Learning Foundation for Change

Introduction

Learning is an essential part of not only child development but also continues as an essential element of adulthood. This ability to continue to learn has become even more important with the rapid rate of change that is occurring in our society today. Acquisition and use of knowledge is an essential part of daily life and our understanding of learning processes can provide benefit to ourselves and those we interact with on a daily basis. Within this paper, the role learning theory plays in human development is examined from a number of scientific disciplines including biology, sociology, psychology, and information systems. While a great deal of past attention in learning theory has been on child development the intent here is to understand the basic learning processes that occur in childhood so as to better understand how these learning processes may continue to influence adult learning.

Over the history of the study of learning, many different disciplines have been involved. A number of early theories are briefly summarized here to establish a foundation of learning theory. More recent theories build on that foundation, building a firmer understanding of adult learning. Theories reviewed range from simple habituation to classical and operant conditioning to the more complex observational and transformational learning theories.

Overview of Learning Theory

Within the academic research, there are many definitions of learning. However, most involve some element of change. Cronbach says simply "learning is shown by a change in behavior as a result of experience" (Knowles, 1990, p. 6). In this and other similar definitions of learning, experience is used very broadly to be anything from simple conditioning to active involvement with the process itself. Beyond this simple definition researchers break learning into process, product, and function in both the extension of their definition and their approach to researching the subject. Process "emphasizes what happens during the course of a learning experience," whereas product "emphasizes the end result or outcome of the learning experience" (Knowles, 1990, p. 6). In both cases, the same phenomenon is studied with observation taking place either during or after the process itself. In the third approach to studying learning, function focuses attention on a specific functional area involved in learning "such as motivation, retention, and transfer, which presumably make behavioral changes in human learning possible" (p. 6). Gagne further breaks down learning processes into five domains: motor skills, verbal information, intellectual skills, cognitive strategies, and attitudes. (p. 9). The first two areas are more involved in the area of child development, whereas the later three areas have significant relevance in the area of adult learning as well as child development. Intellectual skills require prior learning of prerequisite skills and cognitive strategies require repeated occasions in which challenges to thinking are presented. In addition, the fifth learning domain of attitudes has direct impact on learning within the context of change. This is especially true within an organizational change process because attitudes are most effectively learned using human models and "vicarious reinforcement" (p. 9) and are thereby reinforced or extinguished within the organizational environment.

Within science, growth in knowledge occurs as an incremental process where new knowledge extends the existing knowledge base by adding additional insights and broader explanations. Not only does the history of learning theory support this point of view but the

process of cognitive development is also depicted in the same manner in how knowledge is captured and stored in the brain for later recall and use. This idea is embodied in Miller's theory of complex ideas where learning occurs with hierarchical building blocks with the simple building the complex. (Mazur, 1990, pp. 28-30) However, de Gelder observed that knowledge sometimes grows in a step-wise manner with a jump between stages. Likewise, scientific discoveries are sometimes ground breaking in their magnitude leaping from the foundation upon which they were built. (de Gelder, 1986, pp. 462-467) This idea of step-wise learning is supported by the different learning theories that involve learning stages. However, biological support is difficult without a separation of awareness of the capability from when such capability may have actually been developmentally accomplished.

Within this paper, a wide range of learning theories are discussed and compared. Some are foundational such as association and adaptation theory. Others described the various stages of learning, while classical and operant conditioning provide experimental study of learning components. Further, information-processing concepts can explain aspects of the learning processes. Finally, a brief overview of observational learning theory is presented. In evaluating the different theories presented, little of the theory presented is contradictory to other material and the differences more related to the area of learning studied and the approach taken. The approaches taken by learning researchers range from elementary description to controlled laboratory experiments and areas studied range from simple animals to humans, from reflexes to higher cognitive skills, and from memory functions to decision making.

Association Theory

Aristotle provided early thoughts on learning and could be called the first associationist though he never used the term. Together, his three principles form an early theory of association in memory processes for how one thought leads to another. These principles include elements of the similarity of concepts as well as the difference or contrast between concepts. His third principle involves contiguity as "the more closely together (contiguous) in space or time two items occur, the more likely will the thought of one item lead to the thought of the other" (Mazur, 1990, pp. 17-18). Associations as the core of learning was central to the theory developed by the British Associationists in the 17th to 19th centuries. While they did no experiments, they saw associationism as a unifying theory of knowledge. This group of researchers is also called the "British Empiricists because of their belief that every person acquires all knowledge empirically - that is, through experience" (p. 18). However, a subgroup might be called nativists because of their belief that some ideas are innate and do not necessarily depend on an individual's experience. From this group comes the foundation for some of the early work in experimental learning and the role evolution plays in molding organisms with highly developed systems capable of interacting with their environment. Collectively, this group of early researchers is closely aligned with the later cognitive psychologists studying observational learning, but without the experimental rigor seen later. (p. 24)

