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AUTHOR Grider, Clint
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ABSTRACT

Cognitive-learning theories hold a unique place in history: they explore the depths of the mind from the perspective of process. This paper discusses the history of cognitive-learning theories and how they grew to shape the way one perceives, organizes, stores, and retrieves information. The paper, after providing a definition and synopsis of cognitive theory and its basic concepts, turns to the theories' philosophical foundations, beginning with Plato. The psychological foundations of the functions of the mind, and the pioneering efforts of the structuralists and Wilhelm Wundt are discussed. As psychology matured, practitioners like William James and John Dewey rejected structuralism, believing it to be too narrow to understand the mind. The mind's mechanisms then underwent numerous, pivotal shifts in interpretation moving from the Gestalt viewpoint and its variations, like those introduced by Edward Tolman, to the role of motivation in learning as expounded by Kurt Lewin, to Frederic C. Bartlett's concept of schemata, to Jean Piaget's explications of cognitive growth and development, and finally, to the refinement of Piaget's theory by Jerome S. Bruner. The paper concludes with a brief description of the contributions made by other disciplines to cognitive understandings such as those advances made by the linguist Noam Chomsky, and the powerful impact of the computer on cognitive psychology. (RJM)

Foundations of Cognitive Theory: A Concise Review

Clint Grider

How do we learn? Within psychological thought, cognitive learning theories have, perhaps, encompassed the broadest array of methodologies. From philosophical roots to evolving constructs and proponents, cognitive strategies provide a divergent yet distinct emphasis on the mental processes that enable individuals to learn and to use knowledge.

Defining Theory

Definition

The dominant aspects of cognitive theory involve the interaction between mental components and the information that is processed through this complex network (Neisser, 1967). As individuals learn, they actively create cognitive structures which determine their concepts of self and the environment (McEntire, 1992). Interestingly, the specific process of learning is not the primary area of concern in cognitive research; instead, learning is viewed as only one of the many processes comprised by the human mind (Anderson, 1980). Although all cognitive theorists examine these functions to discover more about human learning and behavior, they often differ regarding emphasis. Some approaches deal with detailed analyses of information-processing skills, while others focus on mental models or cognitive growth and development (Mayer, 1981). Thus, cognitive psychologists do not adhere to a particular set of rules or methodologies in their research.

Basic Concepts

Cognitive theorists believe that learning involves the integration of events into an active storage system comprised of organizational structures termed schemata (Baron & Byrne, 1987). Schemata serve a number of functions in human cognition. In addition to storing information in long-term memory, they formulate frameworks into which new information must fit in order to be understood. Furthermore, schemata regulate attention, organize searches of the environment, and "fill in the gaps" during information processing (Bell-Gredler, 1986, p. 160). Thus, the mind uses schemata to selectively organize and process all the information individuals receive from the world (Baron & Byrne, 1987).

This comprehensive network is managed by an executive monitor that coordinates the vast flow of sensory input (Blumenthal, 1977). The system chooses, arranges and encodes for storage new information based on the individual's interests, motivations, and particularly, perceptions (Bell-Gredler, 1986). Within this process, attention deals with what individuals notice, while encoding involves the preparation of data for storage. When encoding new information, schemata seldom copy the input exactly as received; instead, it is changed or distorted to fit the individual's existing framework of schemata, or script (Baron & Byrne, 1987). Similarly, when retrieving information from memory, schemata only select that which corresponds to the currently active script (Mayer, 1981). Therefore, one's learning and application of knowledge depends on one's schematic framework.

The processing of information for storage includes several key cognitive components. When one experiences sensory input, the raw data is briefly captured in a sensory buffer. This receiver has unlimited capacity, but information disappears quickly unless attention transfers it to short-term memory (STM). STM holds approximately seven items, although chunking techniques can cluster information to increase this amount (Mayer, 1981). Working memory (WM) is similar to STM, except that this store is utilized for specific mental operations such as addition. Information that is encoded into long-term memory (LTM) is organized, meaningful, and permanent; additionally, LTM has unlimited capacity (Mayer, 1981). Within LTM are two categories of memory: semantic and episodic. Semantic memory consists of information that is received directly from the environment (e.g., addresses, equations, directions), while episodic memory revolves around events experienced by the individual (Bell-Gredler, 1986). Each of these components plays an active role within the realm of information processing.

