

FOURTH EDITION

**SENSATION  
AND  
PERCEPTION**

STANLEY COREN

LAWRENCE M. WARD

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F O U R T H   E D I T I O N

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## Preface. . .

*Take away the sensations of softness, moisture, redness, tartness, and you take away the cherry. Since it is not a being distinct from these sensations; a cherry, I say, is nothing but a congeries of sensible impressions or ideas perceived by various senses; which ideas are united into one thing. . . .”*



*George Berkeley, 1713*

Virtually everything we know about our world has entered our minds through our senses. We all realize that without even some of our senses, our experiences would be incredibly limited. Consider the impossible problem of explaining the difference between the color blue and the color green to a person who has been blind since birth. Or how would you explain to a person who has no taste buds how the tastes of chocolate and vanilla differ from each other? Such aspects of the world will never exist for these individuals. For the blind person, salt and pepper differ only in taste. For the person with no ability to taste, salt and pepper differ only in color. For those of us who have senses of sight, hearing, taste, touch, and smell, our world is a continuous flow of changing percepts. Each new sensation carries with it information about our world.

This book provides an introduction to the study of sensation and perception. It has been revised substantially since the third edition, and has been updated with several hundred new references. These changes reflect many of the recent findings that have emerged, or coalesced into meaningful patterns, since the completion of the third edition. We have rewritten all of the chapters, with some sections revised “from the ground up.” We have tried to retain

the general structure and organization of the third edition so that the book will still feel familiar to our previous users. We have also retained all those features that instructors felt made the previous editions such useful teaching tools. For instance, concrete examples are used throughout the text in order to make the subject matter “come alive” for students. Whenever possible, common or natural instances of perceptual phenomena are described during the discussion of the concepts underlying them. Each chapter is preceded by an outline that serves as a preview to its contents. These outlines also provide a structure to guide students as they review the chapters.

Although terms are defined when they are introduced in the text, a glossary is provided at the end of each chapter as well. Any item printed in **boldface** in the text is also listed in the chapter glossary. Students will find that these glossaries serve as a succinct review and chapter summary. They can also be used for self-testing and study purposes.

One special feature of our textbook is the inclusion of more than 100 *Demonstration Boxes*. Each box describes a simple demonstration designed to allow students actually to experience many of the perceptual phenomena described in the text. Most require only the

stimuli in the box itself, or commonplace items that can be found in most homes or dormitory rooms. The majority of these demonstrations require only a few moments of preparation, and we feel that this is time well spent in improving understanding of the concepts under discussion and in maintaining student interest. Some instructors have reported that having students perform the demonstrations in class has been very useful. In such cases the demonstrations may also serve as the focal point for a lecture or for classroom discussion.

For a bit of amusement, this edition also includes a cartoon at the end of each chapter. The humorous aspect of each cartoon depends upon knowledge of a particular term, concept, or principle described in the chapter, so “getting the joke” requires that the student has read the material.

This textbook is designed to survey the broad range of topics generally included under the heading of *sensation and perception*. The reader will notice that no single theory of perception is championed. In general, we have attempted to be as eclectic as possible, describing the various viewpoints in areas of controversy and attempting to present a balanced overview so that instructors of different opinions might be comfortable using the book.

The topics in this book were selected on the basis of our experience in teaching our own courses; therefore, much of the material has already been class tested. We have included three chapters—*Attention, Speech and Music*, and *Individual Differences*—that are not always seen in sensation and perception textbooks. These areas have attracted a good deal of experimental work in recent years, and they are sufficiently relevant to many issues in perception that we felt students should be aware of their existence.

In order to keep the book to a manageable size, we have occasionally been selective in our coverage. It was our first priority to cover the

central concepts of each topic in enough detail to make the material clear and coherent. To have included all the topics ever classified as part of the field of sensation and perception, we would have had to present a “grocery list” of concepts and terms, each treated superficially. Such an alternative was unacceptable to us.