Much of this early work on the importance of associations in memory processes continues today to influence elements of observational learning and other disciples such as marketing and advertising. Thomas Brown's Secondary Principles of Association (Mazur, 1990, pp. 194-201) expands on Aristotle's earlier list and the work of other associationists:

- The length of time of the relationship influences the strength of the recall association.
- The liveliness or vividness of the image or concept affects the strength of the association. This closely relates to the attentional process that is involved in observational learning.
- The frequency with which the pairing occurs affects the strength of the association.
- Recent pairings have stronger associations that then fade with time.
- Prior associations can affect the establishment of new associations depending on the situation. In change, processes and transformative learning the existence of prior associations may either aid or hinder the creation of new associations. Some pairings may also be easier to establish due to innate defense responses or behavioral associations linked to basic survival such as a food link. Conditioning theory is closely related to this aspect of association.
- Different individuals may be constitutionally different in their ability to establish associations.
- The emotional state of the individual can affect the ability to establish associations.
- Likewise, the physical state of health or impairment, such as intoxication, can hinder the associative ability.
- Prior habits can also play a part in establishing strong associative pairings. This closely relates to the precursors that are needed for observational learning to take place.

The mechanism involved in establishing associations for memory recall or for problem solving is thought to be either geometric or featural in design. The geometric model has all memories being relative to all others with the closer the physical distance the stronger the relationship. One of the problems that occurs in the geometric model of topic categorization is that not all items are known to the same degree. Since all items should be more similar to itself than any other item, there is the problem of having different knowledge levels of assurance of similarity, which causes further problems when using the same scale of similarity for other items. Another problem with the geometric model is that the associative distance between two items should have the same degree of similarity in both directions. However, lesser-known items are judged more similar to better-known items and not the other way around. A further complication with the geometric model involves the possible relationships between multiple associations. For example, "a" may be similar to "b" and "b" may be similar to "c" but the relationship between "a" and "c" may not be known because the first two associations involve different criteria to describe the similarity. By adding another categorical criterion, the geometric model adds another dimension to the model. This creates the potential of having to use higher dimensional models to represent the relationships, which in turn would require higher cognitive skills than a memory model built on low-dimensional representations. Defenders of the geometric model of categorization counter that the model is more to describe probability of similarity and should not be held to a standard of direct judgement of similarity. (Smith, 1990, pp. 39-40)

In the featural approach, the number of descriptive features in common determines similarity between items. This commonality of features may remain at the abstract level or go so far as to include common group membership. While the membership categorization process produces strong associations it is difficult to apply where the relationship rules are established as abstract summaries and not discrete feature sets. It is also difficult to create sufficient membership groups to describe all combinations that may be necessary, especially those that arise from mental constructs and not necessarily from experience.

Within the featural model of categorization is the ability to overcome some of the limitations of the geometric model. As in the geometric model, better-known items are likely to have more known features and therefore have more relationships to lesser-known items than the other way around. However, an easy explanation is that the feature set is larger when well known and therefore more likely to have a feature match than trying to match to a smaller set of features in the lesser-known item. Similarly, the degree of similarity can be shown to be greater when comparing an item to itself since the feature set in the comparison will be the same and therefore identical in all comparisons. In the case of trying to establish relationships between "a" "b" and "c" each will have its own feature set that can be used to explain the degree of overlap and thereby explain the degree of similarity for the relationship. The same feature sets can be also used to explain areas of difference between "a" and "c." (Smith, 1990, p. 41)

Association theory is still an active area for research, especially for the phenomenon of forgetting. Associations in memory may have additional relationships with new stimuli or events that cause interference in recalling the original memory. In these situations, many instances of forgetting are more a case of retrieval failure where eventual memory retrieval is possible with repeated attempts or hints that retrieve other closely related associations. In this manner, any action or event that can trigger the memory later really has the power to aid in long-term memory by providing additional methods of retrieving the original memory. (Mazur, 1990, p. 252) A desirable aspect of forgetting is involved in transformative learning where existing memory associations must be replaced in order to complete the change process involved in the memory transformation process.