Meaningful learning occurs when knowledge stored in long-term memory is shifted to short-term memory to integrate new information into the mind (Bell-Gredler, 1986). The most important cognitive associations occur when individuals relate stored knowledge to sensory input and consequently encode the stimuli into long-term memory (i.e., new schemata) (Bell-Gredler, 1986); therefore, cognitive learning emphasizes the internal mental processes of association. This concept differs from the behavioral view of association which is based upon external motivation. As Bell-Gredler states, "successful learning depends on the learner's actions rather than on events in the environment" (1986, p. 171).

Tracing Foundations

Philosophical Foundations

The roots of cognitive theory can be traced to systems of ancient philosophy that date as far back as 400 B.C. Plato's idealism is based on the premise that reality only consists of spirit and mind. According to Plato, the universe is comprised of good and perfect absolutes that are orderly and eternal. One's spiritual essence, or soul, is also durable and permanent. Values reflect the inherent good in the universe, and ethical conduct grows out of one's moral education. Idealism holds that all knowledge is innate; thus, introspection is the only method of discovering truth. Plato believed that one should constantly exercise the mind by studying mathematics and the classics (Bell-Gredler, 1986).

Descartes and his 17th century philosophy of rationalism would build on Plato's concept of innate knowledge. Rationalism holds that one develops intellect by strongly contemplating a few innate ideas; Descartes' concept of "I think; therefore I am" demonstrates the emphasis on logical thought and deduction. Based on mathematics, rationalism's model for mental growth is a vast system that revolves around just a few axioms (Bell-Gredler, 1986). The concepts of introspection, deduction, and internal mental processes in these two philosophies would later influence the theoretical development of cognitive psychology.

Psychological Foundations

Earnest attempts to explore and understand the functions of the mind began in Germany in the late 1800s. Wilhelm Wundt, the founder of experimental psychology, was the first to research the cognitive structures involved in mental processing (Bell-Gredler, 1986). Though not considered a cognitive theorist, Wundt formulated a basis for cognitive research and development. Wundt's "physiological psychology" holds that the mind's structure is similar to the classifications in developmental biology and chemistry; just as matter is comprised of atoms and molecules, so is the mind composed of basic, unchanging elements (Bell-Gredler, 1986).

According to Wundt, human experience first consists of measurable mental functions such as awareness, reaction, and perception (Blumenthal, 1977). As the experience becomes more focused to the individual, mental organization increases and transforms "vague awareness into clear attention"; at this point, "creative synthesis" results (Blumenthal, 1977, p. 16). Thus, experiences at this "high" level are fundamentally distinct from lower reactions. Wundt described, "in essence, an internal construction under the direction of central self-control processes" (Blumenthal, 1977, p. 16). This approach, later termed structuralism, would become one of psychology's first major theories. Wundt's principles would eventually evolve into the cognitive concepts of executive monitor and structures.

As psychology began to emerge as an independent science, several Americans rejected structuralism. William James and John Dewey believed that Wundt's methodical analysis and classification of cognitive elements was too narrow (Bell-Gredler, 1986). Strongly influenced by Darwin's theory of evolution, James emphasized the process of cognition as it related to environmental adaptation (McEntire, 1992). Similarly, Dewey felt that psychology should transcend classification by focusing on the entire scope of consciousness and behavior including the relationship between biological adaptation and the environment (i.e., psychology should be an applied science) (Bell-Gredler, 1986). Thus, while structuralism narrowly relies on introspection and self-report (i.e., inconsistent information), this approach looks at expansive factors involving the mind-body relationship. Dewey's functionalism would emerge as the second prominent theory of psychology at the turn of the century. The emphasis on total process as related to mental activity would later become a key component of cognitive psychology.

As John Watson's behaviorism, the third dominant theory, began to take shape in the early 1900s, so did a competing viewpoint: Gestalt psychology. Max Wertheimer, Wolfgang Kohler, and Kurt Koffka augmented Dewey's principle of total process by researching distinctions between mental components and the individual's whole experience (Hansen, 1986). Gestaltists believe that one's experiences can not be fully understood by reducing them to specific elements or stimuli; instead the properties of the unified whole (i.e., the overall context) are considered to be most important (Bell-Gredler, 1986).

The Gestalt theory's explanation of behavior and learning is based on one's perceptual organization of events and objects (Blumenthal, 1977). The individual is constantly involved in organizing the vast amount of stimuli in his or her phenomenal field. The item on which the person focuses is termed the figure, while the rest of the field is called the ground. Anything in the field can emerge as a figure; however, two events can not be figures simultaneously (Hansen, 1986). One's perception of stimuli determines which object will become the figure at any given time.

