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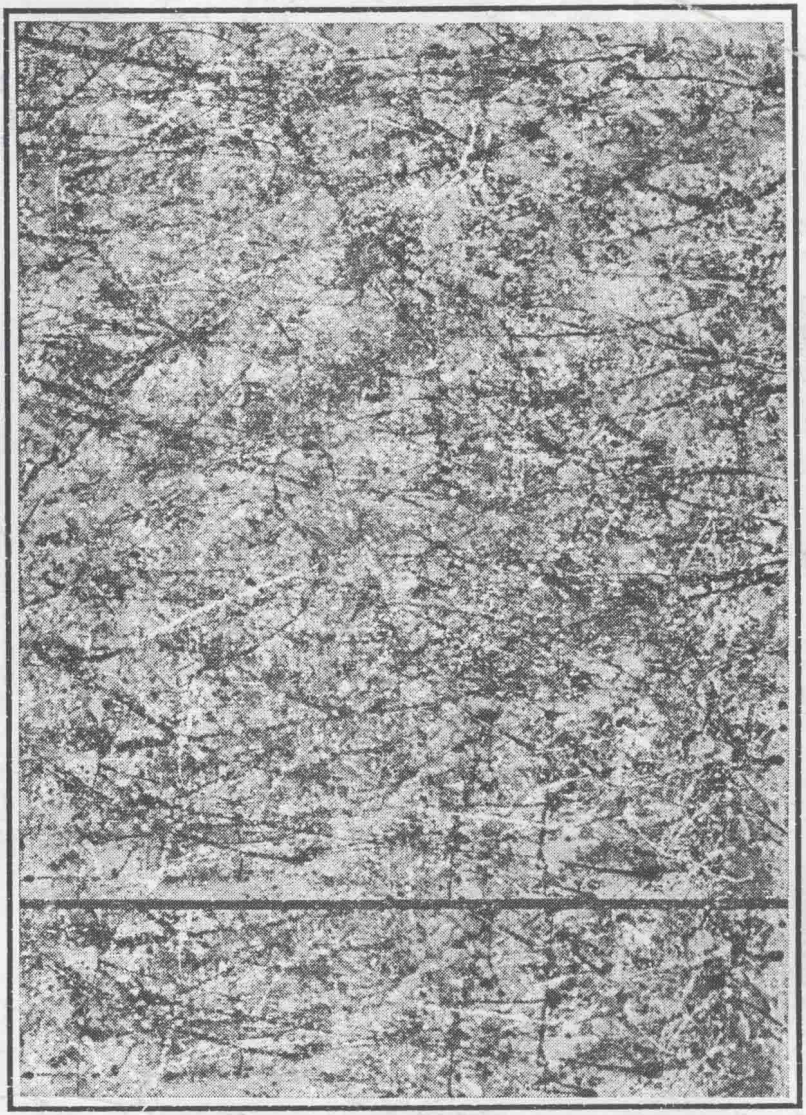

Theories of Learning

GORDON H. BOWER ■ ERNEST R. HILGARD

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Fifth Edition

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I dedicate this book to my students—past and present—
who have enriched my life with learning. —G.H.B.

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PREFACE

Psychology seems to be constantly in a state of ferment and change, if not of turmoil and revolution. In attempting to understand mental life, thousands of psychologists are continually proposing new perspectives, ideas, phenomena, experimental results, and investigative methods at a pell-mell pace. The professional often feels that he is drowning in a torrential flood of information and loses track of whether he is in a mainstream or a side eddy; the new student doesn't know where to enter the waters or in which direction to swim. In such situations, a time-tested method for reducing the information overload is to examine the genesis of major, integrative perspectives and to study their development into the contemporary research scene. The historical perspective provides a major organizing scheme for student and professional alike, since many of the "big questions" about mental phenomena were posed long ago, and the answers to the questions advanced by the historically prominent positions serve as prototypes, of which contemporary hypotheses can often be seen as sophisticated progeny.

The aim of this text is to provide the student with an understanding of modern learning theory, its historical context and background. To this end we review the theories of learning expounded by the major "schools" of psychology—behaviorism, gestalt, cognitivism, information-processing—as well as the learning theories associated with major intellectual figures such as Thorndike, Pavlov, Guthrie, Hull, Tolman, Skinner, and Estes.

