2

Theories of Learning

We know more about how animals (especially rodents and pigeons) learn than about how children learn; and we know much more about how children learn than about how adults learn. Perhaps this is because the study of learning was early taken over by experimental psychologists whose canons require a rigid control of variables. And it is obvious that the conditions under which animals learn are more controllable than those under which children learn; and the conditions under which children learn are much more controllable than those under which adults learn.

The fact is that most of the "scientific" theories of learning have been derived from the study of learning by animals and children.

Propounders and Interpreters

In general, there are two types of literature about learning theory: that produced by propounders of theories (who tend to be dogmatic and argumentative), and that produced by interpreters of theories (who tend to be reconciliatory). Just so you'll have a perspective on this literature, I have extracted from the sources I have been studying a list of the major propounders and major interpreters and displayed them in Table 2-1. To provide a sense of historical development, they are listed more or less in the order of

Table 2-1
Propounders and Interpreters of Learning Theory

Propounders	Interpreters
Ebbinghaus (1885)	
Thorndike (1898)	
Angell (1896)	
Dewey (1896)	
Pavlov (1902)	
Woodworth (1906)	
Watson (1907)	
Judd (1908)	
Freud (1911)	
Kohler (1917)	
Tolman (1917)	
Wertheimer (1923)	
Koffka (1924)	Kilpatrick (1925)
Pressey (1926)	
Guthrie (1930)	Rugg (1928)
Skinner (1931)	Hilgard (1931)
Hall (1932)	
McGeoch (1932)	
Lewin (1933)	
Piaget (1935)	
Miller (1935)	
Spence (1936)	
Mowrer (1938)	
Katona (1940)	Bode (1940)
Maslow (1941)	Melton (1941)
Festinger (1942)	Cronbach (1943)
Rogers (1942)	Brunner (1943)
Estes (1944)	Lorge (1944)
Krech (1948)	
McClelland (1948)	
Sheffield (1949)	
Underwood (1949)	
Dollard (1950)	Schaie (1953)
Tyler (1950)	Garry (1953)
	Koch (1954)
	McKeachie (1954)
	Birren (1954)
Bloom (1956)	Getzels (1956)

Table 2-1. Continued

Propounders	Interpreters
Bruner (1956)	Bugelski (1956)
Erikson (1959)	Kuhlen (1957)
Crowder (1959)	Kidd (1959)
Lumsdaine (1959)	Botwinick (1960)
Combs and Snygg (1959)	Miller (1960)
Ausubel (1960)	Glaser (1962)
Glaser (1962)	Flavell (1963)
Gagne (1963)	
	Hill (1963)
	Gage (1963)
	McDonald (1964)
Jourard (1964)	Goldstein (1965)
Suchman (1964)	Reese and Overton (1970)
Crutchfield (1969)	Goble (1971)
Friere (1970)	
Knowles (1970)	
Tough (1971)	
Houle (1972)	
Dave (1973)	
Loevinger (1976)	
Cross (1976)	
Botwinick (1977)	Howe (1977)
Gross (1977)	Knox (1977)
Srinivasan (1977)	
Cropley (1980)	Chickering (1981)
Mezirow (1981)	Darkenwald (1982)
Smith (1982)	Merriam (1982)
Wlodkowski (1985)	Brookfield (1986)
Daloz (1986)	

their appearance in the evolving body of literature. To keep the list within reasonable bounds, I have defined "major" as those who have made the greatest impact on the thinking of others as I sense the literature.

It must be admitted that the distinction between propounders and interpreters is not absolute. Some theorists, such as Pressey, Estes, Lorge, Gagne, Hilgard and Kuhlen, made contributions of both sorts and have been placed in the column representing their major work. It is interesting to note that the bulk of the theory-production

occurred in the first half of the century and that the bulk of the interpretation has appeared since 1950. Perhaps we have entered an era of integration. It is also interesting to note that both the theorists and interpreters from 1970 on have been concerned almost exclusively with adult learners.

Types of Theories

The proliferation of propounders has presented a major challenge to the interpreters in their quest to bring some sort of order into the system. In perhaps the most comprehensive interpretive work to date, Hilgard and Bower organize their review according to eleven categories.

Thorndike's Connectionism
Pavlov's Classical Conditioning
Guthrie's Contiguous Conditioning
Skinner's Operant Conditioning
Hull's Systematic Behavior Theory
Tolman's Sign Learning
Gestalt Theory
Freud's Psychodynamics
Functionalism
Mathematical Learning Theory
Information Processing Models

They then share their frustration in arranging these disparate categories into a pattern.

