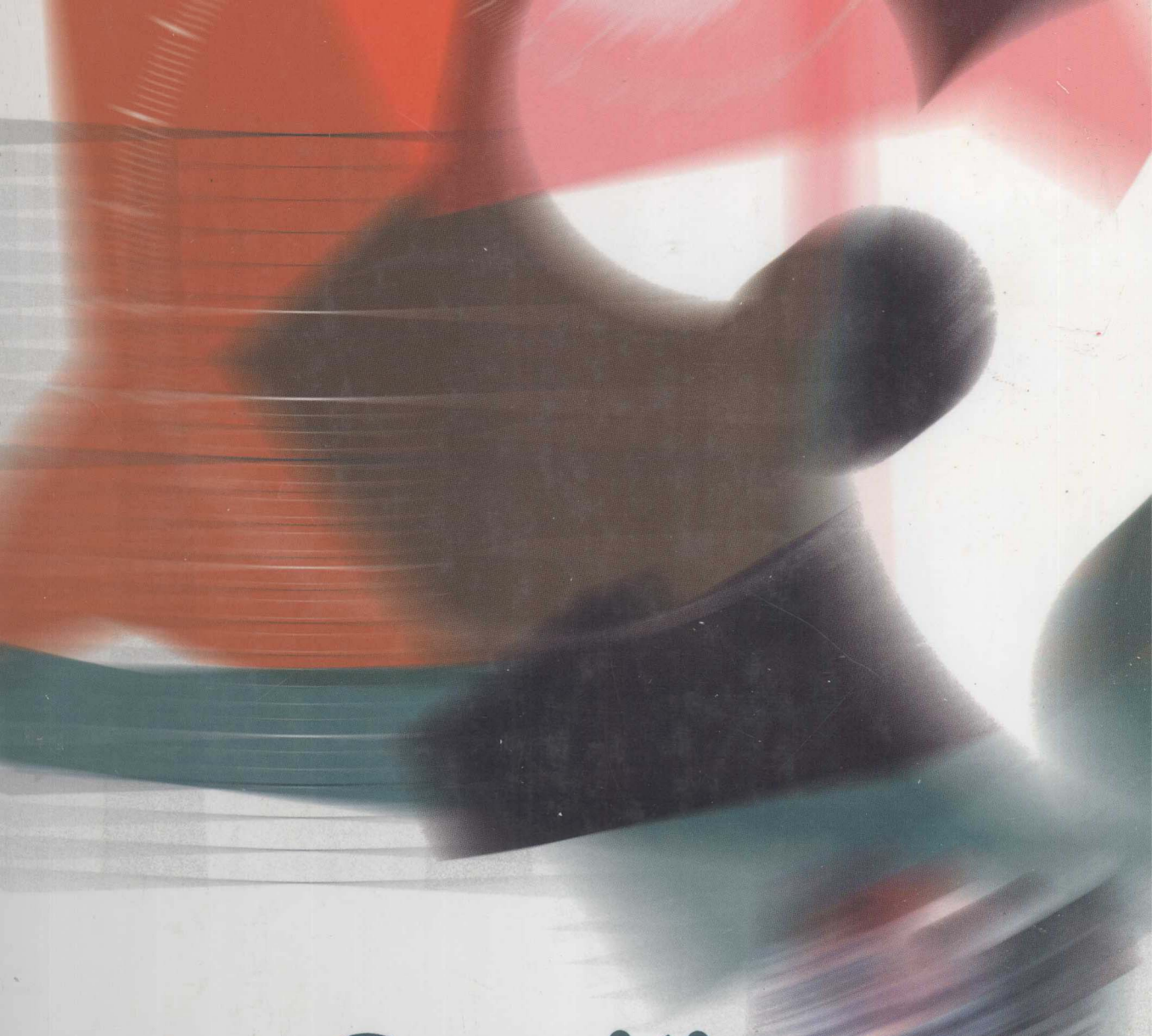

Cognitive Psychology

Third Edition

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

Cognitive Psychology

Third Edition

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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

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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 uncertainly 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.

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—Douglas Medin, Brian Ross, and Arthur Markman