According to the general law of Pragnanz, "psychological events tend to be meaningful and complete" (Bell-Gredler, 1986, p. 40); thus, individuals perceptually fill in any gaps within their figures. The principle of closure describes how people perceive incomplete figures as complete (e.g., a drawing of a circle with gaps is still perceived to be a circle). The principle of proximity involves the relative distance of stimuli from each other (i.e., individuals perceive items that are close in proximity to be a group). The principle of similarity refers to one's tendency to group similar stimuli (e.g., similar shape, color, etc.) together (Hansen, 1986). These concepts further illustrate the impact of perception on cognition.

According to Gestalt theory, stimuli only have meaning as they are cognitively organized by the person. Learning is based on changes in the perceptual process; thus, true learning, or insight, occurs when the individual perceives new relationships within the field (Bell-Gredler, 1986). For example, if a person does not understand how to use a certain tool, insight will not occur until he or she figures out the relationship between the tool and its function. After that point of discovery, his or her perception of the object will be consistently linked to its usage. Gestaltists' holistic emphasis on perception, fields, and insight provided the basis for a number of cognitive concepts, including schemata. Though behaviorism became the dominant movement during the next few decades, Gestalt theory was the true beginning of cognitive psychology.

During the 1930s, Edward Tolman complemented the Gestalt viewpoint with his concept of purposive behaviorism. According to Tolman, individuals learn specific events that result in the satisfaction of particular goals. Thus, in this system, all behavior is goal-oriented (Bell-Gredler, 1986). Learning involves one's expectations in a given situation. If the expectancies are fulfilled, then they are confirmed and remain part of one's schematic framework. Naturally, one's perceptions of a situation greatly influence one's expectations within that scenario.

In one of Tolman's intriguing experiments, three sets of rats ran a maze daily for several weeks. The first group received food at the end of the maze while the second did not. The last group received no food for the first ten days, but was then given the reward on the eleventh day. The third group's performance subsequently improved to the extent that its error rate virtually matched that of the first group (Bell-Gredler, 1986). Thus, the third set of rats learned by receiving the food; however, the reward was not *required* for learning to take place. This concept of latent learning separates the process of learning from performance (Blumenthal, 1977). Tolman's view sharply contrasts behavioral learning theories that directly link stimulus with response. The theorist eventually determined that individuals develop cognitive maps of the environment that formulate the basis for perceptions and expectations. Cognitive mapping involves the psychological processes that develop one's viewpoints about relative locations and attributes in one's environment (Bell-Gredler, 1986). Tolman's emphasis on expectations in addition to his separation of process from product contributed significantly to cognitive theory.

During this period, Kurt Lewin took a somewhat different approach to cognitive psychology by focusing on aspects of motivation in learning. In several prominent studies, rote rehearsal of information resulted in little or no success when the individual did not plan to learn the information. Therefore, according to Lewin, one learns only when one specifically intends to do so (d'Ydewalle & Lens, 1981). Lewin developed the concept of cognitive structures to distinguish motivational learning from other types of learning (Bell-Gredler, 1986). Factors such as needs, motivations, and future time perspective interact with these structures to instigate thoughts and behaviors (d'Ydewalle & Lens, 1981).

Lewin further stated that cognitive behavior is contingent upon one's whole psychological environment, which includes a number of positive and negative psychological forces. These forces greatly affect one's reactions to certain situations, or life spaces (Bell-Gredler, 1986). When the individual encounters a region of life space with two positive forces, the event is termed an approach-approach conflict. For example, if a child were going to a playground with others, he or she would get to play with the friends in addition to enjoying the rides. When both positive and negative forces are exerted in a situation, the conflict is called approach-avoidance, while avoidance-avoidance conflicts result from two negative forces (Bell-Gredler, 1986). Individuals experience these cognitive influences in virtually every aspect of life.

Eventually, Lewin studied social norms and comprehensive group processes as related to these functions (Baron & Byrne, 1987). His concepts of motivation and psychological forces formed a foundation upon which other theorists would later build; for example, Bernard Weiner's influential attribution theory expounded upon Lewin's cognitive motivation by studying success and failure as related to social behavior (Bell-Gredler, 1986). Indeed, Lewin's emphasis on motivation became prominent within cognitive thought.