> Learning theories fall into two major families: *stimulus-response* theories and *cognitive* theories, but not all theories belong to these two families. The stimulus-response theories include such diverse members as the theories of Thorndike, Pavlov, Guthrie, Skinner, and Hull. The cognitive theories include at least those of Tolman and the classical gestalt psychologists. Not completely and clearly classifiable in these terms are the theories of functionalism, psychodynamics, and the probabilistic theories of the model builders. The lines of cleavage between the two families of theories are not the only cleavages within learning theories: there are other specific issues upon which theories within one family may differ. [Hilgard and Bower, 1966, p. 8]

McDonald breaks the theories down into six categories in his analysis:

Recapitulation (Hull)
Connectionism (Thorndike)
Pragmatism (Dewey)
Gestalt and field theory (Ogden, Hartman, Lewin)
Dynamic psychology (Freud)
Functionalism (Judd) [McDonald, 1964, pp. 1-26]

Gage identifies three families of learning theories: (1) conditioning, (2) modeling, and (3) cognitive. [Gage, 1972, p. 19] Kingsley and Garry, two sets: (1) association or stimulus-response (Thorndike, Guthrie, and Hull), and (2) field theories (Lewin, Tolman, and the gestalt psychologists). [Kingsley and Garry, 1957, p. 83] Taba agrees with the two-family set, but uses different labels: (1) associationist or behaviorist theories, and (2) organismic, gestalt, and field theories. [Taba, 1962, p. 80]

Obviously, the interpreters had not succeeded up to this point in organizing the field of learning theories in a really fundamental way—at least not in a way that satisfied most of them, and certainly not me. Then, in 1970, two developmental psychologists, Hayne W. Reese and Willis F. Overton, presented a way of conceptualizing the theories in terms of larger models, and the mist began to clear.

The Concept of Mechanistic and Organismic Models of Development

Reese and Overton start with the proposition, "Any theory presupposes a more general model according to which the theoretical concepts are formulated." The most general models are the world views or metaphysical systems which constitute basic models of the essential characteristics of man and indeed of the nature of reality. [Reese and Overton, 1970, p. 117]

Two systems which have been pervasive in both the physical and the social sciences are the *mechanistic* world view, the basic metaphor of which is the machine, and the *organismic* world view, the basic metaphor of which is the organism—the living, organized system presented to experience in multiple forms.

The *mechanistic model* represents the universe as a machine composed of discrete pieces operating in a spatio-temporal field. These pieces—elementary particles in motion—and their relations form the basic reality to which all other more complex phenomena are ultimately reducible. When forces are applied in the operation of the machine a chain-like sequence of events results; and, since these forces are the only efficient or immediate causes of the events, complete prediction is possible—in principle. As Reese and Overton point out, "A further characteristic of the machine, and consequently of the universe represented in this way, is that it is eminently susceptible to quantification." [*Ibid.*, p. 131]

When applied to the sphere of epistemology and psychology, this world view results in a *reactive*, passive, robot, or empty-organism *model of man*. The organism is inherently at rest; activity is viewed as the resultant of external forces. Psychological functions, such as thinking, willing, wishing, and perceiving, are seen as complex phenomena that are reducible to more simple phenomena by *efficient causes*. Change in the products or behavior of the organism is not seen as resulting from change in the structure of the organism itself.

> The appearance of qualitative changes is considered either as epiphenomenal (caused by another phenomenon) or as reducible to quantitative change, since the organism, like the elementary particles of classical physics, does not exhibit basic qualitative changes. [*Ibid.*, pp. 131-132]

The *organismic model* represents the universe as a unitary, interactive, developing organism. The essence of substance it perceives to be activity, rather than the static elementary particle proposed by the mechanistic model.

> From such a point of view, one element can never be like another, and as a consequence, the logic of discovering reality according to the analytical ideal of reducing the many qualitative differences to the one is repudiated. In its place is substituted a search for unity among the many; that is, a pluralistic universe is substituted for a monistic one, and it is the diversity which constitutes the unity. . .Thus, unity is found in multiplicity, being is found in becoming, and constancy is found in change. [*Ibid.*, p. 133]

The whole is therefore organic rather than mechanical in nature. "The nature of the whole, rather than being the sum of its parts, is presupposed by the parts and the whole constitutes the condition of the meaning and existence of the parts." [*Ibid.*] Accordingly, efficient cause is replaced by formal cause—cause by the essential nature of the form. Thus, the possibility of a predictive and quantifiable universe is precluded.