Stage Theories of Learning Development

Freud, Erikson, and Piaget have all approached human development from different disciplines but all have learning theories built on the concept of stair-step stages in developmental accomplishment. In addition to having different backgrounds there is also differences in their view of stage transition as being a smooth transition or discontinuous. There are also differences in the focus on being social, intellectual, or physical in origin as well as the role of evolutionary predisposition versus environmental nurturing. (Blake, 1995, p. 105)

Freud's best work on learning theory dates back to a "Project for a Scientific Psychology" which he wrote at the age of 39. He "ultimately disowned it and wanted it eradicated from his bibliography because the Project is completely outer-directed, with all the emphasis being placed upon the environment's impact upon the organism and the organism's reaction to it" (Anthony, 1989, p. 104). Viewed relative to current learning theory it "is surprising up to date with the latest developments in information theory and cybernetics" (p. 104). As a theory for learning it had "an active interchange with the environment, a memory system, procedures for reality testing and attention cathexes, and the presence of a range of cognitions such as judgment and . . . theoretical thought" (p. 105). However, while the Project created the foundation for much of Freud's later work further development of the learning theory was not attempted other than the learning component that is incidental to the stages of child development as theorized by Freud.

Within the context of developmental states, as one would expect, Freud's stages are psychosexual, centered on erogenous zones: oral, anal, phallic, latency prior to puberty, and the genital stage at adolescence. No additional stages are identified after adolescence but the

developmental failure at any one of these stages will need to be resolved at a later age for the person to meet the individual's full potential.

> According to Freud, a behavior can be understood only if one knows how it developed in the person's early history. . . . The early interactions between children's drives and their social environment set the pattern for latter learning, social adjustment, and coping with anxiety. (Miller, 1993, p. 123)

With the onset of each stage theorized to be biologically triggered there is also the possibility of developmental failure where the next phase of development starts prior to resolving all issues in the earlier stage. The unfinished development in the earlier stage then carries problems forward for later resolution. This possibility of overlapping stages is very different from that of Piaget's theory where each stage has a seamless transition to the next stage without interruption or overlap.

Erikson uses age breaks very similar to Freud's but describes the stages in psychosocial terms: trust, will power, initiative, competence, and identity. In addition, Erikson continues with developmental stages past childhood defining a young adulthood, maturity, and old age stages. These stages are tied to both the aging process and social role of parenthood. Young adulthood is associated with intimacy in the family unit versus individual isolation. The maturity stage is concerned with establishing and guiding the next generation versus developmental stagnation and self-absorption. This development goes beyond simply bearing children to include "faith in the future, a belief in the species, and the ability to care about others" (Miller, 1993, p. 166). The last stage Erikson describes is wisdom associated with old age and can vary between satisfaction and despair with one's life accomplishments.

Like Freud, Piaget's work identifies developmental stages in children and does not include the post-adolescent stages that Erikson includes. However, unlike Freud, Piaget has a greater number of stages, particularly in the first couple of years, which focus on motor skill development. "Each stage derives from the previous stage, incorporates and transforms that stage, and prepares for the next stage" (Miller, 1993, p. 39). The stages follow an invariant sequence and the transition into each phase is accomplished through an initial period of preparation with loosely organized structures that give way to a final period of achievement for that stage. In the early stages, there are numerous learning elements in early motor skill development including habit formation of repeating body movements for a desired effect, accidental discovery of interacting with nearby objects, and deliberate trial-and-error exploration. (pp. 42-51) At each stage transition, Piaget has identified a key test of developmental accomplishment. Moving from the early sensorimotor period (first 2 years of life) to the preoperational period (age two to seven) the test shifts from motor skill accomplishment to the use of language or other mental symbols to stand for an object or event. (p. 51) At this stage the child is very egocentric with rigidity of thought and by focusing on one feature, the child will miss other key elements. Reasoning skills are also unidirectional with the inability to reason backwards to the root cause. Logical reasoning is also limited to loose relationships from one particular element to another particular element without the ability to generalize the relationship to a broader association. Social cognition is also limited to the physical result of a person's action, ignoring the intent of the original action. (pp. 51-56)

