Schiff Perception: An Applied Approach

Perception: An Applied Approach

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Preface

This book is concerned with how we can and do use our senses to apprehend our world and our relation to it. It treats these topics in both a traditional manner and a functional manner. The first approach is that of classical psychophysics. The latter approach is similar to the functional psychophysics proposed by James J. Gibson and Eleanor J. Gibson. They have stressed how we may use our senses to obtain useful information found in natural environments and their representations. The approach stressed in this book is clearly indebted to their conception of perceptual processes.

For whom is this book meant? It is intended for persons who have taken an introductory psychology course and want to know more about perception and its applications than is available in introductory texts. It is meant for undergraduate psychology majors and for graduate students or practitioners in such fields as psychology, education, communication, industrial psychology, engineering psychology, nursing, and special education. It should provide useful information for persons who are not perceptual scientists, but who are contemplating thesis research involving perceptual tasks or tests. Its approach is primarily practical and broad, rather than theoretical and specialized.

Unlike many books dealing with perception, this book is not a comprehensive review of perceptual theories. It cites and discusses some theories and uses theory in the selection of topics and explanatory frameworks. It is impossible to discuss perception without reference to theory, but that is not the same as being *about* theories. The decision was made to limit theoretical treatments in order to keep the book to a manageable length and to develop an applied text. Many excellent theoretical approaches are already available.

Because some readers desire specifics, and because specifics often aid understanding, specifics have been included. Where the details are of a highly technical or discursive nature, they have been *set off* from the main text in special boxed sections. Some readers may elect to read some or all of these sections. Readers operating under time pressure, or reading for other purposes, may wish to read these sections later or not at all. Terminology is often explained in the text. Where it is not, the reader is referred to a comprehensive glossary provided at the end of the book.

Finally, the book contains numerous references that direct the interested reader to technical papers or more comprehensive treatments of certain topics. Such references are particularly useful to readers interested in research applications and thesis development. For convenience, they are provided as footnotes on the same page where the corresponding text footnote number appears rather than at the end of each chapter or the end of the book. A name index is also provided to aid in cross referencing and further research.

I am indebted to many psychologists and former professors for a good deal of what is in this book. I am especially indebted to James J. Gibson and Eleanor J. Gibson for their personal help and their intellectually stimulating approach to perceptual topics. And, I am now able to express proper gratitude to Ray Hartley, whose course in perception provided my first contact with the perceptual world. He may be the book's "first cause."

Several reviewers deserve credit for considerable improvements to the current manuscript over earlier versions: Peter E. Comalli, Temple University; Robert Fox, Vanderbilt University; William R. Mackavey, Boston University; Donald H. Mershon, North Carolina State University at Raleigh; and Joachim F. Wohlwill, Pennsylvania State University. Much of the balance and restraint found in the book is due to their helpful criticisms.

I am also grateful to New York University for their sabbatical policy, which provided me with much of the time required to complete a substantial portion of the work on this book.

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W.S.

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Perception: An Applied Approach

Sensory Perception and the Functions of Perceptual Systems

PART ONE

Perception involves being aware of the world, its characteristics, objects, places, and events. It involves obtaining information about the world with our sense organs and sense-organ systems. At first glance, this would seem to involve only the problems of how physical stimulus energies (light, sound, mechanical pressure) reach our sense organs and are somehow transduced into neural impulses to give our brains coded information about the world and our relation to it.

However, perceptual processes are not so simple. If they were, neuroanatomists and neurophysiologists would have all the answers to perceptual questions. The histories of perceptual psychology and the neurosciences suggest otherwise. Many questions concerning how we come to sense and know our worlds are barely formulated — much less answered.