When applied to the sphere of epistemology and psychology, this world view results in an inherently and spontaneously *active organism model of man*. It sees man as an active organism rather than a reactive organism, as a *source* of acts, rather than as a collection of acts initiated by external forces. It also represents man as an organized entity.

> . . .a configuration of parts which gain their meaning, their function, from the whole in which they are imbedded. From this point of view, the concepts of psychological structure and function, or means and ends, become central rather than derived. Inquiry is directed toward the discovery of principles of organization, toward the explanation of the nature and relation of parts and wholes, structures and functions, rather than toward the derivation of these from elementary processes. [*Ibid.*, pp. 133-134]

> The individual who accepts this model will tend to emphasize the significance of processes over products, and qualitative change over quantitative change. . . . In addition, he will tend to emphasize the significance of the role of experience in facilitating or inhibiting the course of development, rather than the effect of training as the source of development. [*Ibid.*, p. 134]

With this and the preceding set of concepts as a frame of reference, let us turn to a brief examination of the theories about learning derived from the study of learning in animals and children.

Theories Based on a Mechanistic Model

The first systematic investigation in this country of the phenomenon we call learning was conducted by Edward L. Thorndike. It was a study of learning in animals, first reported in his *Animal Intelligence*, published in 1898.

Thorndike conceived learners to be empty organisms who responded to stimuli more or less randomly and automatically. A specific response is *connected* to a specific stimulus when it is rewarded. In this situation the stimulus, *S*, is entirely under the control of the experimenter (or teacher), and in large measure so is the response, *R*, for all the experimenter has to do to connect the particular *R* to a particular *S* is to reward the *R* when the organism happens to make it. This association between sense impressions and impulses to action came to be known as a bond or a connection. Thus, Thorndike's system has sometimes been called *bond psychology* or *connectionism*, and was the original stimulus-response (or S-R) psychology of learning.

Thorndike developed three laws which he believed governed the learning of animals and human beings: (1) the law of readiness (the circumstances under which a learner tends to be satisfied or annoyed, to welcome or to reject); (2) the law of exercise (the strengthening of connections with practice); and (3) the law of effect (the strengthening or weakening of a connection as a result of its consequences). In the course of a long and productive life (he died in 1949), and with help from many collaborators, both friendly and critical, Thorndike's system of thought became greatly refined and elaborated, and provided the subfoundation of the behaviorist theories of learning.

Soon after Thorndike started his work on connections in this country the Russian physiologist, Ivan Pavlov (1849-1936), inaugurated his experiments which resulted in the concept of conditioned reflexes. Hilgard describes his classical experiment.

> When meat powder is placed in a dog's mouth, salivation takes place; the food is the *unconditioned* stimulus and salivation is the *unconditioned* reflex. Then some arbitrary stimulus, such as a light, is combined with the presentation of the food. Eventually, after repetition and if time relationships are right, the light will evoke salivation independent of the food; the light is the *conditioned stimulus* and the response to it is the *conditioned reflex*. [Hilgard and Bower, 1966, p. 48]

Pavlov developed several concepts and accompanying techniques which have been incorporated into the behaviorist system. One was *reinforcement*, in which a conditioned reflex becomes fixed by following the conditioned stimulus repeatedly by the unconditioned

stimulus and response at appropriate time intervals. Another was *extinction*: when reinforcement is discontinued and the conditioned stimulus is presented alone, unaccompanied by the unconditioned stimulus, the conditioned response gradually diminishes and disappears. Another was *generalization*, in which a conditioned reflex evoked to one stimulus can also be elicited by other stimuli, not necessarily similar to the first. A fourth basic concept was *differentiation*, in which the initial generalization is overcome by the method of contrasts in which one of a pair of stimuli is regularly reinforced and the other is not; in the end, the conditioned reflex occurs only to the positive (reinforced) stimulus and not to the negative (nonreinforced) stimulus. Pavlov's system has been termed *classical conditioning* to distinguish it from later developments in *instrumental conditioning* and *operant conditioning*.

John B. Watson (1878-1958) is generally credited with being the father of behaviorism.