Piaget refers to the developmental stage roughly between seven and 11 years old as the concrete operational period. This is when the child becomes less egocentric and starts to take intention into account in making moral judgements of other's actions. The main

characteristic of this developmental stage is the operation, which is "an internalized action that is part of an organized structure. With the ability to use these operations or concepts, the child's representations are no longer isolated, rigid, or simply juxtaposed, as in the preoperational period" (Miller, 1993, p. 57). Piaget developed a number of interesting tests to diagnose successful progress through this stage. Four of these tests are conservation, class inclusion, relations, and temporal-spatial representations. There are a number of conservation tests that all relate to changing one factor and then testing the child to test the understanding of the effect of the change. For example, volume conservation starts with two identical glasses of water. One glass is poured into a third glass that is narrower and taller. Successful volume conservation would identify the fact that the same volume of water remains even though it is now in a different shaped container. A pre-developmental child would say that the new glass has more water in it than the first because the water level is higher; ignoring the fact that no additional water was added and the new glass is narrower. Likewise, class inclusion has the younger child unable to successfully identify sub-classes. This is tested with 20 wooden beads, 17 that are brown, and three white. The preoperational child would say that there were more brown beads than wooden beads, seeing only the color classes and not the higher order group of wooden material. Similarly, the preoperational child would not have learned to identify relationships and be able to logically infer that if a>b and b>c that it would follow that a>c. The temporal-spatial representation is also relational where the child is asked to draw a picture of a tipped bottle of water. The preoperational child draws the water level relative to the bottle ignoring the effect that gravity would have on the water in the bottle. It can therefore be seen that this stage has a great amount of learning taking place in being able to identify causation and logical relationships between multiple concepts or structures. (Miller, 1993, pp,. 56-59)

Piaget identified the formal operational period as occurring between the ages of 11 and 15. In this period, the child is capable of constructing "operations on operations; [where] thought has become truly logical, abstract, and hypothetical" (Miller, 1993, p. 60). Some egocentrism remains but more from a function of being

> impressed with the power of thought and naively [underestimating] the practical problems involved in achieving an ideal future for themselves or for society. . . . Piaget noted that this starry-eyed egocentrism is squelched when adolescents undertake their first real job! (p. 62)

During this period, learning is focused on systematic problem solving, and thought processes that are logical, abstract, and flexible. While this is the last developmental stage identified by Piaget it is noted that further development continues throughout adulthood as formal operations are applied to new content and situations. Egocentrism also continues to diminish as experiences are gained in adult activities and related social situations.

Four factors cause progress through the stages: biological maturation, experience with manipulating physical objects, experience in social situations, and equilibration. (Miller, 1993, pp. 104-105) As Piaget used the term equilibrium is the seesaw like learning action where new situations are experienced and the child learns to accommodate to the situation and become at ease in future encounters by developing operational schemata for the situation. However, like the seesaw coming up to equilibrium there is the possibility of continued movement into new situations. An example might be a baby seeing its hand for the first time and realizing that it is possible to control the hand movement. Such awareness and practiced ability opens up a larger number of other situational opportunities. Equilibrium also extends

to cognitive structures were new learning can lead to new possibilities not realized without the foundational learning. While Piaget uses equilibration as a general process, he also uses the terms learning and equilibrium in a specific manner in relation to each other. In strict terms, learning is more closely related to the content from external sources while the internal form of the schema allows assimilation to establish equilibration. (Miller, 1993, p. 97 and Anthony, 1989, pp. 115-116)

Miller (1993, pp. 86-97 and 222) calls Piaget's developmental stages more a description of development than a real theory of development. By this Miller refers to the great amount of detail that Piaget uncovered to categorize developmental abilities from one stage to another. However, Piaget's theory does not encompass the mechanism enabling the transition. The concept of stages that identify acquisition of knowledge is descriptive and does not identify what happens psychologically at developmental stage transitions or explain how the acquired knowledge applies in a specific situation. In cases of similar learning, such as conservation of substance, knowledge of conservation of volume can be exhibited a few years before conservation of weight without explanation for the time delay. Piaget also slighted learning associated with social and emotional development in favor of motor and operational skills. Anthony (1989) says, "like Freud, Piaget was a structuralist in that he postulated the formation of certain mental structures that were crucial for learning about external reality" (p. 112). The concern was then with relationships between parts of the learning process and between an earlier and later stage of development.

Adaptive learning

The adaptationist approach to learning is not so much a theory of learning but the evolutionary adaptation and physiology that are involved in reacting to a changing environment and the need to change behaviors under different situations. The hereditary predisposition makes some associations and adaptive responses more (or less) likely to occur. This is closely related to the theory of evolution and is applicable across a wide range of species.

> Staddon argued that both general learning principles and species-specific learning abilities can be understood from the adaptationist perspective. He proposed that all types of learning are methods for making inferences about the future. These inferences can sometimes be wrong, but they will usually be right. (Mazur, 1990, p. 212)

The ability to learn that a stimulus is an important signal for an upcoming event is a critical necessity for classical conditioning. In addition, to be responsive to the positive or negative consequences of one's action is required for operant conditioning and observational learning. Treating a biological constraint on some learning ability as a weakness is to ignore the earlier development of the species that favored the development of the current biology. In this way, inter-species differences in the ability to create associations and the presence of different learning abilities are a reflection of the differences in evolutionary development.