Each of the chapters has been written so that it is relatively self-contained and independent of the other chapters. When this is not completely possible, such as when material from other chapters is used in a discussion, the location of that information is always cited. This has been done to provide instructors with maximum flexibility in the sequence of chapter presentation. By altering the sequence in which chapters are presented, an instructor can impress his or her orientation upon the material. A brief appendix on some basic aspects of neurophysiology has also been provided, and may be used where needed.

We have organized the book by sensory systems, with the first half of the book covering the basic physiology and sensory responses and the second half covering those topics involving more complex and cognitive interactions. Chapters 1 and 2 provide an introduction to the problems of sensation and perception along with methodological and theoretical aspects of psychophysical measurement. Chapters 3, 4, and 5 cover the physiology and basic sensory qualities of vision; Chapters 6 and 7 do the same for audition; and Chapters 8 and 9 cover the chemical and mechanical senses. These first nine chapters thus cover the major topics usually grouped together under the heading of *sensation*. Chapters 10 through 15 cover the perception of space, form, speech and music, time and motion, perceptual constancies, and the perceptual aspects of attention. Chapters 16, 17, and 18 look at how individual factors such as age, experience, learning, gender, culture, drugs, and personality variables may affect the per-

ceptual response. Thus the last nine chapters cover the topics most frequently grouped together as *perception*.

Those of you who have encountered earlier versions of this book will notice that we have added a new author (James T. Enns). His insights have helped us to expand and update our coverage of the field, and he adds a bit of a new "flavor" to the writing. In our attempts to collect and interpret the information for this textbook, we have been assisted at various stages by a number of people. Specifically, we would like to thank the personnel of the University of British Columbia's *Human Neuropsychology and Perception Laboratory*, *Psychophysics Laboratory*, and *Attention Laboratory*, with special thanks to David Wong and Juliet Armstrong, for assisting with library work and all of the small but necessary chores that eat up innumerable hours of a textbook writer's time.

In addition, we would like to thank Barry S. Anton, University of Puget Sound; Ira H. Bernstein, University of Texas, Arlington; Janet D. Larson, John Carroll University; Robert M.

Levy, Indiana State University; Susan Petry, Adelphi University; Charles E. Sternhein, University of Maryland, College Park; and Benjamin Wallace, Cleveland State University, for their helpful comments and suggestions after reviewing this edition.

Finally, the reader might notice that there is no dedication page. This is not to say that we do not wish to dedicate the book to anyone. It reflects the fact that too many people have been important in our personal and professional lives to list on any single page (no matter how small the print). Perhaps it is best simply to dedicate this book to all of those researchers who have provided the knowledge that we have attempted to organize and review between these covers, and to all of those researchers who will provide further insights into sensation and perception for future authors to collate, review, digest, wonder at, and learn from.

S.C.  
L.M.W.  
J.T.E.

# Contents

## **PREFACE / V**

## **CHAPTER 1 SENSATION AND PERCEPTION / 3**

Aspects of the Perceptual Process / 12  
Theories of Perception / 13  
The Plan of the Book / 15

## **CHAPTER 2 PSYCHOPHYSICS / 19**

Detection / 21  
Identification / 33  
Discrimination / 39  
Scaling / 46

## **CHAPTER 3 THE VISUAL SYSTEM / 65**

Light / 66  
The Structure of the Eye / 66  
Neural Responses to Light / 79  
The Visual Pathways / 84  
The Visual Cortex / 90

## **CHAPTER 4 BRIGHTNESS AND SPATIAL FREQUENCY / 103**

Photometric Units / 104  
Factors in Brightness Perception / 107  
Visual Acuity / 114  
Spatial Frequency Analysis / 118

Spatial Context Effects / 129  
Temporal Context Effects / 136  
Darkness Perception / 139

## **CHAPTER 5 COLOR / 145**

Color Stimulus / 146  
The Physiology of Color Vision / 156  
Color Perception / 169

## **CHAPTER 6 THE AUDITORY SYSTEM / 181**

Sound / 182  
The Structure of the Ear / 187  
Electrical Activity of the Auditory Nerve / 201  
The Auditory Pathways / 204  
The Auditory Cortex / 207