> The behaviorists, then and now, had and have in common the conviction that a science of psychology must be based upon a study of that which is overtly observable: physical stimuli, the muscular movements and glandular secretions which they arouse, and the environmental products that ensue. The behaviorists have differed among themselves as to what may be inferred in addition to what is measured, but they all exclude self-observation. [Hilgard and Bower, 1966, p. 75]

Watson placed emphasis on kinesthetic stimuli as the integrators of animal learning and, applying this concept to human beings, conjectured that thought was merely implicit speech—that sensitive enough instruments would detect tongue movements or other movements accompanying thinking.

Edwin R. Guthrie (1886-1959) built on the works of Thorndike, Pavlov, and Watson and added the principle of contiguity of cue and response. His one law of learning, "from which all else about learning is made comprehensible," was stated as follows: "A combination of stimuli which has accompanied a movement will on its recurrence tend to be followed by that movement." [Hilgard and Bower, 1966, p. 77] In his later work, Guthrie placed increasing emphasis on the part played by the learner in selecting the physical stimuli to which it would respond; hence, the importance of the attention or *scanning* behavior that goes on before association takes place.

Guthrie's system of thought was further clarified and formalized by his students, Voeks and Sheffield, but the next major advance in behaviorist psychology was the result of the work of B.F. Skinner and his associates. It is from their work that the educational technology of programmed instruction and teaching machines so popular in the 1960s has been derived. Skinner's ideas are summarized in Chapter 4.

Another development in behaviorist psychology occurring during the middle decades of the century was the construction of Clark L. Hull's *systematic behavior theory* and its elaboration by Miller, Mowrer, Spence, and others. Hull's theory is a conceptual descendant of Thorndike's, inasmuch as he adopted reinforcement as an essential characteristic of learning. Hull constructed an elaborate "mathematico-deductive" theory revolving around the central notion that there are intervening variables in the organism which influence what response will occur following the onset of a stimulus. He developed sixteen postulates regarding the nature and operation of these variables, and stated them in such precise terms that they were readily subjected to quantitative testing. Hilgard's assessment of the effect of Hull's work follows.

> It must be acknowledged that Hull's system, for its time, was the best there was—not necessarily the one nearest to psychological reality, not necessarily the one whose generalizations were the most likely to endure—but the one worked out in the greatest detail, with the most conscientious effort to be quantitative throughout and at all points closely in touch with empirical tests. . . .Its primary contribution may turn out to lie not in its substance at all, but rather in the ideal it set for a genuinely systematic and quantitative psychological system far different from the *schools* which so long plagued psychology. [Hilgard and Bower, p. 187]

His work also no doubt stimulated the rash of mathematical models of learning which were developed after 1950 by Estes, Burke, Bush, Mosteller and others—it should be pointed out that these are not themselves learning theories, but mathematical representations of substantive theories.

Theories Based on an Organismic Model

The first direct protest against the mechanistic model of the associationists was made by John Dewey in 1896. Although his

work falls into the category of educational philosophy rather than learning theory, his emphasis on the role of interest and effort and on the child's motivation to solve his own problems became the starting point for a line of theorizing that has been given the label *functionalism*. Translated into schoolroom practices, functionalism provided the conceptual basis for progressive education, which, as Hilgard states, "at its best was an embodiment of the ideal of growth toward independence and self-control through interaction with an environment suited to the child's developmental level." [Hilgard and Bower, 1966, p. 299]

The spirit of experimentalism fostered by functionalism is reflected in the work of such learning theorists as Woodworth, Carr, McGeogh, Melton, Robinson, and Underwood. The flavor of functionalism is summarized by Hilgard.

1. The functionalist is tolerant but critical.
2. The functionalist prefers continuities over discontinuities or typologies.
3. The functionalist is an experimentalist.
4. The functionalist is biased toward associationism and environmentalism. [Hilgard and Bower, 1966, pp. 302-304]