Each theory is expounded in terms of its historical setting and the scientific problems that the theorist was addressing. As theoretical ideas are introduced, the salient experimental evidence related to them is briefly surveyed. Each theory is expounded initially from a sympathetic perspective. However, each chapter ends with a critical discussion and evaluation of the evidence for the theory's claims.

Comparing this new edition with the fourth edition, the reader will note many changes in content. As before, the first chapter introduces the philo-

sophical antecedents of psychology, contrasting the theories of mind advocated in philosophical Empiricism and Rationalism. Since these contrasting themes are powerful and recurrent, we have used them to reorganize the chapters of this new edition. The early chapters are examples of the Empiricist methodology: these are learning theories heavily influenced by associationism and behaviorism; included are chapters on Thorndike, Pavlov, Guthrie, Hull and the neo-Hullians, the Verbal Learning Tradition, Skinner, Estes, and Recent Developments in Behavior Theory. Following those are a contrasting set of examples of Rationalist theories: these are learning theories heavily influenced by ideas of organization and cognitive structure; included are chapters on Gestalt psychology, Tolman, Information-Processing theories, and Recent Developments in Cognitive Psychology. Following these two major sections are chapters surveying two related, important fields, the neurophysiology of learning, and applications of learning principles to education and instruction. Each chapter has been substantially revised and updated to show the contemporary relevance of the historical positions by citing current research that builds on the previous ideas.

Adoption of the Empiricism vs. Rationalism framework required recasting the form and focus of several chapters from the earlier edition. Thus, the chapter on Functionalism, which was always an inchoative maverick on the scene, has been rewritten as Human Associative Learning (Chapter 6) to emphasize its views on learning. It is grouped in the first set of chapters because the verbal learning tradition (the strongest modern issue from Functionalism) has always had an associationist cast. Since this book historically has been oriented around theorists rather than fields, the chapter on Mathematical Learning Theory has been rewritten so that it revolves around the theoretical writings of William Estes. More so than the efforts of others working in mathematical learning theory, Estes's stimulus sampling theory has the coherence and range that marks it as a global theory of learning in the tradition of Guthrie, Hull, and Tolman. Although each theory chapter mentions recent research of relevance to that theory, the two Recent Developments chapters survey research related to general issues addressed by a class of theories (behavioral vs. cognitive). Thus, Chapter 9 surveys recent developments in behavioral theories, including work on biofeedback control of involuntary responses, theories of Pavlovian conditioning, equilibrium theories of reinforcement, and applications of behavioral techniques to medical and psychiatric problems. Chapter 13 surveys recent work in cognitive psychology such as theories of short-term memory, depth of processing, imagery, episodic memory, semantic memory, story memory, and social learning. Chapter 15 on education has been thoroughly rewritten to emphasize the instructional techniques in education that have been suggested or supported by learning theory. We hope that with these changes, the text will provide a firm foundation for the student to understand and perhaps contribute to modern theories of learning or its applications.

Regrettably, the chapters on Piaget and Freud in the previous edition have been deleted from this edition, because a survey of teachers using the text indicated that those chapters were not being used in the typical course in learning theory.

This text can serve many instructional purposes and provide reading materials for a variety of standard college courses. It is tailored for a course (of one or two academic terms) on Learning Theory. Portions of the text will fit well into a course on History of Psychology (notably, chapters 1–7, 10–12). Instructors teaching learning classes who wish to emphasize phenomena or principles of conditioning and animal learning will find that a course can be built around Chapters 2–9, 11, and 14. If instructors wish to build their course around human memory and cognitive information processing, then the relevant material is in chapters 1, 6, 8, 10, 12, 13, and 15. Thus, the book should be viewed as a resource to be used in flexible ways. (We might note that for many years this text is more often cited and used than almost any other, as necessary for preparing for Ph.D. qualifying or certification exams in psychology.

Revising a comprehensive text is an extensive job, and we are pleased to acknowledge the help of several people. First, we were aided by Joyce Lockwood, who cheerfully endured the retyping of the several drafts of the manuscript. The manuscript was substantially improved by the high-quality copy editing of Larry Barsalou (a Stanford graduate student in psychology) and Robert Mony. The final shepherding of the manuscript into print was overseen by our production editor, Joyce Turner, and our editor at Prentice-Hall, John Isley. To all of them, we extend our sincere thanks.

