memory	208
		Implicit and Explicit Memory	210
		Spared Learning in Amnesia	211
		Implicit and Explicit Memory with Normal-Memory Adults	215
		Evaluation of the Implicit-Explicit Distinction	218
		Two Models of Memory	220
		Introduction	220
		The ACT Theory	220
		A Parallel Distributed Processing Model of Memory	229
		Summary	240
		Key Terms	241
		Recommended Readings	241
		Appendix: Learning in a Parallel Distributed Processing Model	243
		 Chapter 7 Remembering New Information: Beyond Basic Effects	 248
		Introduction	249
		Schemas: Understanding and Remembering Complex Situations	250
		Introduction and Motivation	250
		Understanding	253
		Schemas	254
		Scripts	257
		Schema Activation	261
		Problems with Schemas	262
		Summary	262

Reconstructive Memory	263	Memory for Faces	322
Encoding-Retrieval Interactions		Summary	322
Revisited	263	Summary	322
Schemas and Stereotypes	265	Key Terms	324
Summary	267	Recommended Readings	324
Memory in the World	267		
Introduction	267	Part IV Language and Understanding	325
Eyewitness Testimony	268		
Flashbulb Memories	273	Chapter 9 Language	327
Recovered Memories	278	Introduction	328
Summary	282	Language and Communication	328
Knowing Your Memory	284	Principles of Communication	329
Introduction	284	The Given-New Strategy	330
Strategies and Knowledge	284	Presupposition and Assertion	330
Metamemory	287	Conversational Maxims	331
Summary	290	Summary	332
Summary	290	The Productivity of Human Languages	333
Key Terms	291	Productivity and Novelty	333
Recommended Readings	291	Ambiguity	334
		Phonology	335
Chapter 8 Spatial Knowledge, Imagery, and Visual Memory	293	Phonological Rules	335
Introduction	294	Speech Perception	339
Representations	295	Summary	343
Relations Between Representations and Referents	295	Syntax	343
Analog Representations	296	The Need for Structure	343
Summary	298	Structure	344
Spatial Knowledge	299	Phrase Structure	345
Maps and Navigation	299	Transformations	347
Spatial Representations From Descriptions	300	The Psychological Reality of Syntax	349
Hierarchical Representations of Space	302	Summary	350
The Brain and Spatial Cognition	305	Understanding Language	350
Spatial Representations and Development	305	Heuristics and Strategies	351
Summary	305	Minimal Attachment	353
Imagery	306	Text Comprehension	356
Evidence for Use of Visual Imagery	307	The Brain and Language	360
Representation of Images	310	Summary	362
Summary	314	Key Terms	363
Visual Memory	315	Recommended Readings	364
Remembering Details	315		
Memory for Pictures	316	Chapter 10 Concepts and Categories: Representation and Use	365
The Picture-Superiority Effect	319	Introduction	366
		Why Categorize	366
		Computational Complexity	366