Edward C. Tolman (1886-1959) in a sense represents a bridge between the mechanistic and the organismic models. His system was behavioristic in that he rejected introspection as a method for psychological science, but it was *molar* rather than *molecular* behaviorism—an act of behavior has distinctive properties all its own, to be identified and described irrespective of the muscular, glandular, or neural processes that underlie it. But most importantly, he saw behavior as purposive—as being regulated in accordance with objectively determined ends. Purpose is, of course, an organismic concept. He rejected the idea that learning is the association of particular responses to particular stimuli. In contrast to the associationists, who believed that it is the response or sequence of responses resulting in reward that is learned, Tolman believed it is the route to the goal that is learned. He believed that organisms, at their respective levels of ability, are capable of recognizing and learning the relationships between signs and desired goals; in short, they perceive the significance of the signs. [Kingsley and Garry, 1957, p. 115] Tolman called his theory *pur-*

posive behaviorism, but Hilgard referred to it as *sign learning* and Kingsley and Garry as *Sign-Gestalt-Expectation Theory.*

The most complete break with behaviorism occurred at the end of the first quarter of the century with the importation of the notion of *insight learning* in the gestalt theories of the Germans Wertheimer, Koffka, and Kohler. They took issue with the proposition that all learning consisted of the simple connection of responses to stimuli, insisting that experience is always structured, that we react not to just a mass of separate details, but to a complex pattern of stimuli. And we need to perceive stimuli in organized wholes, not in disconnected parts. The learner tends to organize his perceptual field according to four laws.

1. *The law of proximity.* The parts of a stimulus pattern that are close together or near to each other tend to be perceived in groups; therefore, the proximity of the parts in time and space affects the learner's organization of the field.
2. *The law of similarity and familiarity.* Objects similar in form, shape, color, or size tend to be grouped in perception; and familiarity with an object facilitates the establishing of a figure-ground pattern. (Related to this law is the Gestaltists' view of memory as the persistence of *traces* in the brain which allows a carry-over from previous to present experiences. They view these traces not as static, but as modified by a continual process of integration and organization.)
3. *The law of closure.* Learners try to achieve a satisfying end-state of equilibrium; incomplete shapes, missing parts, and gaps in information are filled in by the perceiver. (Kingsley and Garry observe that "closure is to Gestalt psychology what reward is to association theory.") [1957, p. 109]
4. *The law of continuation.* Organization in perception tends to occur in such a manner that a straight line appears to continue as a straight line, a part circle as a circle, and a three-sided square as a complete square.

Gestalt psychology is classified by most interpreters as within the family of *field theories*—theories which propose that the total

pattern or field of forces, stimuli, or events determine learning. Kurt Lewin (1890-1947) developed what he referred to specifically as a *field theory.* Using the topological concepts of geometry, Lewin conceptualized each individual as existing in a *life space* in which many forces are operating. The life space includes features of the environment to which the individual is reacting—material objects he encounters and manipulates, people he meets, and his private thoughts, tensions, goals, and fantasies. Behavior is the product of the interplay of these forces, the direction and relative strength of which can be portrayed by the geometry of vectors. Learning occurs as a result of a change in cognitive structures produced by changes in two types of forces: (1) change in the structure of the cognitive field itself, or (2) change in the internal needs or motivation of the individual. Because of its emphasis on the immediate field of forces, field theory places more emphasis on motivation than any of the preceding theories. Lewin felt that success was a more potent motivating force than reward and gave attention to the concepts of ego-involvement and level of aspiration as forces affecting success. He saw change in the relative attractiveness of one goal over another, which he called *valence,* as another variable affecting motivation. Since some of the strongest forces affecting an individual's psychological field are other people, Lewin became greatly interested in group and institutional dynamics; and, as we shall see later, it is in this dimension of education that his strongest influence has been felt.

The most recent development in the field theoretical approach has appeared under several labels: phenomenological psychology, perceptual psychology, humanistic psychology, and third-force psychology. Since the bulk of the work with this approach has been with adults, major attention to it will be reserved for a later section. But two phenomenologists, Arthur Combs and Donald Snygg, have focused on the learning of children and the education of teachers of children so recently (1959) that their theories are not treated in most books on learning theory.

Since phenomenologists are concerned with the study of the progressive development of the mind—or, as our contemporaries would insist, the person—they see man as an organism forever seeking greater personal adequacy. The urge for self-actualization is the driving force motivating all of man's behavior.

> The adequate personality is one that embodies positive percepts of self, a clearly developing concept of self, a growing acceptance of self and identification with others, and finally a rich, varied, available perceptive field of experience. [Pittenger and Gooding, 1971, p. 107]

The flavor of Combs and Snygg's system of thought can be caught from statements from Pittenger and Gooding, 1971.