## **CHAPTER 7 HEARING / 213**

Detection of Sounds / 214  
Subjective Dimensions of Sounds / 231  
Auditory Scene Analysis / 245

## **CHAPTER 8 TASTE AND SMELL / 253**

The Gustatory (Taste) Sense / 254  
The Olfactory (Smell) Sense / 267

## CHAPTER 9 TOUCH AND PAIN / 285

The Skin Senses / 286  
Touch / 293  
Kinesthesia / 301  
Warmth and Cold / 307  
Pain / 313

## CHAPTER 10 SPACE / 327

Types of Depth Perception / 328  
Pictorial Depth Cues / 329  
Physiological Cues for Depth / 338  
Motion and Motion Parallax / 339  
Binocular Depth Perception / 341  
Interaction of Depth Cues / 351  
Perception of Direction / 354  
Development of Space Perception / 357

## CHAPTER 11 FORM / 365

The Problem of Visual Form Perception / 366  
Contour Detection and Feature Extraction / 368  
Perceptual Organization / 375  
Object Recognition and Identification / 390  
Theories of Object Identification / 398

## CHAPTER 12 SPEECH AND MUSIC / 407

Music / 408  
Speech / 417

## CHAPTER 13 TIME AND MOTION / 443

Time / 444  
Motion / 453

## CHAPTER 14 THE CONSTANCIES / 483

The Task of Perception / 484  
Perceptual Constancies / 486  
Size Constancy / 487  
Shape Constancy / 497  
Lightness or Whiteness Constancy / 501  
Color or Hue Constancy / 504  
Other Constancies / 506

## CHAPTER 15 ATTENTION / 511

Varieties of Attention / 512  
Orienting / 512  
Filtering / 521  
Searching / 528  
Expecting / 539  
Theories of Attention / 542

## CHAPTER 16 DEVELOPMENT / 549

Perception in Infants / 550  
Perceptual Change through Childhood / 565  
Perceptual Change in Adults / 571

## CHAPTER 17 LEARNING AND EXPERIENCE / 579

Experience and Development / 580  
Sensory-Motor Learning / 588



Context and Meaning / 595  
Environmental and Life History Differences /  
601

## **CHAPTER 18**

### **INDIVIDUAL DIFFERENCES / 617**

Physiological Differences / 618  
Gender Differences / 627  
Personality and Cognitive Style Differences /  
632

## **APPENDIX**

### **PRIMER OF NEUROPHYSIOLOGY /**

### **639**

Neurons and the Nervous System / 640  
The Nature of Neural Activity / 641  
Techniques to Measure Neural Function /  
643