Functions of Concepts	367	An Example of Mapping	431
Concepts and Misconceptions	369	A Return to Similarity	431
Summary	371	Summary	433
Structure of Natural Object Categories	371	Mental Models and Intuitive Theories	434
The Classical View	372	Intuitive Theories	438
The Probabilistic View	373	Hypothesis Testing and Scientific Reasoning	441
Between-Category Structure	382	Summary	444
Does Similarity Explain		Key Terms	445
Categorization	386	Recommended Readings	445
Concepts as Organized by Theories	390		
Putting Similarity in Its Place	391	Chapter 12 Problem Solving	446
Are There Kinds of Categories	393	Introduction	447
Summary	395	Problems, Problems, Problems	447
Use of Categories in Reasoning	396	What Is a Problem	447
Goals and Ad Hoc Categories	396	Types of Problems	448
Conceptual Combination	396	Methods for Studying Problem Solving	448
Categories and Induction	397	Summary	452
Summary	399	Problem Solving as Representation and Search	452
Key Terms	400	Introduction	452
Recommended Readings	400	The Problem Space Analysis	453
		Problem Solving as Search	456
Part V Thinking	403	Problem Solving as Representation	461
Chapter 11 Reasoning	405	Summary of Problem Solving as Representation and Search	469
Introduction	406	Reliance on Specific Relevant Knowledge	470
Logic and Reasoning	406	Introduction	470
Validity and Truth	408	The Influence of Related Problems	470
Deductive Versus Inductive Reasoning	409	Summary	478
Summary	410	Summary	479
The Psychology of Deduction	410	Key Terms	479
Conditional Reasoning	411	Recommended Readings	480
Conditional Reasoning in Hypothesis Testing: The Selection Task	414		
Summary	418	Chapter 13 Expertise and Creativity	481
The Psychology of Inductive Reasoning	419	Introduction	482
Probabilistic Reasoning	420	Expertise	482
Test Quality: A Case Study of Base Rates	421	Introduction	482
Base Rate Neglect	423	Comparing Experts and Novices	482
Confusing Conditional Probabilities	424	Developing Expertise	492
Argument Structure and Relevance	425	Expert Systems	500
Summary	427	Adaptive Expertise	503
The Importance of Content	427	Summary	504
Analogy and Similarity	427		

Creativity	505	Adaptive Decision Making	535
Introduction	505	Further Heuristics and Biases	536
The Traditional View	507	Availability Heuristic	537
Some Recent Views of Creativity	509	Representativeness Heuristic	540
Summary	514	Anchoring and Adjustment	541
Summary	516	Causal Schemas	541
Key Terms	516	Hindsight Bias	542
Recommended Readings	517	Overconfidence	542
 Chapter 14 Judgment and Decision Making		Relativity of Judgment and Use of Norms	543
Introduction	518	Summary	544
Rational and Normative Models	520	Are There Kinds of Decisions	545
Expected Value Theory	521	Mental Accounting	545
Expected Utility Theory	522	Summary	548
Limitations of Expected Utility and Alternatives to It	523	Key Terms	548
Violations of Expected Utility	523	Recommended Readings	549
Prospect Theory	529	 Glossary	551
Regret Theory	531	References	563
Decision Making Over Time	532	Credits	613
Summary	534	Author Index	617
Dealing With Complexity	534	Subject Index	627
Strategies for Dealing With Complexity	535		



PART I OVERVIEW

Chapter 1

Possibilities, Information, and Approaches to the Study of the Mind



Chapter 1

Possibilities, Information, and Approaches to the Study of the Mind

Introduction

Domain of Cognitive Psychology

Puzzles

Possibilities

A Framework

A Closer Look

Themes and Implications

Knowledge and Experience

Ways of Knowing

Experimentation

Cognitive Psychology and Experimentation

Roots of Cognitive Psychology

Introspectionism

Behaviorism

Critique of Behaviorism

Cognitive Psychology

The Emergence of Cognitive Science

Cognitive Neuroscience Techniques

Event-Related Potentials

Positron Emission Tomography

Functional Magnetic Resonance Imaging

Levels of Analysis

Marr's Three Levels

Recursive Decomposition

Diversity of Approaches

Degree of Formalism

Explicit Versus Implicit Structure

Connectionist Models

Ecological Validity

Summary

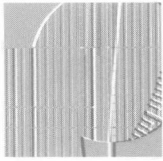
Key Terms

Recommended Readings

*All nature is but Art, unknown to thee;
all chance, direction, which thou canst not see.*

—Alexander Pope

INTRODUCTION



Domain of Cognitive Psychology

As you read this, you are engaged in information processing. In fact you've spent much of your life processing information as you attend, perceive, learn, solve problems, and reason about your world. In short you have been doing exactly what cognitive psychologists attempt to understand—how people acquire, store, retrieve, and use knowledge. If we are going to spend a whole book talking about **cognitive psychology**, then we ought to take a moment to think about what cognitive psychology is. Simply put, cognitive psychology is the study of thought. Thought goes all the way from the ability to perceive the world around us by sight, hearing, touch, and smell, through our ability to reason, to solve problems, to use language, to learn and remember, and to move and act in the world.