> Lorenz suggests that no animal below man is capable of driving a nail straight into a piece of wood . . . not because of lack of strength, of inability to hold or swing a hammer, or of lack of interest. . . . What is lacking are the rules of coordination that govern the strokes which compensate for each slight deviation from the vertical. Lower organisms do not have the capacity for this elementary degree of learned skill which can be called "control of an action pattern by continuous compensatory movements."

> Intelligence is found, thus, not in the activity as such, but in the rule which implicitly governs this activity. (Furth, 1969, p. 171)

In this way "biology clearly sets limits on what each species can learn, when it can learn the behavior, and how quickly it can learn it" (Miller, 1993, p. 188). The definitions of learning given earlier were consistent in their inclusion of adaptation to change. The biology that is involved in responding to environmental change is seen as not only a learning enabler but also a potential limitation to evolutionary survival if the species is unable to adequately respond to change. Miller summarizes the relationship of adaptation to conditioning and observational learning in the following statement.

> The ability to learn from experience, especially the sensitivity to reinforcement, allows an organism to adapt to whatever demands the environment makes. The ability to process and store information, abstract general rules, and translate this information into behavior is obviously adaptive for humans. (p. 219)

In this manner, the subject of learning is seen as being central and indivisible from the evolutionary process itself.

A great deal of research has been underway to understand learning at the cellular level. (Mazur, 1990, pp. 28-32) Part of this research focuses on the structural changes that differentiate short-term memory storage from long-term memories. An unknown has been whether learning is accomplished through the growth of new axons and/or new dendrites to build new synapses or whether learning involves changes in already existing synapses. Some experimental work has revealed growth in number and complexity of neurons and associated synapses in the presence of sensory rich environments. However, the quick change is too short for significant cellular growth, which opens up the possibility of chemical changes at the synaptic level being responsible for some short-term results followed by cellular growth. In other research image recognition is being studied to determine whether single neurons or groups of neurons are involved in the recognition process.

The effect of biochemical change has been shown to be associated with the process of habituation, which is so primitive a biological function as to be found in one-celled organisms. In habituation "there is a decrease in the probability of a reflexive response after repeated presentations of the eliciting stimulus" (Mazur, 1990, p. 48). This decreased responsiveness to later occurrences of the stimulus is caused by the lingering biochemical changes in the synapses from the earlier stimulus. In this way, habituation can be seen as an evolutionary development that permits heightened alertness at the first stimulus and reduced response on later occurrences of the stimulus thereby permitting a response without later disruptions. The Solomon and Corbit theory of emotion can be applied to explain the underlying biology of habituation. In this theory, there is not one response, but two. The first (or "a") response is the primary affect peaking with a gradual decline to a plateau and an immediate return to the baseline state with the removal of the stimulus. The second response (or "b") is a delayed reaction in the opposite direction with decay to the normal baseline. In the case of the "b" response there is not the immediate return to the baseline with removal of the stimulus but the continued decay. When combining the two responses, there is an initial peak and decline, followed by overcompensation in the opposite direction with a gradual return to the normal baseline. Critical to the theory is that the "a" reaction is lessened with repeated stimulation and the "b" reaction not only happens quicker but also is heightened in

its response. This combined effect is thought to be a biological protection for emotional situations such as pain where the "b" effect counteracts the primary "a" effect. The effect of the "b" process can be seen in experimental situations where dogs have a "fit of joy" after a painful stimulus is stopped. This cessation of stimulus eliminates the "a" response but leaves the "b" effect. (Mazur, 1990, pp. 48-53)

However, while this mechanism is successful in protecting the body from prolonged, intense emotions it does create a situation that can lead to addictive behavior. An example of a non-destructive behavior that is influenced by habituation in emotional responses is parachuting.

> Novice parachutists appear terrified during a jump; after the jump they look stunned for a few minutes, then return to normal. Experienced parachutists appear only moderately anxious during a jump, but afterward they report feelings of exhilaration and euphoria that can last for hours. They claim that this feeling of euphoria is one of the main reasons they continue to jump. (Mazur, 1990, p. 52)

In this example, the prolonged and heightened "b" reaction is similar to the dog's fit of joy and encourages repeat behavior. However, in the case of drug use, the situation is reversed with the drug producing a pleasurable "a" response and an aversive "b" after-reaction after the drug wears off. Through continued drug use, the "a" effect is diminished through the development of a stronger, longer lasting "b" effect. The drug user then gets to the point of taking the drug for the elimination of the "b" response rather than for the "a" response that was desired initially. While this is not the only theory of drug use, it is consistent with the evidence.