G. H. B.
E. R. H.

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Related Fields

I
THE NATURE OF LEARNING THEORY

It is no secret that psychology developed out of philosophy. The really fascinating and absorbing questions of psychology were not "discovered" by modern psychologists, but rather have been matters of deep concern to philosophers for many centuries. Philosophical psychology began as an attempt to deal with the nature of man; later, psychology split off to become the "science of mental life." The questions were: What is mind, consciousness, awareness? What is the relation of the mind to the body? How does the mind develop from birth? How does it acquire knowledge of the world? How does it come to know other minds? To know itself? What drives us to action? What is the self? What produces continuity of personal identity? These and many other questions have provided the intellectual underpinning of modern psychology.

MEMORY AND KNOWLEDGE

This is a book about *learning* and *memory,* which is a branch of modern psychology. The study of learning and memory came from two philosophical sources: the analysis of knowledge (how we come to know things), and the analysis of the nature and organization of mental life. The first issue concerns what philosophers call *epistemology,* the theory of knowledge. The second issue concerns the nature and contents of our concepts, thought, images, discernments, reminiscences, and imaginations; the further question here concerns what operations, rules, or laws underlie these mental phenomena. The study of learning may be aptly called experimental epistemology, since learning and knowing seem related in the same way as a process is to its result, as acquiring is to a possession, as painting is to a picture. The close relation between the meanings of *learn* and *know* is obvious and can be found in any dictionary—say, the *American Heritage Dictionary:*

> *to learn* (verb): (1) to gain knowledge, comprehension, or mastery through experience or study. (2) To fix in the mind or memory; memorize. (3) To acquire through experience. (4) To become informed of, to find out.
>
> *to know* (verb): (1) To perceive directly with the senses or mind; apprehend with clarity or certainty. (2) To be certain of; accept as true

beyond doubt. (3) To be capable of, have the skill to do. Used with *know how* to do something. (4) To have a practical understanding through experience with something. (5) To experience, to be subjected to. (6) To have firmly secured in the mind or memory. (7) To be able to distinguish, recognize, discern. (8) To be acquainted or familiar with.

To *learn* means "to gain knowledge through experience"; but one of the meanings of "experience" is "to perceive directly with the senses," a meaning that appears initially in the definition of *know*. But *knowledge* is defined, among other things, as *learning* (erudition) and as familiarity or understanding gained through experience, and learning is defined as acquired knowledge. So we come full circle.

Consider the two further terms *memory* and *remembering*. *Memory* is the faculty of retaining and recalling past experiences, or the ability to remember, and *remembering* is defined as recalling an experience to mind or thinking of it again. These clearly form an interconnected cluster of concepts. More than that, in our everyday dealings, memory (or remembering) is one of the primary ways by which we know things and by which we support knowledge-claims. The status accorded in the law courts to testimony from firsthand witnesses attests to the evidential power-to-persuade of direct memories: "How do I know that John stole the money? Because I *remember* seeing him with his hand in the till." The existence of such memories constitutes a prima facie case for the knowledge-claim—unless other considerations enter to cause doubts. In fact, one of the earliest uses of the psychological study of memory was to undermine its validity for supporting knowledge-claims. These studies showed that many memories of remote events reported in testimony were inaccurate, distorted, and subjectively biased. These mistakes were especially likely in memories of emotionally laden crimes, fights, or disasters.

ALTERNATIVE EPISTEMOLOGIES

One of the most engaging issues within the theory of knowledge is the question of how concepts and knowledge arise, and what is the relation between experience and the organization of the mind. Two opposing positions on this matter are *empiricism* and *rationalism*. These have been constant combatants within the intellectual arena for centuries, and strong forms of them are still recognizable today in "scientific" psychology.

Empiricism

Empiricism is the view that *experience* is the only source of knowledge. Special emphasis is given to sensory experience, although some knowledge is derived from intellectual reflections regarding relations among experiences. Our ideas are derived from sense impressions, either as direct copies of sensory impressions (so-called simple ideas) or combinations of several simple or complex ideas. The sensory impression of an object (say, an orange) is decomposable into sensory qualities—sensations corresponding to its color, smell, size, texture, taste, and so on. These sensory qualities become connected (or "associated") in the mind because they occur closely together in time or in space as we interact with the object. The idea of an orange is complex, but reducible to interassociations among simpler, more primitive ideas. Further "knowledge" acquired about oranges can be expressed by associating this complex of ideas to the other relevant ideas—for example, that oranges are fruits and are edible.