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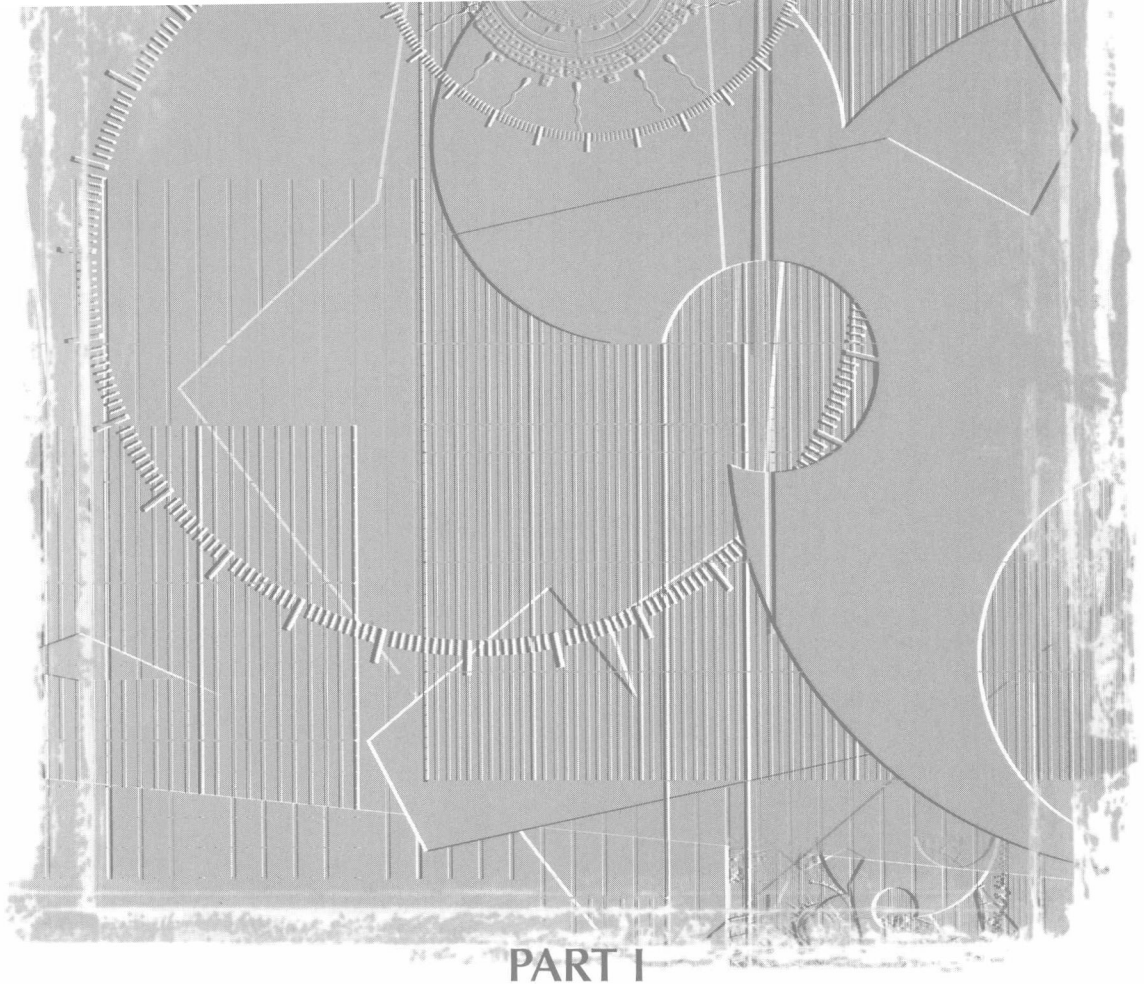

PART I
OVERVIEW

Chapter 1

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

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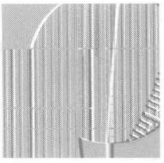
Possibilities, Information, and Approaches to the Study of the Mind

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

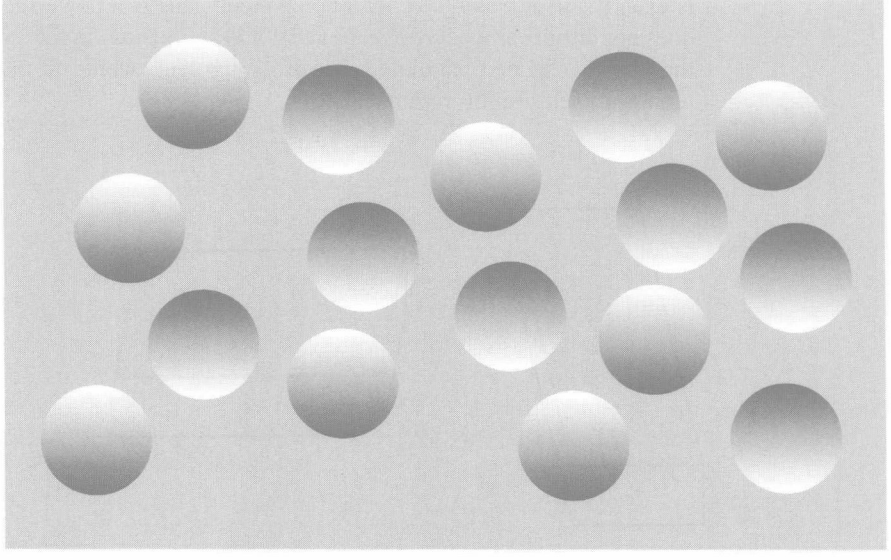


Figure 1.1 **A Mixture of Shaded Objects With One of Two Patterns of Illumination** The objects that are lighter on top appear to be convex and those lighter on the bottom appear to be concave.

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.

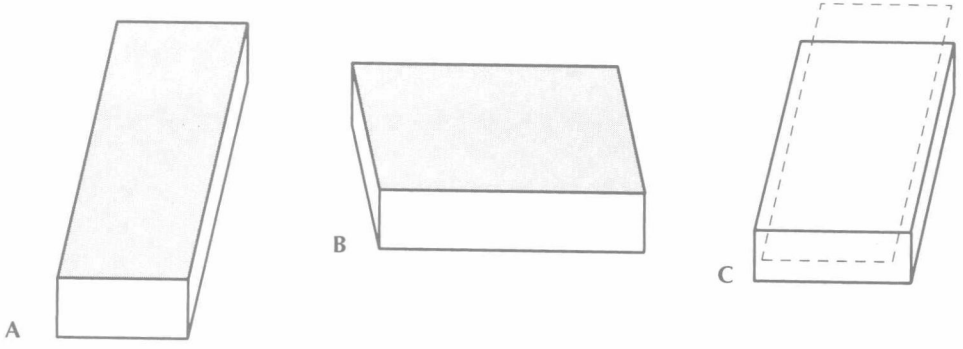


Figure 1.2 **A Shape Constancy Illusion** The shaded parallelogram in part B is congruent with the one in A and with the dashed outline in C (that is, if you cut out the shaded area in A it would fit exactly on the shaded area in B). If you are skeptical, try tracing the outlines of these parallelograms on thin paper and placing them on top of one another.

Source: Shepard, 1981.