The effect of the habituation response to emotion opens up the possibility of applying the theory to change processes. In this situation, involvement in a change process often produces stress that may keep people from working through the change process to its conclusion. However, once the change is successfully implemented there is the elimination of the stress and a new sense of accomplishment can be experienced. This raises the possibility of creating numerous, small change situations where individuals can learn to experience the full change process to its conclusion – recognizing small wins. The research hypothesis is that through such repetition the "a" response to the stress should be overshadowed by the heightened and stronger "b" response associated with the accomplishment. Many change processes do recommend short-term gains to reflect progress toward the goal. However, the research recommends further study to investigate a conditioned response that can aid in adaptation to a changing environment with a process similar to that experienced by parachutists.

Classical and Operant Conditioning

The early conditioning researchers could be classified as behaviorists and relied heavily on animal subjects in their experimental research. Their emphasis was on external events and the resulting behavior with little speculation on the internal processes occurring within the organism. It was only later that researchers within the area of cognitive psychology did start to focus more attention on the intermediate steps that occurred between the stimulus and response effect studied within classical and operant conditioning. These later researchers also went beyond animal research and directed attention on language, reading, and complex problem solving that required human subjects for the research. This later research built on the conditioning research that allowed generalization from animals to

humans, which is not possible when learning research is focused solely on humans. Moreover, because this earlier group was the first to study learning as an experimental science their work is sometimes called traditional learning theory. (Mazur, 1990, pp. 12-13)

Classical conditioning research is in the tradition established by Pavlov and is commonly studied within schoolchildren's science curriculum. In fact, Pavlov's experiments employing the dog's salivating response is probably the one area of learning theory taught as a subject to all science students in the U.S. Within this area of learning research, the reflexive behavior elicited by some specific stimulus in animals is generalized to humans. In these studies, an existing response that is innate or already learned is transferred to a new stimulus. The response itself is unchanged, only the method of eliciting the response is new.

Turning from classical conditioning to operant conditioning, the focus shifts to a higher level of conditioned learning involving voluntary control of behavior as a response to a given stimulus. In this way, the researcher can incrementally shift behavior toward a desired response that is different from the pre-existing stimulus-response pattern. Central to operant conditioning is the inducement of the desired behavior through a process of successive approximations that slowly closes the gap between the pre-existing behavior and the desired behavior. This is a form of enactive learning, which involves learning-by-doing. Using positive reinforcement or rewards, the behavior that produces desirable results is reinforced and will therefore recur more frequently. Behavior that fails to produce desirable results will either be ignored or receive negative feedback which will then tend to weaken the likelihood that such behavior will be initiated for the selected stimulus. In this way, undesirable behavior moves toward extinction. In animal experiments, the reward commonly used for positive reinforcement is food. In addition, an electrical shock may be used when a negative reinforcement is wanted to reduce the occurrence of an undesirable behavior. In both cases, the subject is being encouraged toward a desired behavior as defined by the researcher or controller of the conditioning exercise. If the reinforcement were to cease the new behavior would be expected to slowly extinguish toward the original baseline behavior. Therefore, there is some question on the long-term continuation of the desired behavior after the reinforcement ends. Even in humans, learning may be both conditional and situational and not self-motivated to continue without periodic reinforcement. However, patterned responses may become habitual and thereby long-term behavioral change may be produced. (Mazur, 1990, pp. 140-141)

The likelihood of behavior reversion can be influenced by the reward schedule used in the reinforcement phase. While there are many different approaches to the timing and process of giving a reward for a desired response to a stimulus there are four broad classes used most often to describe the type of reward schedule used. These are the fixed ratio, variable ratio, fixed interval, and variable interval. The ratio schedules involve a pattern that is dependent on the subject's responses. Moreover, the interval schedules is dependent on the time interval between reinforcement and the next possible reinforcement. As might be expected, fixed refers to the number or time interval remaining unchanged between rewards. In a variable pattern, there is a change in number of responses required for a reward or a variable time interval between rewards. A fixed ratio reinforcement of one would be continuous reinforcement after each correct response to the stimulus. After each response, there is a postreinforcement pause from reward satiation followed by constant, rapid responding after restarting. This length of postreinforcement pause increases with an increase in the ratio due to the additional work needed to gain a reward. In addition, as the ratio increases there is a