## **REFERENCES / 649**

## **AUTHOR INDEX / 717**

## **SUBJECT INDEX / 735**

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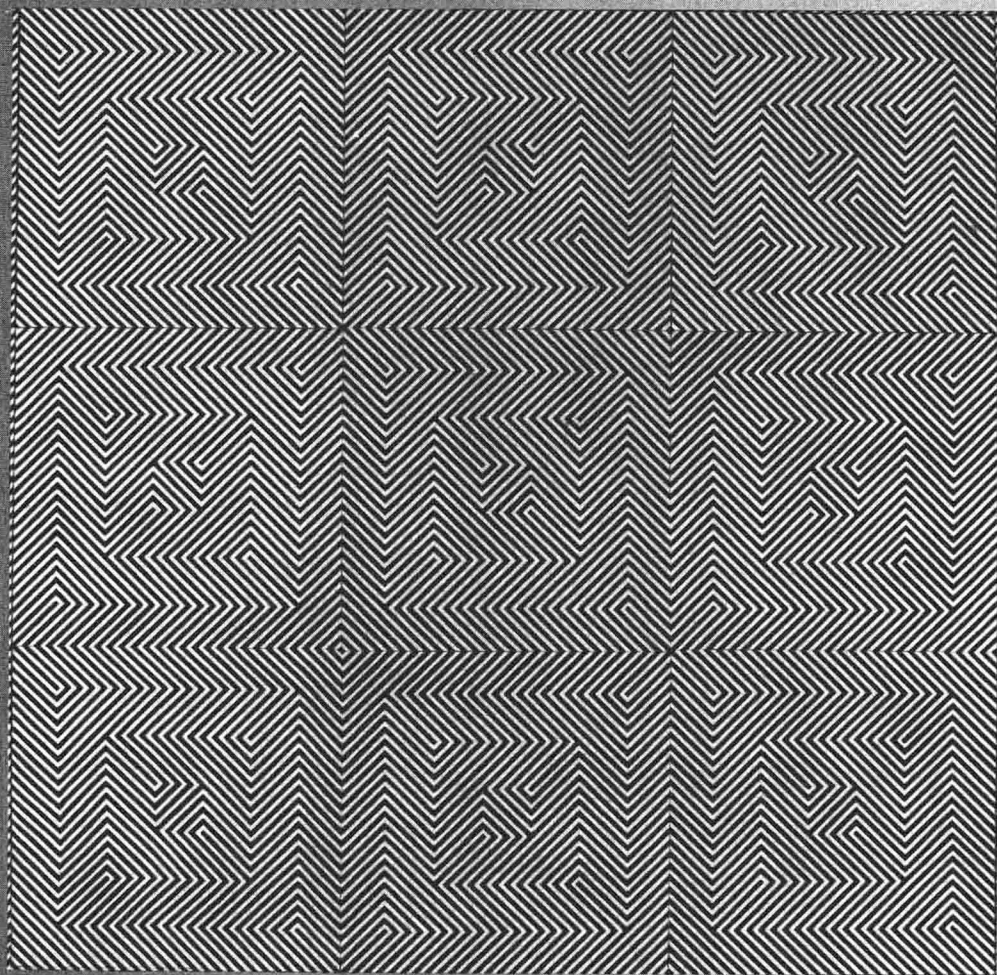
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# SENSATION AND PERCEPTION

Aspects of the Perceptual Process

Theories of Perception

The Plan of the Book

*Chapter ...*

**C**an you answer the following questions? What color is the sky? Which is warmer—fire or ice? Which tastes sweeter—sugar or vinegar? Which has a stronger smell—burning wood or burning rubber? Which sounds louder—a chirping bird or the crack of a rifle? Such questions probably seem quite trivial, and the answers obvious. Well, perhaps we should phrase the questions differently. How do you know what color the sky is? How do you know how hot fire is relative to ice? How do you know that sugar is sweet? Again, you might feel that the answers are obvious. You see the color of the sky, you feel the temperatures of a flame and an ice cube, and you taste the sweetness of sugar—in other words, the answers come through your senses.

Let us push our questioning one step further. How do you know anything about your world? You might say that you learn from books, television, radio, films, lectures, or the actual exploration of places. And how do you obtain the information from these sources? Again, the answer is through your senses. In fact, without your senses of vision, hearing, touch, taste, and smell, your brain, the organ that is responsible for your conscious experience, would be an eternal prisoner in the solitary confinement of your skull. You would live in total silence and darkness. All would be a tasteless, colorless, feelingless, floating void. Without your senses, the world would simply not exist for you. The philosopher Thomas Hobbes recognized this fact in 1651 when he wrote, “There is no conception in man’s mind which hath not at first, totally or by parts, been begotten upon the organs of sense.” The Greek philosopher Protagoras stated the same position around 450 B.C. when he said, “Man is nothing but a bundle of sensations.”

You may protest that this is a rather extreme viewpoint. Certainly, much of what we know about the world does not arrive through our eyes, ears, nose, and other sense organs.

We have complex scientific instruments, such as telescopes, that tell us about the size and shape of the universe by analyzing images too faint for the human eye to see. We have sonar to trace out the shape of the sea bottom, which may be hidden from our eyes by a hundred feet of water. We have spectrographs to tell us about the exact chemical composition of many substances, as compared to the crude chemical sensitivity of our noses and tongues.