Empiricism has the following features: (1) *sensationalism*, the hypothesis that all knowledge is derived through sensory experience; (2) *reductionism*, the thesis that all complex ideas are built up out of a basic

stock of simple ideas, and that complex ideas are in turn reducible to these simple ideas; (3) *associationism,* the thesis that ideas or mental elements are connected through the operation of association of experiences that occur closely together in time (contiguity), and (4) *mechanism,* the thesis that the mind is like a machine built from simple elements with no mysterious components.

Empiricism involves two basic learning mechanisms: (1) internal representations of simple ideas ("memory images") which originate by simply *copying* their corresponding sense impressions into the memory store; and (2) complex ideas are formed by connecting together in memory simple ideas that are experienced contiguously; they are connected by an associative bond. The memory that event A was followed immediately by event B is recorded in memory as an association from idea *a* to idea *b*. This is in effect copying into memory the fact of the co-occurrence of mental contents *a* and *b*. Such associations can record temporal or causal sequences of events, such as striking a match—lighting the match—heat—fire. Activating or reviving these associative sequences from memory is the presumed method by which the mind moves in thought from one idea to another. This method accounts for the order of succession in a chain of ideas during idle thinking or goal-directed thinking. To illustrate goal-directed thinking, suppose that the final event in a chain becomes a goal ("I want to eat ice cream"). Then thinking of that goal will call to mind an immediate precursor of it from the past ("Buy some at the shop"), and that thought in turn will bring to mind what must first occur in order to cause it ("Get money and go to the shop"), and so on. Thus, a goal-directed chain of ideas may unwind backward from effect to cause until it arrives at some action that can be performed now to initiate the thought-out sequence. Associative chains that reflect causal sequences can be used in two basic ways: they may run forwards from *a* to *b* to *c* to *predict,* anticipate, or expect future events from the present event or action; and they may run backwards from *c* to *b* to *a* to *explain* why event *c* happened or to *plan* how to bring *c* about. Predicting, explaining, and planning are fundamental skills by which we deal with the world, and the associative theory suggests ways to do these things.

Empiricists included in their theory of mind the notion of "reflection," whereby the mind supposedly can call up from memory several ideas, compare them, and arrive at some conclusion which would be recorded as another association. The idea of reflection was needed to explain how we gain knowledge by abstraction, inference, and deduction. By "abstracting" the common, critical properties out from the varying, accidental, nonessential properties, we form a general concept of a type of thing from experience together with a set of its widely varying examples. In deduction, we bring into conscious reflection a logical consequence of other things we know. Thus, if we know that Bill is taller than John, and John is taller than Pete, then upon reflection the mind can deduce (and store in memory) that Bill is taller than Pete. According to the empiricist doctrine, reflection is the only mechanism the mind has available to free itself from being a totally passive recorder of sequences of sensory impressions.

Empiricism and associationism as explanations of mental phenomena were greatly elaborated by such philosophers as Thomas Hobbes, John Locke, David Hume, James Mill, and John Stuart Mill. One development of particular interest concerned the laws of association-formation. Assuming contiguity of experienced events to be the necessary and sufficient condition for association-formation, the empiricists proposed that the *degree* of association (or amount of memory) would vary directly with the *vivid-*

ness of the experience, its *frequency,* its *duration,* and its *recency* (closeness in time) to the retention test. Such conjectures have generated much experimental research on learning and memory, and every learning theory deals with these factors in one way or another.