One might think that the fact we've spent our lives processing information would give us some special insight into how people think. Given that we all spend a great deal of time explaining other people's behavior as well as our own, we should all be experts on cognition. But it's not so simple. We also have spent all of our lives eating food—does that mean we are all experts on digestive processes, liver functioning, and the like? Probably not. Still it is hard to resist the idea that everyone knows quite a bit about thought because we've done so much of it.

Intuitions about how the mind works may be helpful sometimes but at other times they are useless or even very misleading. One of our strongest intuitions is that perception involves nothing more and nothing less than seeing the world as it is, a view known as **naïve realism**. There are two serious problems with this view. One is that it is wrong. A clear demonstration of this fact comes from a study conducted by two social psychologists who asked undergraduates to view a film of a football game and rate the behaviors of the competing teams (Hastorf & Cantril, 1954). The game in question pitted two long-term rivals, Princeton University and Dartmouth College, and the game was very rough. Numerous fights and penalties punctuated the hard-fought game. Princeton and Dartmouth undergraduates who were shown the film of the game a month later gave strikingly different responses. Princeton students saw a succession of Dartmouth violence and poor sportsmanship, with Princeton players sometimes retaliating out of self-defense. Dartmouth students saw the teams as equally aggressive and interpreted their team's infractions as reasonable responses to the brutality of the Princeton players. The Princeton and Dartmouth students literally saw two different games. Still it is hard to resist the impression that we are just seeing things the way they truly are.

The other problem with naïve realism is that it doesn't provide any explanation of how perception is actually accomplished. It is only when researchers have tried to provide an information processing account of perception that we have come to realize just how complex it is. In fact, there is a real sense in which perception is impossible! Therefore, it is a deep puzzle how we are able to do it. More generally, much of cognition involves these sorts of challenges. In the rest of this chapter we will provide an overview of these puzzles and then offer a framework for understanding them.

Puzzles

This book is about the obvious and the nonobvious. Hidden under the cognitive tasks that people find natural and easy are some of the most challenging and mysterious puzzles concerning human intelligence. Most people do not spend a lot of time thinking about how we perceive objects and events in our environment. Our experience is of seeing the world more or less directly. But there is a great deal more to perception than meets the eye. So much information is lost during the imaging process that projects light from the three-dimensional world into two-dimensional images on the retina of the eye that any perceptual experience has an unlimited set of possible interpretations. So how do we see the world accurately enough to make our way through it? To deal with ambiguity, the perceptual system appears to make assumptions about the nature of the world (see, for example, Poggio, Torre, & Koch, 1985).

Look at the shaded objects in Figure 1.1 (taken from Kleffner & Ramachandran, 1992). They appear to fall into two natural groups, one type being concave (curving inward) and one type being convex. Now turn your book upside down. The objects that before appeared to be concave now appear convex and vice versa. Why does this happen? According to Kleffner and Ramachandran, the visual system assumes that the light source is from “above.” Consider the object in the lower right-hand corner. If light came from above, the pattern of shading would make sense if the object were concave. The shading pattern for the object in the lower left-hand