Although such pieces of apparatus exist to measure phenomena not directly available to our senses, this does not alter the fact that it is the *perception of the scientist* that constitutes the subject matter of every science. The eye of the scientist presses against the telescope or examines the photograph of the distant star. The ear of the scientist listens to the sound of sonar tracing out the size and distance of objects, or the scientist’s eyes read the sonograph. Although the tongue of the scientist does not taste the chemical composition of some unknown substance, the eye, aided by the spectrograph, provides the data for analysis. Really, the only data that reach the mind of the scientist come not from instruments but from the scientist’s senses. The instrument he or she is looking at can be perfectly accurate, yet if the scientist misreads a digital readout, or does not notice a critical shift in the operation of a measurement device, the obtained information is wrong and the resulting picture of the world is in error. The minds of the scientist, the nonscientist, our pet dog sniffing about the world, or a fish swimming about in a bowl—in fact, the minds of all living, thinking organisms—are prisoners that must rely on information smuggled in to them by the senses. Your world is what your senses tell you. The limitations of your senses set the boundaries of your conscious existence.

Because our knowledge of the world is dependent on our senses, it is important to know how our senses function. It is also important to



know how well the world that is created by our senses corresponds to external reality (that is, the reality measured by scientific instruments). At this point, you may be smiling to yourself and thinking, "Here comes another academic discourse that will attempt to make something that is quite obvious appear to be complex." You might be saying to yourself, "I see my desk in front of me because it is there. I feel my chair pressing against my back because it is there. I hear my phone ringing because it contains a bell that makes sounds. What could be more obvious?" Such faith in your senses is a vital part of existence. It causes you to jump out of the way of an apparently oncoming car, thus preserving your life. It provides the basic data that cause you to step back from a deep hole, thus avoiding a fall and serious bodily harm.