Associationism led to the experimental investigation of learning. The first experiments on human memory, by the German scientist Hermann Ebbinghaus (1885),[1] explicitly set out to test certain proposals of associationist doctrine; the first experimental monograph on animal learning, by Edward Thorndike (1898), was titled *Animal intelligence: An experimental study of the associative processes in animals.*

Developments within the American schools of psychology over the last seventy years have hardly altered the associationistic approach. Theories have become more precise, and much more detailed information has been accumulated. Also, the important roles of motivation, reward, and punishment in learning and performance have received greater systematic treatment than was accorded them in the classical associationist tradition. The behavioristic revolution, led by John Watson, substituted observable stimuli and responses for the mentalistic ideas and images of earlier times. But the associationistic cast of the "acquisition mechanism" (or learning device) remained. It is thus fair to say that empiricism and associationism formed the mold into which contemporary learning theory has flowed and jelled—perhaps even solidified. Unfortunately, there appear to be several flaws in the assumptions of classical associationism, considered either as an epistemology or as a means for reconstructing the contents of mental life. These flaws become apparent when we examine the opposing epistemological position, *rationalism.*

[1] References are cited in parenthesis by year. The reference list is at the back of the book.

Rationalism

Rationalism is the general philosophical position that reason is the prime source of knowledge, that reason rather than sense data, authority, revelation, or intuition is the only valid basis for knowledge, belief, and action. In their writings, rationalist philosophers such as Descartes, Leibniz, and Kant confront empiricism at almost every turn. Rationalists have an entirely different perspective on the role of "sense data" in our construction of reality. For the empiricist, our ideas are passive copies of sense data; for the rationalist, sense data are unstructured, undifferentiated chaos and only provide raw material to an interpretive mechanism that considers these raw data as clues regarding their probable source and meaning. The raw data can be interpreted only according to certain forms—more precisely, according to certain classes of innate perceptual assumptions with which the mind begins.

What are these forms, these interpretive assumptions? Different rationalist philosophers have considered different notions as "self-evident" truths. One example of an interpretive assumption is that events always appear to us embedded in a temporal-spatial framework: physical events (and even most things we call mental events) occur at a particular time and at a particular place—or, at least, we cannot prevent ourselves from interpreting them in that way. Kant and Descartes thought that our knowledge of space was simply the projection onto the world of the "self-evident truths" of Euclidean geometry with which we were born. Kant rejected Bishop Berkeley's earlier empiricistic attempt to *derive* the perception of depth (of objects in three dimensions) and of the perceptual constancies from empirical correlations between sensations on the two-dimensional retina and the sense of touch—for example, reaching the hand to the object in view. This issue still absorbs the interest of psy-

chologists who study perceptual development (see T. G. R. Bower, 1965; E. J. Gibson, 1969), and recent evidence appears to favor the "innate" hypothesis of depth perception. That is, newborn infants appear to see objects in depth, and they perceive an object to be the same whether it is near or far from them, which changes its image on the retina.

Perceptual Organization

A general criticism rationalists have leveled against classical empiricism is that the empiricist theory of perception provides an inadequate account of the unitariness of percepts and the role relations play in creating perceptual unities. The rationalists claim that relations among elementary sense points are just as primary and psychologically vivid as the sense points themselves; we do not hear a series of tones but a coherent melody; we do not see a particular brightness but the ratio of reflectances between a spot and its surround; we do not see successive stills of an object's changing locations but its "continuous motion" through visual space. The color of an object "adheres" or sticks to its surface as an inalienable property of a unity: we do not sense "redness" and "apple," but rather the unity of "a red apple." Gestalt psychology, reviewed in Chapter 10, began as a revolt against the elementaristic and reductionist analyses of perceptual experience provided by classical empiricism. The Gestalters supposed that perceptual experience revealed "emergent" properties (e.g., apparent motion) not derivable from additive combinations of the properties of its elements (e.g., sequences of stills). Perceptions were said to become *organized* according to certain laws of segmentation, relational grouping, and simplicity; perceptual processes were said to seek out "good forms" and to impose such organizations and interpretations upon chaotic or amorphous "matter," to use Kant's term.

One example of an innate presupposition of the mind, according to Kant, is the notion of *causality* of events in time and space. The empiricist, David Hume, had earlier raised skeptical doubts about the concept of causality, arguing that "Event A causes B" was reducible primarily to "A is invariably followed by B." Kant argued instead that causality was just as basic or perceptually primitive an experience as temporal succession. Rationalists felt that the mind was preset to "project" causality into our interpretations of successive events in the world.