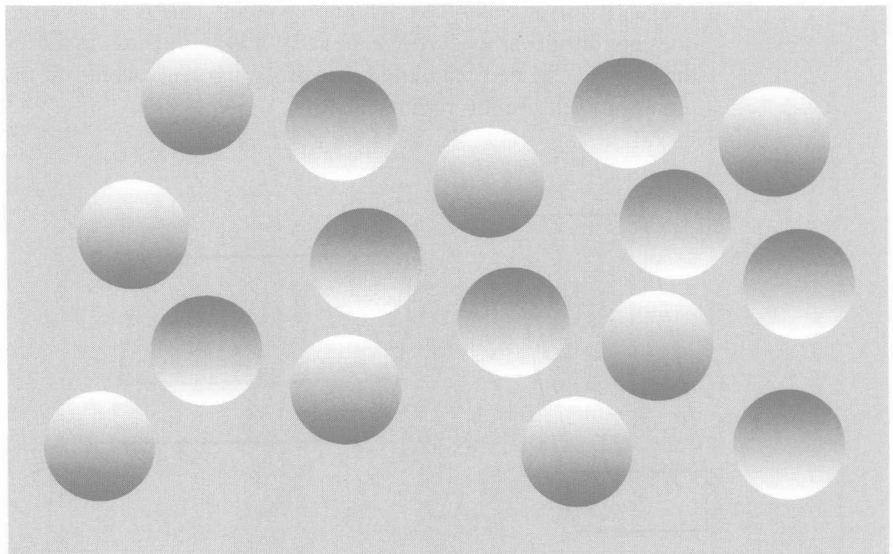


Figure 1.1

A Mixture of Shaded Objects With One of Two Patterns of Illumination The objects that are lighter on top appear to be convex and those lighter on the bottom appear to be concave.

Source: Kleffner & Ramachandran, 1992.

corner is consistent with a convex figure (as long as the light source is from above). If you turn your book sideways, the objects appear more ambiguous and it is less easy to see them as two distinct groups. In this case the pattern of shading is inconsistent with a single light source. Note that the default assumption that the source of illumination is from above is usually (but not always) correct.

The assumptions that the perceptual system makes are accurate enough that we can successfully get along in our environment, but they are not infallible. When these assumptions fail, they may give rise to perceptual illusions that demonstrate that we do not just simply see things the way they are. For example, our visual system is structured so that the apparent shape of objects does not change across a variety of viewing conditions that produce different images on the retina. If you hold a pen or pencil in your hand and rotate it, it does not appear to stretch or shrink in size as you shift from a broadside view to more of an end view. This phenomenon, known as *shape constancy*, generally serves us well. But now consider the shaded parallelograms in Figure 1.2.

Although parts A and B are two-dimensional, the connected lines provide cues to depth, and we see the top ends of each figure to be farther from us than the bottom ends. That is, we see the objects as three-dimensional. The processes that allow us to achieve shape constancy operate on the retinal image such that we see the vertical component of the shaded parallelograms in parts A and B as being longer than they really are. Therefore, we are surprised to find that the horizontal part of A's parallelogram is equal to B's vertical component and that B's horizontal component is exactly as long as A's vertical component. This is a powerful visual illusion that does not disappear when we realize that it is an illusion. In fact, you may not believe that the two shaded parallelograms are congruent (would fit on top of each other) until you measure it for yourself.

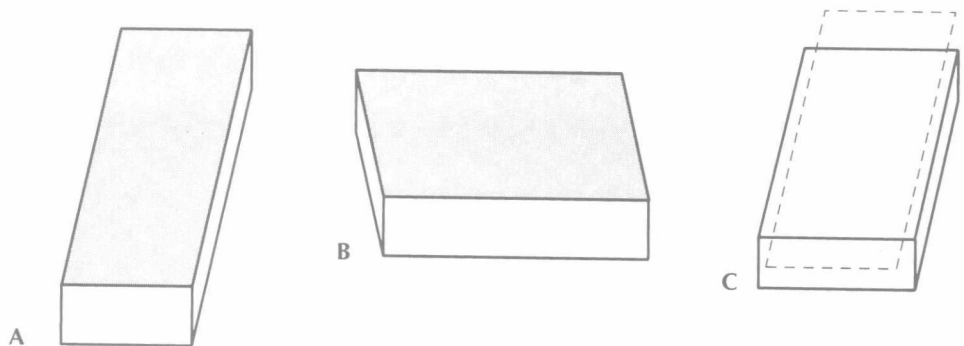


Figure 1.2

A Shape Constancy Illusion The shaded parallelogram in part B is congruent with the one in A and with the dashed outline in C (that is, if you cut out the shaded area in A it would fit exactly on the shaded area in B). If you are skeptical, try tracing the outlines of these parallelograms on thin paper and placing them on top of one another.

Source: Shepard, 1981.