The field of perception is one of the oldest in psychology. There is an abundance of facts, hypotheses, and theories (large and small) concerned with how *we get information about the world,* what *information we get, and what we* do *with it after it reaches our nervous systems. Surprisingly, none of these facts, hypotheses, or theories (large or small) is clearly sufficient to account for perceptual experience or perceptual behavior.*

The philosophical foundations of much of perceptual psychology are found in associationistic empiricism, *best developed by Bishop George Berkeley in the eighteenth century.*[1] *It is primarily from these foundations that most psychologists developed the view of perceptual processes as a matter of associating meanings to cores of sensations, which are in themselves meaningless consequences of stimulation by physical dimensions of energy. These foundations led, in part, to analyses such as those provided by* classical sensory psychophysics, *which examines the relationships between parameters of physical energy on the one hand (physics) and of perceptual experience on the other (psycho-), to yield the science of psychophysics.*

Classical psychophysics asks questions pertaining to the minimum amount of energy or minimum difference in amount of energy the eye (ear, skin) can detect. The psychologist manipulates the intensity of light, for example, under ideal or "noisy" field conditions to determine the minimum amount of energy or difference in amount of energy required for an observer to report "I hear it" ("see it," "smell it," "feel it") 50 percent of the time. From these data the psychologist then plots a series of curves that express absolute thresholds *for minimum amounts of energy and* differential thresholds *for minimum differences in amounts of energy. Such absolute and differential thresholds can be stated for intensities, wavelengths, frequencies, and other dimensions of light or sound. They can be stated for pressures applied to the skin and for chemical concentrations applied to taste or olfactory receptors. We have rather good data for a wide variety of stimulus conditions.*

But we need to know not only what sorts of information analyzed into constituent intensities, wavelengths, durations, pressures, and the like the senses can respond to; we also need to know what sorts of information the senses ordinarily do *respond to. Recognizing this need, J. J. Gibson has proposed a* functional *approach to sensory-perceptual sensitivity, an approach stressing the* useful *dimensions of sensitivity.*[2] *Functional analysts, such as Gibson, are interested in how we distinguish one object or surface from another, not just in the two-point threshold or intensive threshold for the skin. It is possible to consider senses as* information *detectors, not just* energy *detectors.*[3] *Table 1 presents Gibson's version of the dimensions of interest to a functional approach when studying the senses, and it further suggests what information is obtained by the senses in each case.*

Functional approaches to sensory-perceptual processes are provocative. But most studies of the subject have followed the classical psychophysical model rather than a functional model. The result is that data from functional approaches are currently too sparse to yield an adequate picture of perceptual processes.

This section of the book, then, will consider data from both approaches, rather than selecting data from one approach to the exclusion of the other.

TABLE 1 The perceptual systems

SYSTEM	*MODE OF ATTENTION*	*RECEPTIVE UNITS*	*SENSE*	*ACTIVITY OF THE ORGAN*	*STIMULI AVAILABLE*	*EXTERNAL INFORMATION OBTAINED*
Basic orienting	*General orientation*	*Mechano-receptors and gravity-receptors*	*Vestibular organs*	*Body equilibrium*	*Forces of gravity and acceleration*	*Direction of gravity, being pushed*
Auditory	*Listening*	*Mechano-receptors*	*Ear*	*Orienting to sounds*	*Vibration in the air*	*Nature and location of vibratory events*
Haptic	*Touching*	*Mechano-receptors and possibly thermo-receptors*	*Skin, joints, and muscles*	*Exploration of many kinds*	*Deformations of tissues* *Configurations of joints* *Stretching of muscle fibers*	*Contact with the earth* *Mechanical encounters* *Object shapes* *Material states; solidity or viscosity* *Heat or cold*
Taste-Smell	*Smelling*	*Chemo-receptors*	*Nose*	*Sniffing*	*Chemical composition of the medium*	*Nature of odors*
	Tasting	*Chemo- and mechano-receptors*	*Mouth*	*Savoring*	*Chemical composition of ingested objects*	*Nutritive and biochemical values*
Visual	*Looking*	*Photo-receptors*	*Eyes and the ocular system*	*Accommodation* *Pupillary adjustment* *Fixation, convergence* *Exploration*	*Light, and variables of structure in ambient light*	*Information about objects, animals, motions, events, and places*