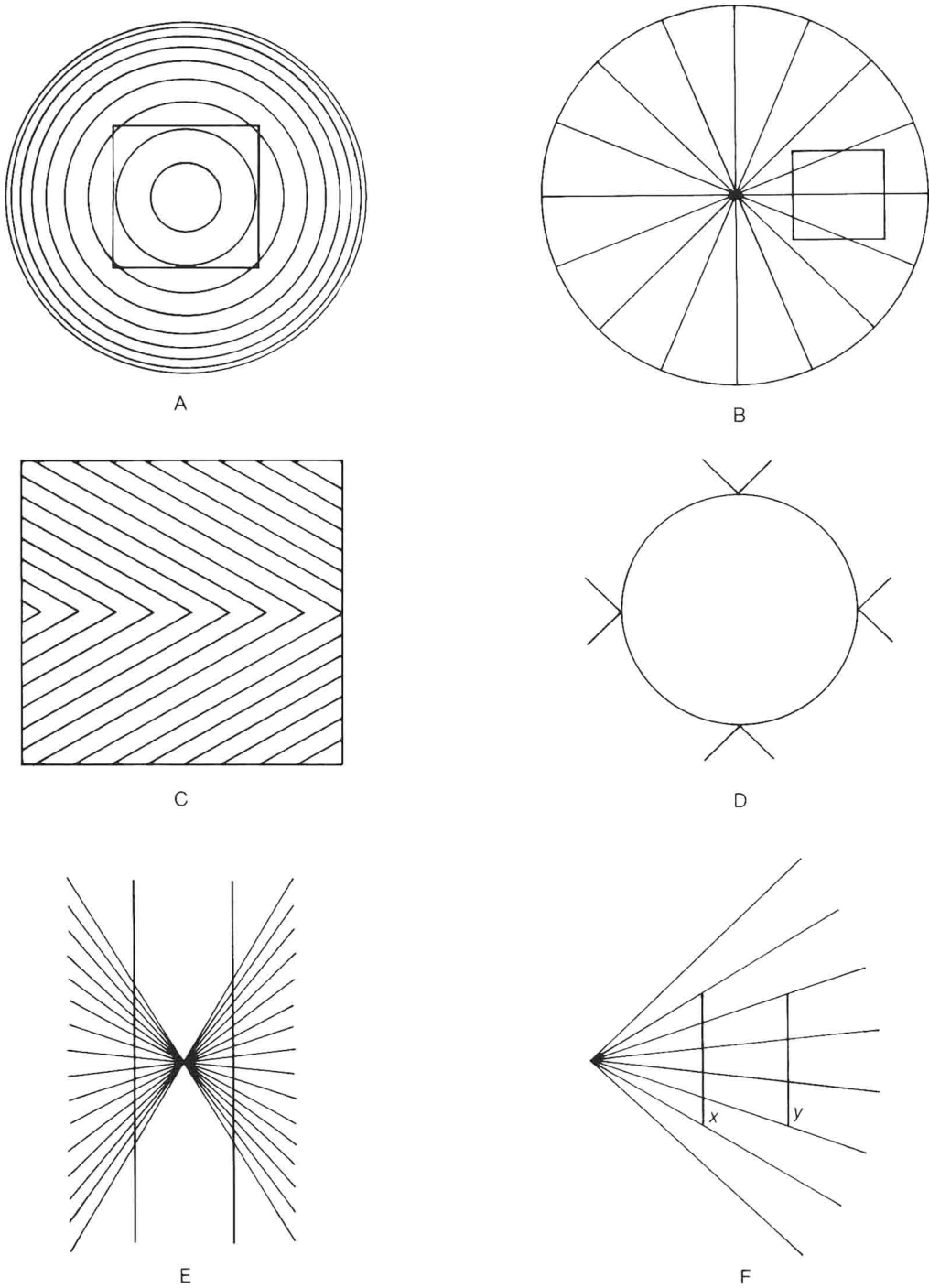
Such faith in our senses is built into the very fabric of our lives. As the old saying goes, "Seeing is believing." Long before the birth of Christ, Lucretius stated this article of faith when he asked, "What can give us surer knowledge than our senses? With what else can we distinguish the true form from the false?" Perhaps the most striking example of this faith is found in our courts of law, where people's lives and fortunes rest solely on testimony via the eyes and ears of witnesses. A lawyer might argue that a witness is corrupt or lying, or even that his memory has failed, but no lawyer would have the audacity to suggest that her client should be set free because the only evidence available was what the witnesses saw or heard. Certainly no sane person would charge the eye or ear with perjury!

The philosophical position that perception is an immediate, almost godlike knowledge of external reality has been championed not only by popular sentiment, but also by philosophers of the stature of Immanuel Kant (1724–1804). Unfortunately, it is wrong. Look at the drawings shown in Figure 1-1. Clearly, they are all com-

posed of outlined forms on various backgrounds. Despite what your senses tell you, A, B, and C are all perfect squares. Despite the evidence of your senses, D is a perfect circle, the vertical lines in E are both straight, and the lines marked X and Y in F are both the same length.

The ease with which we use our senses—seeing, apparently through the simple act of opening our eyes, or touching, apparently by merely pressing our skin against an object—masks the fact that perception is an extremely sophisticated activity of the brain. Perception calls on stores of memory data. It requires subtle classifications, comparisons, and myriad decisions before any of the data in our senses become our conscious awareness of what is "out there." Contrary to what you may think, the eyes do not see. Many individuals have perfectly functioning eyes yet have no sensory impressions. They cannot perceive because they have injuries in those parts of the brain that receive and interpret messages from the eyes. Epicharmus knew this in 450 B.C. when he said, "The mind sees and the mind hears. The rest is blind and deaf."

"So what?" you mutter to yourself. "So sometimes we make errors in our perceptions. The real point is that the senses simply carry a picture of the outside world to the brain. The picture in the brain represents our percept. Of course if we mess up the brain we will distort or destroy perception." Again, this answer is too simple. If we look outside and see a car, are we to believe that a picture of a car is present somewhere in our brain? If we notice that a traffic light is green, are we to believe that some part of the brain has turned green? And suppose such images were present in the brain, carried without distortion from the senses—would this help us to see? Certainly, images in the brain would only be of value if some other eyes in the head would look at these pictures and interpret them. If this were the case, we



**Figure 1-1** Some instances where the senses tell lies.

would be left with the question of how these internal eyes see. Thus, we would eventually be forced to set up an endless chain of pictures and eyes and pictures and eyes, because the question of who is perceiving the percept, and how, still remains.