Modern experiments by Michotte (1954) and others suggest that people are strongly biased to ascribe causality to perceptual events related in tightly specified ways. For example, if people watch a movie depicting a red ball moving left to right and touching a resting black ball, which then moves left to right off the edge of the screen, they do not see the two objects as moving independently. Rather they have a powerful experience of causality, of the red ball "colliding with and launching" the black ball. The perception depends critically upon the timing of the beginning motions of the red and black balls and the correspondence of their two paths of motion. Depending on these factors, perceivers see the red ball variously as launching the black one, or picking it up and carrying it, or chasing it, or moving independently of it. Such experiments suggest that perceptual judgments of causality are just as immediate and finely tuned as are judgments of brightness or color. These issues will be clarified in our later discussion of Gestalt theory, but the important point now is that Gestalt psychology began as a brand of philosophical rationalism.

Mental Organization

As we shall see, rationalism has been somewhat successful in its attack upon the doctrine of associationism (Anderson &

Bower, 1973; DeGroot, 1965; Duncker, 1945; Mandler & Mandler, 1964). For one thing, it is clear that "associations" between ideas carry with them information regarding the *type of relation* involved. For example, in our mind a restaurant is associated with eating, a glutton with eating, a fork with eating, and a steak with eating. But the unadorned "associative link" of the classical doctrine does not explain our knowing that the relation between the first pair of ideas is that of *location* to action, the second pair of *actor* to action, the third pair of *instrument* to action, and the fourth pair of *object* to act. The mind requires a representation of knowledge wherein interassociated ideas are *labeled* according to their type of relation: for example, that *animal* is labeled as a superordinate of *bird,* that *canary* is a subordinate of *bird,* that *wings* or *feathers* are properties of *birds,* and that *sings* or *flies* are possible actions of birds. Such labeling seems necessary in order to conduct efficient searches through memory for information that meets certain requirements. For instance, it is not clear how the associationists' mental apparatus would answer any question of the form "What has relation R to concept X?" (e.g., "What is an instance of a bird?"). If associations are tagged with relational labels, then restricted searches and retrievals are possible. The way in which we use associations can be determined by instructions stating general goals ("Give me the opposite association of each word—up-*down,* left-*right,* tall-*short* . . ."); after a short while, these "determining tendencies" become unconscious, and automatically direct the associative process as it operates on the stimulus words (taking *heavy* into *light* and so on). Classical associationist doctrine has no way to represent the influence of these selective determining tendencies.

The associative theory of mind has been further criticized because it fails to explain how the mind imposes a structure onto incoming (sensory) perceptual data. That is, the theory provides no restrictions or constraints on what could be associated with what; there were no inherent principles for determining the "belongingness" of items of experience (see Thorndike's treatment of "belongingness" in Chapter 2), no restrictions regarding "well-formedness" of input structures. The rationalists argued that "raw experience" together with associative learning principles are not sufficient to prevent the accumulation of a disorganized mass of accidental vagaries that collapse in a booming, buzzing chaos of overwhelming particulars. Rather, certain "constraints" must be imposed (as innate forms or principles) in interpreting events; only hypotheses of particular forms are acceptable by the human mind.

Language Acquisition: A Rationalist's Example

Nowhere is this hypothesis of innate constraints advanced more vigorously than in certain modern accounts of how children acquire their first language. Linguists such as Chomsky (1972), Lenneberg (1967), and McNeill (1970) argue that empiricist assumptions are inadequate in principle to account for the learning of the linguistic competence shown by every native speaker. The language learner must learn a fantastically complex and abstract set of rules for transforming strings of speech sounds into meanings, and vice versa. Modern analyses of linguistic competence illustrate just how abstract are the grammatical rules that children exemplify in their dealings with language—in judging whether utterances are grammatical, whether they are unambiguous, and whether two sentences mean the same thing. The problem for the empiricist is that this abstract and complex language competence seems to be learned more or less uniformly by all children at about the same early age with relatively little variation (ignoring dialects). The problem is compounded by the fact that recordings of

adult utterances to preverbal children reveal many halts, slips, grammatical mistakes, fragmentary utterances, hems-and-haws, changing of sentences in mid-utterance, and utter nonsense. In short, from a grammatical point of view, the speech input to preverbal children is noisy slop. Moreover, the parent-as-trainer tends to react to a child's utterance according to its intention, use, or truth or falsity rather than its approximation to good grammar. A typical scenario is: "Daddy went store?" "No, he went to the office"; "Daddy office?" "Yes, that's right: Daddy office." Such episodes hardly seem optimal for the child to learn the rules of grammar.