Source: Adapted from The Senses Considered as Perceptual Systems, *by James J. Gibson. Copyright © 1966 by James J. Gibson. Reprinted by permission of Houghton Mifflin Company. Revised by A. H. Buss,* Psychology: Man in Perspective, *1973. By permission of John Wiley & Sons, Inc.*

The same plan is carried through the rest of the book. Functional limits of perceptual systems are often related to absolute and differential sensitivities of sense organs, but they are seldom equivalent. The passive sense organ of the classical psychophysical study may not produce data typical of the active sense organ functioning as part of a perceptual system. By perceptual system *is meant a system that provides us with meaningful information about the world and our relation to it. A* sensory system *may be considered one that responds to the classical variables of physics, the gram-centimeter-second dimensions of energy.*[4] *The anatomy of the eye, ear, or skin does* *not necessarily give us a grasp of how a perceptual system gathers information about the world. But we should be familiar with basic structures.*

Part 1 presents some relatively basic information regarding our major senses. Some of it is anatomical, although I have purposely refrained from stressing this aspect of perception. More of it is psychophysical, describing the sensitivities (or one kind of sensitivity) of our major senses: vision, audition, touch, kinesthesis, vestibular sensitivity, and the so-called chemical senses — smell and taste. This section should provide the reader with a broad view of the anatomical arrangements of the senses and a knowledge of the classical sensitivities of these systems. Some of this material will be a foundation for what will come in later chapters. Along with this basic information, some recent and some not-so-recent applications are introduced. The list of applications is hardly exhaustive. The list grows daily. But noting some of these applications should not only inform you but also make your study of perception more real, more rewarding, more useful, and perhaps even more memorable.

A number of discoveries coming from classical psychophysics are extremely important in applied fields. Knowing the limits of sensory or perceptual systems permits engineers to design equipment optimally suited for the human operator's capabilities, as well as for environmental and cost demands. Classical threshold functions are useful for detecting and diagnosing sensory deficits. Color blindness, hearing losses, and visual acuity problems are but a few examples. Questions regarding the optimum brightness of television or cathode-ray tubes used to present material for instructional purposes must be posed according to what is known about visual sensitivities. Questions pertaining to the optimal type sizes or optimal sizes and lengths of messages on road signs must be answered largely with data from appropriate studies of reading and print legibility. Even placement of stereo speakers in one's living room can benefit from the information presented in this section.

Finally, there is the question of defining perception. *What is our definition of the processes discussed in this book? There are almost as many definitions of perception as there are writers on the subject. Definitions usually differ as functions of theoretical bias. Gibson, for example, has defined* perception *as the process by means of which we maintain contact with the environment or obtain information about the world.*[5] *Forgus has defined it more simply as information extraction.*[6] *Realizing that no definition of perception — simple or complex — will be entirely satisfactory, let me provide two that will be used as a basis in this book. Perception involves awareness of objects, events, scenes, and their representations in the environment and sometimes within our bodies, such awarenesses having arrived through the senses in the very recent past. Perception also involves searching for, obtaining, and sometimes processing information.*

[1] G. Berkeley, *An essay towards a new theory of vision* (London: J. M. Dent and Sons, Ltd., Everyman's Library Edition, 1957; originally published, 1709).

[2] J. J. Gibson, The useful dimensions of sensitivity, *American Psychologist, 18* (1963), 1–15; J. J. Gibson, *The ecological approach to visual perception* (Boston: Houghton Mifflin, 1979).

[3] Ibid.

[4] J. J. Gibson, *The senses considered as perceptual systems* (Boston: Houghton Mifflin, 1966).

[5] Gibson, 1966; 1979.

[6] R. H. Forgus, *Perception: The basic process in cognitive development* (New York: McGraw-Hill, 1966); R. H. Forgus and L. E. Melamed, *Perception: A cognitive-stage approach,* 2nd ed. (New York: McGraw-Hill, 1976).