gradual response decrease from lack of sufficient rewards to keep the subject motivated to continue responding. Use of larger rewards can shorten the postreinforcement pause all other factors being equal. Shifting to a variable ratio pattern eliminates or greatly reduces the length of the postreinforcement pause with the subject immediately starting rapid and steady responses. This behavior is caused by the unpredictability of the reward and since the next reinforcement is not known, the quicker the responses are made the quicker the reward will be received. This behavioral response can also be seen in a number of sporting activities and games of chance where the chance of winning is directly proportional to the number of times played. In the fixed interval reinforcement schedule the post reinforcement pause is really a slowed response rate after reward that gradually increases with expectation of getting closer to the reward. In the variable interval reinforcement schedule there is a steady, moderate response rate since a faster response rate would not be productive in hastening the reward. In all reinforcement schedules, the subject learns through trial and error to find the optimum response pattern that yields the reward with the least effort. In this manner, higher-level operant conditioning may be a sub-class of observational learning. The learner is making associations between stimuli, responses, and rewards with a cognitive decision to repeat the response pattern to gain the reward. (Mazur, 1990, pp. 126-131)

Information Processing

With the advent of the computer as a model of information processing the study of learning shifted "from the acquisition of performance capabilities to the processing, storage, and retrieval of information" (Bandura, 1986, p. 107). While not structurally like a computer many models of memory and problem solving are now stated using computer metaphors. There is input or stimulus, real-time information processing, and output in the form of stored information in memory, physical behavior, or a decision to a problem. (Miller, 1993, p. 234) "Information-processing theorists view humans as active, organized, self-modifying systems. . . . The essence of development is an increasingly efficient system for controlling the flow of information" (p. 289). As an area of theory information processing is not a single theory, but a framework for a large number of research projects on different aspects of learning.

In memory capability "young children have appropriate strategies but are deficient in knowing when, where, and how to use (produce) them effectively. . . . Even after children develop and use strategies, they continue to refine them" (Miller, 1993, p. 252). Much of the learning research associated with memory relates to associations discussed earlier. Difficulties encountered by young children in memory storage and recall is thought to be related to their tendency "to form categories on the basis of perceptual features of objects, whereas older children may be more likely to use conceptual features" (p. 255). This abstraction allows easier formation of associations to existing knowledge, which facilitates better memory creation and linkages for recall. Associations between items in memory are also related to ability to recall what is of greater interest than information of lesser interest. The explanation relates to a larger network of associations being created for subjects of interest. With more similar memories being created in memory there is greater likelihood that a given recall strategy would be successful in gaining access to the stored memory. Increased quantity of knowledge also creates a larger number of extensions to similar memories thereby filling in gaps that might otherwise exist in the memory map for a given topic. While most associations can greatly aid in memory recall there is the possibility of having the more common associations create associations that are counterproductive to recalling the desired

memory. For example, recalling information about a particular male secretary might be derailed with the common association between secretary and female. (Miller, 1993, pp. 254-258)

Memory is seen not simply as a copy of the world but a dynamic construction from inferences based on previously stored knowledge and relationships among this stored knowledge. Part of the human developmental process is gaining an understanding of personal deficiencies in memory creation and recall and taking action accordingly to aid the memory process. Specifically, this is an understanding that it is sometimes necessary to do something different or take specific action in order to store and/or recall a memory. The necessary action may range from rehearsal, which places emphasis on the memory for increased likelihood of memory storage and creation of associative relationships to the use of metamemory devices. Metamemory is knowledge about memory used to insure the later recall of a memory. An example might be creating something that will trigger the necessary memory such as mentally walking through your day to remember where an item may have been lost. Or it might be a physical device such as note taking, underlining in a book, or writing out a shopping list. In the case of mental reenactment, each memory recalled has the potential of recalling the needed associated memory. The use of a physical metamemory device bypasses the necessity of storing the memory of something only needed for a specific reason, such as a shopping list, or the creation of an external reference resource for later referral.

"Evidence suggests that the maturation of the nervous system throughout childhood causes increases in mental capacity" (Miller, 1993, p. 260). This is the result of both an increase in physical brain capacity and the ability to control its capabilities. Further, practiced cognitive skills also become more efficient yielding an increase in processing power beyond physical growth. "Research on memory . . . shows that much of memory development is caused by the acquisition of strategies, the growing store of domain-specific knowledge, increased metamemory, and greater functional capacity" (p. 288). One such strategy is the possible use of scripts in memory representation. While use of scripts is very much an information processing concept it is not necessarily related to the physical operation of a computer but to a similar process taking place. The process can involve both linguistic representation and nonverbal imagery. One question that arises in the study of procedural knowledge is the possibility that knowledge about how to do something may be stored differently from more factual knowledge not directly involved in activity generation. The information processing approach to these issues is often to create computer simulation models of the learning process itself and then to study the effect of change in processes and assumptions. An interesting use of this approach to study learning is the use of simulation to model Piaget's stages and the different processes that are involved in defining abilities at each stage. This allows Piaget's tests of learning to be broken down into their components to determine the decision points and necessary information collection and discernment that is necessary to master the test.