If we are to understand perception we must consider it in its natural context. Sensation and perception are some of the many complex processes that occur in the continuing flow of individual behavior. No clear line exists between perception and many other behavioral activities. No perception gives direct knowledge of the outside world; rather such knowledge is the end product of many processes. The wet-looking black spot on the edge of a desk could be the place where ink was spilled. Of course, this percept could be wrong. The ink may be dry, or the spot might not be there at all. The desk that is seen and touched might not really exist. We might be dreaming, drugged, or hallucinating. Too extreme, you say? Consider the following example that actually happened to one of the authors of this textbook. One night he walked across the floor of his darkened home. In the dim gloominess of the night, he saw his dog resting on the floor, clearly asleep. When he bent to touch the dog, he found that it was a footstool. He stepped back, somewhat startled at his stupidity, only to bump against the cold corner of a marble-topped coffee table. When he reached back to steady himself, he found that the corner of the table was, in fact, his dog's cold nose. Each of these perceptions—dog, stool, table, and dog again—seemed, when first received in consciousness, to be accurate representations of reality. Yet, sensory data are not always reliable. Sometimes they can be degraded or not completely available. No sudden break seems to occur between perceiving or sensing an object and guessing the identity of an object. In some respects, we can say that all perception of objects requires some guessing. Sensory stimu-

lation provides the data for our hypotheses about the nature of the external world, and it is these hypotheses that form our perceptions of the world. The importance of what we have been discussing is that no matter how convincing a percept may be, it still may be wrong, as is shown in Demonstration Box 1-1.

Many human behaviors have been affected by the fallible and often erroneous nature of our percepts. For example, the most elegant of the classic Greek buildings, the Parthenon, is bent. The straight, clean lines, which bring a sense of simple elegant grandeur, are actually an illusion. If we schematically represent the east wall of the building as it appears, it is square (as shown in Figure 1-2A). Actually, the Parthenon was built in a distorted fashion in order to offset a series of optical illusions. As a result of a common visual distortion, we find that placing angles above a line (much as the roof is placed over the architrave) causes the line to appear slightly bowed. One form of this illusion is shown as Figure 1-2B, where the ends of the horizontal line appear slightly higher than the center. If the Parthenon were built physically square, it would appear to sag as a result of this visual distortion. This is shown in an exaggerated manner in Figure 1-2C. The sagging does not appear, because the building has been altered to compensate for the distortion. Figure 1-2D illustrates what an undistorted view of the Parthenon would look like. The upward curvature is more than 6 cm on the east and west walls and almost 11 cm on the longer north and south sides.

The vertical features of the Parthenon (such as the columns) were inclined inward in order to correct for a second optical illusion in which the features of rising objects appear to fall outward at the top. Thus, if we projected all of the columns of the Parthenon upward, they would meet at a point somewhat less than 2 km above the building. Furthermore, the corner columns were made thicker because when



### DEMONSTRATION BOX 1-1 The Fraser Spiral

Look at the figure here. It clearly looks like a spiral, converging toward the center. How much would you be willing to bet that it is a spiral? On the basis of your perception alone, would you ever believe that it is actually a set of concentric circles? It actually *is* a set of circles, and you can verify this for yourself. Place one finger on any line making up the “spiral”. Place a finger from the other hand beside it, and carefully trace the line around with this finger while not moving the

first finger. Eventually the moving finger will come back to the stationary one, since the lines that appear spiral are all part of a set of concentric circles (see Fraser, 1908; Stuart & Day, 1988; Taylor & Woodhouse, 1980, for variations of this illusion). This shows that no matter how convincing a perception might be, since it is based on an *interpretation* of the stimuli reaching us, our conscious experience may be wrong.