Chapter 1

The Visual System

FUNCTIONS OF VISION

When we think of perception, we usually think first of visual perception. This is probably because most of us gather so much information about the world and the objects and events in it with our visual systems. Except for our listening to speech, the preponderance of our everyday activity is visually guided. Almost automatically, we reach for a cup of coffee, thread our way through people on sidewalks, steer our automobiles, and watch hours of television programming. And sometimes we read. It is not surprising that the largest proportion of knowledge and theory in the perceptual areas has dealt with visual perception. In our day-to-day commerce with the world, vision is the most important sense modality. It not only guides our motor behavior in terrestrial space and gives us information concerning what is out there and where it is, but vision also provides us with information about what is going on beyond the direct grasp of our senses through the mediation of photographs, television images, and printed language. Furthermore, our judgments about the emotional states, intentions, likes and dislikes, and social roles of others are based in large part on our visual perceptions.[1] It is little wonder that visual perception is and has been the major

[1] M. Argyle, *Social interaction* (Chicago: Aldine-Atherton, 1969).

interest of physiologists, psychologists, and even philosophers curious about how we obtain information about the world. Many books on perception deal primarily or exclusively with visual perception, in spite of the fact that we rely on other perceptual systems for many sorts of information. For example, we primarily use the haptic-tactual system to determine such properties as the density or weight of an object or the softness, brittleness, or stickiness of some material. The freshness of a container of milk or cream is usually examined with the olfactory system. We cannot ascertain the temperature of liquids with the visual system until they are so cold that they freeze or so hot that they boil. The solidity of a possible locomotor surface, the smoothness of sandpapered wood, the presence of a wall stud behind the wall surface, all this is information we typically obtain with nonvisual modalities.

Two or more perceptual systems may be used to detect or quantify many properties. We can compare the viscosity of liquids by pouring them from one container to another and watching the rates at which the liquids transform their shapes and location. We can also stir the liquids with sticks or our fingers to feel their relative resistances. Such information is redundantly available to two or more perceptual systems, with one source of information confirming the other. But when the multiple sources of information are not in agreement, we often believe our eyes. Although there are exceptions, seeing is a major avenue for belief. This finding is, however, relatively recent in the history of perceptual psychology.[2] When an automobile approaches us, it provides optical, acoustical, and sometimes vibrational information of its approach. Which source of information we use depends on a number of factors, including the ongoing activity or task of the perceiver when the information arrives at the sensory system, learned habits of attention, and the relative sensitivities of the systems for those sorts of information. If the perceiver is a pedestrian, the vibration or noise may lead that person to direct his or her visual system toward the automobile. Visual information is then used to direct further motor behavior, whether it involves a rapid crossing of the street, a retreat to the curb, or a halt in ongoing locomotion. This example shows how the perceptual modalities may work sequentially and in concert, with vision providing the most relevant and accurate information for behavior.

In summary, humans tend to be vision-dominated, but there are many exceptions to this generalization. Vision is used predominantly in localizing objects in three- or two-dimensional space; in ascertaining the size, shapes, and distances of objects; and in guiding both locomotion and movements unrelated to locomotion. While vision functions in communication, it often plays a secondary role to audition. But, as you can see when you read this page, useful linguistic information is available from light patterns picked up by the visua system. Vision appears to be specialized for picking up spatial information and information from distant sources. But vision is no more limited to the processing of spatial information than audition is limited tc the processing of temporal information. As we shall soon discuss, there is useful spatial information in sound patterns, and there is registration of temporal information by the visual system. While vision is a distance sense, we also *look* to discover the nature and location of an object that is tickling our arm.

VISUAL STIMULI

In considering the nature of visual stimuli, we must first look at the simplest forms of energy capable of exciting visual receptors. While a visual system responds to *patterned* light, receptors of the visual system may respond simply to light. Physically, light is a portion of a far large spectrum of electromagnetic radiation. It may be conceived of as particles or as traveling in waves, including very long radio and television

[2] D. Freides, Human information processing and sensory modality: Cross-modal functions, information complexity, memory, and deficit, *Psychological Bulletin, 81* (1974), 284–310; I. Rock and C. S. Harris, Vision and touch, *Sc entific American, 216* (1967), 96–104.