The paradox is how our linguistic competence, which seems to be governed by this abstract set of grammatical rules, could ever be learned from such chaotic linguistic inputs. In rejecting empiricist accounts, Chomsky (1972) argues that the child must begin life innately endowed with a small set of *linguistic universals* as regards both some basic concepts and some basic principles. Examples of basic concepts would be the twenty-odd distinctive features of speech sounds (see Jakobson et al., 1963) out of which all known languages compose their vocabularies; or the grammatical concepts of subject and predicate. Examples of principles would be those that distinguish the deep logical structure of an utterance from its surface phonological, or sound, form (see Chomsky, 1972, for discussions of these terms). Similar components—concepts and rules—are found in all natural languages studied so far: they appear *universal* to human language. The theory is that these abstract principles of universal grammar are part of the child's innate endowment, that they provide an interpretive schema to which any particular language must conform. Chomsky states this argument as follows:

> . . . it seems that knowledge of a language—a grammar—can be acquired only by an organism that is "preset" with a severe restriction on the form of grammar. This innate restriction is a precondition, in the Kantian sense, for linguistic experience, and it appears to be the critical factor in determining the course and result of language learning. The child cannot know at birth which language he is to learn, but he must know that its grammar must be of a predetermined form that excludes many imaginable languages. Having selected a permissible hypothesis, he can use inductive evidence for corrective action, confirming or disconfirming his choice. Once the hypothesis is sufficiently well confirmed, the child knows the language defined by this hypothesis; consequently, his knowledge extends enormously beyond his experience and, in fact, leads him to characterize much of the data of experience as defective and deviant (1972, p. 91).

Chomsky proposes that the guiding metaphor for language acquisition should be not learning but *maturation,* rather like embryonic development of sense organs and limbs under the guidance of the genetic DNA codes within the embryo. The child's "speech apparatus" develops with appropriate triggering events and exposure to a language community, just as any biological organ requires an appropriate milieu for its development.

Chomsky makes no pretense of having discovered a full set of linguistic universals (Greenberg, 1962) or of having provided the details of how specific linguistic hypotheses are formulated (in what language?) and tested. He does argue, however, that such a framework has much more chance of advancing our understanding of language acquisition than the empiricist-associationist account, which has impressed him and other linguists as simply false.

Final Comments on Rationalism

Here, then, we have specific examples of rationalism and their persuasive force. As Kant (1781, p. 1) wrote: "Although all our knowledge begins *with* experience, it by no means follows that it all originates *from* experience." For real knowledge it is necessary to presuppose a certain framework of thought relationships over and above the

raw sense data. You may ask, How did the mind come to acquire these innate structures that one is led to attribute to it? One can answer, "natural selection"—on the premise that the mind is the way it is because it helps the individual adapt to the way the world truly is (less fortunate innate endowments having been eliminated during biological evolution); or one can answer at a deeper level that the exact processes by which the innate organization of the human organism evolved are still a total mystery.

Rationalism, Empiricism, and Modern Learning Theory

The foregoing discussion of empiricism and rationalism provides some background for comparing modern learning theories. All behavioristic theories of learning are also associationistic: they include those of Thorndike, Pavlov, Guthrie, Hull, Skinner, and the school of functionalism. These schools developed out of the combination of associationism with hedonism.[2] Gestalt psychology and the newer information-processing approaches to psychology are clearly at the rationalist end of the spectrum. Tolman's brand of cognitive psychology straddles the fence on several important matters. Mathematical psychology, at least stimulus-sampling theory, is associationistic, although nothing inherent in the use of quantitative theories requires that orientation.

Let us now return to the central topic of this chapter—namely, learning—and note some of the important distinctions that have grown up around this concept. Concept formation in science progresses by drawing distinctions and classifying cases, and so it is with the concept of learning.

[2] In the seventeenth and eighteenth centuries, a great deal of thought was given to human interests, values, and motivations as reasons for action. This was connected with developments in utility theory (see Bernoulli, 1738; Bentham, 1789), which extended the doctrine of *hedonism*. Hedonism asserts that each individual is motivated by the desire for pleasures and by aversion from pain and deprivation. Modern learning theories like Hull's (Chapter 5) can be regarded as the offspring of the intellectual traditions of associationism and hedonism.