As the child develops, normal mental functioning becomes more automatic within a particular domain. This frees learning capacity for other tasks and allows still further development. This also establishes a model of incremental ability in multiple areas. Where the concept of intelligence once focused on academic skills, there is increasing willingness to evaluate multiple areas where learning ability can be illustrated. Hence, the study of multiple intelligence may evaluate not only academic skills, but also artistic, emotional, athletic, and other areas where learning can be demonstrated. This also creates an information-processing

model that provides an explanation for retardation and learning disorders. If an individual has to spend an inordinate amount of mental capacity on simple tasks there is less time to devote to developing and exercising higher mental processing skills. (Miller, 1993, pp. 269-272) Sternberg's theory of intelligence has three components that are all needed for development. The first is the ability to acquire knowledge through the identification of what is important and then the proper capture and storage in memory. The second component is the performance component that solves the problem by drawing on the available knowledge and goals. The third component sits between the other two components and is responsible for linking knowledge in memory to the goal involved in the problem to be solved. This middle component is related to the metamemory discussed earlier and is described by Miller to be "used in planning and decision making in task performance, then [to] combine the new information with previous knowledge to construct an appropriate problem-solving strategy from among the performance components" (p. 270). Beyond explaining a possible cause for learning disorders, this model can provide explanations for the attributes found in gifted individuals. The ability to differentiate relevant and irrelevant information is called selective encoding that not only focuses attention on the information that is critical to the problem but is also much more efficient in the use of mental resources. Gifted individuals may also benefit from the ability to selectively combine information in new and meaningful ways that is more efficient than what might otherwise be normal. Lastly, gifted individuals may be better at comparing newly encoded information to the existing knowledge that has already been acquired. In so doing, more efficient and specific associations can be created in memory. These allow quicker and more relevant recall of knowledge that is pertinent to the problem or activity addressed.

Observational learning

Freud, Erikson, and Piaget were all interested in the developmental interaction of biological maturation and the physical and social world. They saw learning development as being time dependent with little the individual could do to alter the process. In contrast to this underlying assumption of environmental dependency is Bandura's theory of observational learning where the individual is actively involved not only in interacting with the environment but is capable of altering it through the learning process. Bandura calls this process reciprocal determinism because of the two-way environmental interaction. (Miller, 1993, p. 219) Bandura's theory of learning is that through personal observational "the learner can develop some understanding of the desired behavior well before he actually produces his behavior himself" (Mazur, 1990, p. 290). Learning is accomplished vicariously by observing the actions and values of others and in doing so, the individual also observes the consequences of the behavior being observed. In this way, an individual is capable of learning from the mistakes and successes of others through the conscious decision of whether to model the observed behavior. This method of learning is not in lieu of learning from personal experience but a method of greatly saving time that would otherwise be used in personal trial and error learning. Nor is it a repudiation of other learning theories. The learning theory that Bandura presents acts through social learning theory and builds on the traditional principles of classical and operant conditioning plus the addition of learning from others through modeling or imitating the rules of behavior observed. The theory is also built on the adaptationist theory and supporting evidence of there being an innate tendency for animals to imitate the behavior they see others perform. (pp. 269-272)

As the child develops, observational learning extends and further accelerates through use of the spoken and written word. This is accomplished by the ability to observe others through narration without having to actually observe the situation first hand. In this manner, many cultural norms are passed down to the next generation by way of stories and cultural histories. Being able to verbalize rules also greatly aids in clarifying meaning and the creation of associative relationships in memory as well as allowing communication of thought processes that might otherwise not be observable.

Summary

Learning can be seen as change, both as part of the process of human development as well as adaptation to a changing environment. The theories presented within this paper are more complementary than exclusionary. Some theories were based on experimental research and others on philosophical logic. Some approached learning from the discipline of biology, psychology, information processing, or sociology. Some focused on animal studies, some on human development, and others on similarity to inanimate information processing. Collectively, these learning theories provide a better understanding of how we have evolved as a species and continue to develop as individuals and as a society. In a number of instances, relationships were drawn to the role learning plays in responding to social and organizational change. It is in this area where continued research is ongoing and needed to meet our full potential as individuals and as a collective society.

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