waves and very short x-rays. Within this large spectrum of energy, there is a narrow range of energy capable of exciting visual receptors and producing visual experiences, the visible spectrum called *light*. Figure 1.1 shows how the visible spectrum fits into the larger spectrum of energy. The wavelengths of light (when we think of light in terms of waves) are related to our perceptions of color. Light intensity is related to our perceptions of brightness. There are relatively few radiant sources of visible energy in our environment. The sun, electric lamps, and other hot sources radiate visible light, but a far greater number of objects and surfaces *reflect* light. Figure 1.2 shows some of the primary ways that light may be reflected, absorbed, or transmitted in the environment, where it can ultimately be picked up by a visual system.

Objects that usually appear dark (black velvet, for example) absorb most of the light falling on them, and surfaces that usually appear light reflect most of the light falling on them. Polished surfaces reflect light

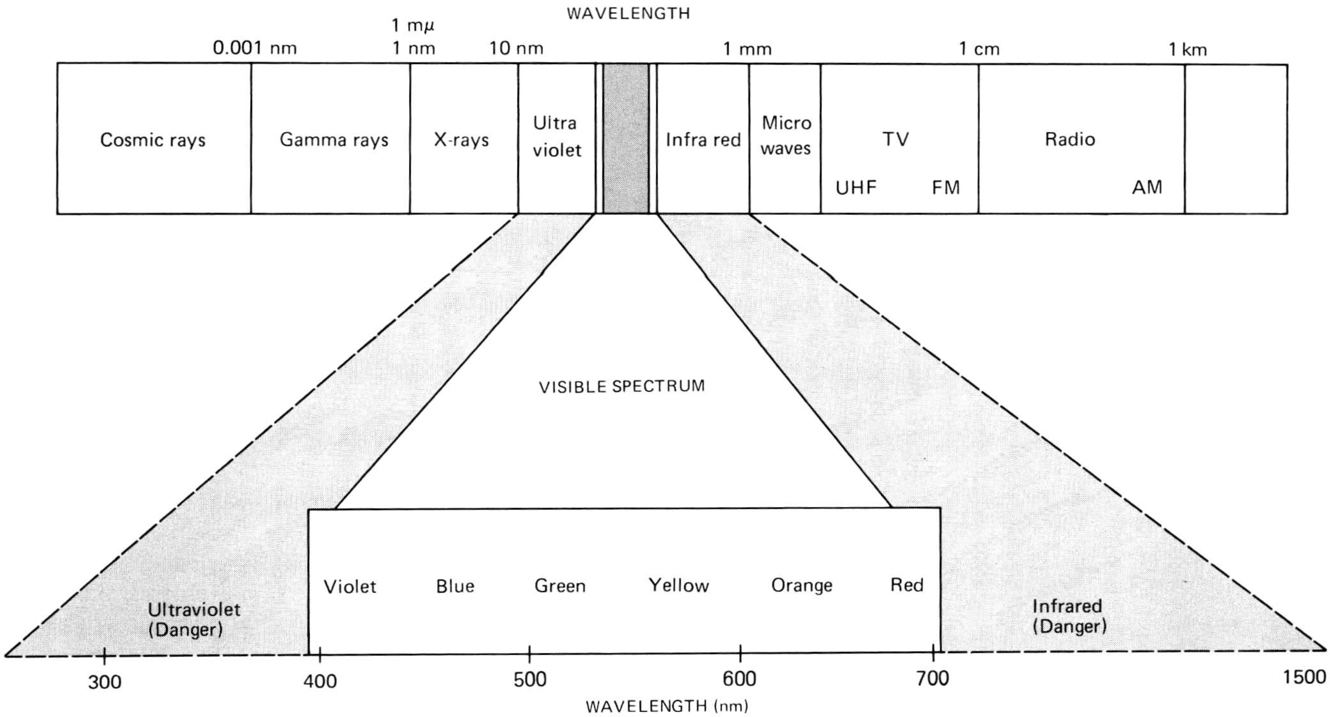

FIGURE 1.1 The spectrum of electromagnetic radiation: Its visible and invisible components.