CHARACTERIZATION OF LEARNING

Learning, as we noted before, is often concerned with the acquisition of knowledge. *Acquisition* refers to a *change* in "possession." At one time, the organism did not "possess" a given bit of knowledge; at a later time, it did. What caused that acquisition? At a minimum, something had to happen to the organism to change its state of knowledge. Typically we suppose that the organism had some specific experience that caused or was in some way related to the change in its knowledge state; either the world put some sensory information into it, or it may have tried out some action and observed the consequences, or it may have thought out a proof of a geometry theorem, or any number of other events.

What is the nature of the knowledge that the organism learns? This can be quite varied—as different as there are different ways of knowing and different contents to be known. The simplest knowledge in anyone's memory is merely a biographical "event record": an event of a particular description happened to me at such-and-such a time in such-and-such a place. This is frequently phrased as storage of a "copy" of sensory experiences, a metaphor so old that even Plato used it. One problem (among several) with the copy, or "image," theory of memory is that in remembering a scene, one usually sees oneself as an actor in the scene—which, of course, could not have been the sense impression one experienced on that occasion. Perhaps it is better to say merely that the organism can be conceived of as "storing a description" of the event that occurred. Typical events might be: "My dog Spot bit the postman,"

"Henry kissed Anne," or "The word *pencil* was presented to me by the experimenter." In the make-believe world of talking animals, Pavlov's dog might say to itself, "The bell was followed by food"; and the giant axon of a squid on a dissecting table might say, "Irritation of my nerve ending is followed by a hell of a shock." Suppose that such event descriptions or event sequences are stored in memory: although they are not profound items of wisdom, they are nonetheless bits of an organism's knowledge about its world.

So the experience causes a change in the organism's knowledge. Does it always change? Well, no; not always: we know the organism might have failed to learn for any number of reasons—perhaps it was not paying attention when the event occurred. So perhaps we had better relax the conditions to say that the experience *may* cause (probably causes) a change in the state of knowledge.

But Doubting Thomas asks, "How do you know that your subject has changed his or her state of knowledge?" Good question: how can you tell what somebody knows? Well, you could ask him or her, "Ahh, please, would you mind telling us what you know?" If the subject is a college professor, you will get no end of blather (sometime next week you'll have forgotten what the question was); if it's the giant axon of a squid, a deadly silence answers back. The question was poorly framed: you want rather to know whether the subject's knowledge about a *specific* event has changed as a result of a specific experience. So you try to frame specific questions—or specific "retrieval cues," as we say. You ask, "What did Spot do?" "Who kissed Anne?" "What word was presented to you by the experimenter a few moments ago?" "What event follows the bell?" "What follows axonal irritation?"

After asking the question, you wait for the subject to answer. What form does the answer take? He or she responds: she says something, he nods his head, she licks her chops, or it generates a synaptic potential. Question, answer; stimulus, response. From the response, we *infer* whether or not the subject has available the specific information of interest—or, at least, we find out whether our question gains access to that stored information. The word *infer* is used advisedly; whether or not somebody possesses a bit of information is not uniformly guaranteed either by our having presented the information to him or by his saying that he knows it (he could be lying or mistaken or have misunderstood the question). So we infer someone's knowledge from inputs to him and outputs from him, and we *infer* learning caused by an experience because of before-to-after changes in his inferred knowledge.

We may summarize our discussion by the sequence of events charted in Table 1.1.[3] This isolates the important happenings within a single learning episode (called a *trial),* going from a possible pretest through presentation of the information to be remembered, and trace formation (or acquisition), through retention, to retrieval and utilization of the stored information. We speak of the *memory trace* as being whatever is the internal representation of the specific information stored at time 2 in Table 1.1. The experiencing and new knowledge state at Times 2 and 3 are usually classified as *perception,* whereas memory, or *retention,* of the perceived information is tested after the retention interval spanning Time 3 to Time *n*. In different experiments, this interval can vary from several seconds to several years; when this interval is varied, we are studying *forgetting.* What is forgetting? That's simply your failing to remember something on a current test when we had reason to believe

[3] Tables and figures have double numbers, the first referring to the chapter number and the second to the figure or table within the chapter.