- Man behaves in terms of what is real to him and what is related to his self at the moment of action. [p. 130]
- Learning is a process of discovering one's personal relationship to and with people, things, and ideas. This process results in and from a differentiation of the phenomenal field of the individual. [p. 136]
- Further differentiation of the phenomenological field occurs as an individual recognizes some inadequacy of a present organization. When a change is needed to maintain or enhance the phenomenal self, it is made by the individual as the right and proper thing to do. The role of the teacher is to facilitate the process. [p. 144]
- Given a healthy organism, positive environmental influences, and a nonrestrictive set of percepts of self, there appears to be no forseeable end to the perceptions possible for the individual. [pp. 150-151]
- Transfer is a matter of taking current differentiations and using them as first approximations in the relationship of self to new situations. [p. 157]
- Learning is permanent to the extent that it generates problems that may be shared by others and to the degree that continued sharing itself is enhancing. [p. 165]

Two other contemporary psychologists, Piaget and Bruner, have had great impact on thinking about learning although they are not literally learning theorists. Their focus is on cognition and the theory of instruction. Piaget has conceptualized the process of the development of cognition and thought in evolutionary stages. According to him, the behavior of the human organism starts with the organization of sensory-motor reactions and becomes more intelligent as coordination between the reactions to objects becomes progressively more interrelated and complex. Thinking becomes possible after language develops—and with it a new mental organization. This development involves the following evolutionary periods:

1. *The formation of the symbolic or semiotic function* (ages two to seven or eight)—which enables the individual to represent objects or events that are not at the moment perceptible by evoking them through the agency of symbols or differentiated signs.
2. *The formation of concrete mental operations* (ages seven or eight to eleven or twelve)—linking and dissociation of classes, the sources of classification; the linking of relations; correspondences, etc.
3. *The formation of conceptual thought* (or formal operations) (ages eleven or twelve through adolescence)—"This period is characterized by the conquest of a new mode of reasoning, one that is no longer limited exclusively to dealing with objects or directly representable realities, but also employs 'hypotheses' . . . " [Piaget, 1970, pp. 30-33]

Some reservations have been expressed about the rigid age scale and minimization of individual differences in Piaget's schema, but his conception of evolutionary stages adds a dimension that is not generally given much attention in the established learning theories.

Jerome Bruner has also been interested in the process of intellectual growth, and his benchmarks were described on page 7. But his main interest has been in the structuring and sequencing of knowledge and translating this into a *theory of instruction*. But he does have a basic theory about the *act of learning*, which he views as involving three almost simultaneous processes: (1) acquisition of new information, often information that runs counter to or is a replacement of what the person has previously known, but which at the very least is a refinement of previous knowledge; (2) transformation, or the process of manipulating knowledge to make it fit new tasks; and (3) evaluation, or checking whether the way we have manipulated information is adequate to the task. [Bruner, 1960, pp. 48–49] We shall return to this theory of instruction in a later chapter.

The main criticism of Piaget, Bruner and other cognitive theorists by other adherents to the organismic model is that they are unbalanced in their overemphasis on cognitive skills at the expense of emotional development; that they are preoccupied with the aggressive, agentic, and autonomous motives to the exclusion of the homonymous, libidinal, and communal motives; and that they concern themselves with concept attainment to the exclusion of concept formation or invention. [Jones, 1968, p. 97]

In recent years new frontiers have been opened in such learning-related fields of inquiry as *neurophysiology* (M. Boucouvalas, K.H. Pri-

bram, G.A. Miller, J.F. Delefresnaye, H.F. Harlow, D.P. Kimble, W.G. Walter, D.E. Wooldridge, J.Z. Young); *mathematical modeling* (R.C. Atkinson, R.R. Bush, W.K. Estes, R.D. Luce, F. Restle); *information processing and cybernetics* (H. Borko, E.A. Feigenbaum, B.F. Green, W.R. Reitman, K.M. Sayre, M. Yovitts, J. Singh, K.O. Smith); *creativity* (J.P. Guilford, R.P. Crawford, J.E. Drevdahl, A. Meadow, S.J. Parnes, J.W. Getzels, P.W. Jackson); and *ecological psychology* (R.G. Barker, P.V. Gump, H.F. Wright, E.P. Willems, H.L. Raush). An example of how one of these frontiers, "whole brain learning," is being developed is presented in Appendix M. But to date these lines of investigation have resulted in knowledge that can be applied to existing theories about learning rather than producing comprehensive learning theories of their own.