Frederic C. Bartlett dramatically impacted cognitive psychology by introducing the concept of schemata in the early 1930s. As part of this development, Bartlett performed a substantial amount of research related to perception, remembering, and comprehension of information (Bell-Gredler, 1986). During these experiments, individuals consistently constructed scenarios to compensate for incomplete information within perceptual sequences. For example, when subjects were shown successive displays of patterns or pictures, they would constantly fabricate the final display before seeing it. In fact, they even stated that they remembered specific details in the initial displays that did not actually exist (Bartlett, 1958). As Bartlett states, "the observers were constantly 'filling up gaps' without waiting for the confirmation of external stimulation'" (1958, p. 144). Perceptual processes, thus, can be directly linked with imagery and recall.

Another of Bartlett's classic experiments involved the relaying of a story from person to person. One subject read a folktale, rewrote it from memory, and then gave it to another person, who followed the same procedure. When the story reached the tenth individual, it had virtually become an entirely different tale from the original version. The people had unknowingly changed segments of the story to fit their expectations (i.e., existing schemata) (Bell-Gredler, 1986). Bartlett's findings helped to develop and undergird the key cognitive concepts of perception and mental processing.

Jean Piaget was another key contributer to psychology with his emphasis on cognitive growth and development. For Piaget, knowledge is created through a dynamic and evolving relationship between internal structures, cognitive processes, and the environment (Mayer, 1981). Individuals interact with their world by constantly collecting and organizing information. As one develops and learns, one's relationship to environmental objects undergoes consistent fluctuation and transformation; the individual can not, however, be separated from these objects (Bell-Gredler, 1986).

During this growth of intellect, one formulates new mental structures (similar to schemata). In assimilation, the individual integrates new information into the existing components. Analogous to many biological processes (e.g., digestion), assimilation involves the "filtering of the stimulus through an action structure so that the structures are themselves enriched" (Bell-Gredler, 1986, p. 198). Accommodation occurs when one's internal structures adjust to the diversity of environmental stimuli. Many times, accommodation results in the reorganization of structures as individuals change their ways of thinking. To prevent fragmentation and disarray within cognitive growth, the active process of equilibration regulates assimilation and accommodation by maintaining stability within the individual (Bell-Gredler, 1986).

Piaget also formulated cognitive levels of development: preoperational, concrete operations, and formal operations (d'Ydewalle & Lens, 1981). In the preoperational stage (ages 2-6), the child begins to create relationships between his or her experiences and mental actions. The world is represented through the use of basic, generalized symbols and language. In concrete operations (ages 6-10), cognitive processes are used to manipulate symbols and language that directly relate to concrete objects. Within these operations, the person organizes information for problem-solving tasks in the immediate present. During the formal operations stage (ages 10-14), the child can delve into abstract thinking. Mental operations involve a number of variables including scientific reasoning and introspection (Bruner, 1960). Piaget's developmental theory would ultimately become distinct from cognitive psychology. Still, his thoughts contributed to cognitive mental models which are based on the concept that the mind constructs models for use in problem-solving, in complex thought, and in the anticipation of situations. Many cognitive theorists would continually build upon Piaget's ideas in their studies.

Jerome S. Bruner was one such individual. Bruner supported Piaget's findings regarding the nature of knowledge at different stages of development, but he went on to describe the levels of process involved in this growth. Bruner's examination of symbolic representation includes three components: enactive, iconic, and symbolic. Individuals experience these stages of development until they master all three (Bruner, 1966). Knowledge in the enactive stage of cognition is manifested through one's actions. For example, one can demonstrate how to ride a bicycle quite easily, but it is extremely difficult to tell how it is done. The iconic level involves one's visual organization and summarization of images. In this stage, the person can recognize specific visual patterns as related to particular situations. Of course, one's perception of the scenario can greatly affect how one visualizes the event or object. In the symbolic stage, experiences are described through symbolic systems such as language (Bruner, 1966). Bruner went on to stress the importance of language in human cognition. By using these concepts, he formulated a prescriptive, instructional theory for effective teaching (Bruner, 1966). Bruner's emphases on symbolic systems and language became key components of cognitive psychology.

For Noam Chomsky, linguistics were the ultimate representation of cognitive processes. In his studies, Chomsky analyzed factors that were responsible for the generation and comprehension of language (Mayer, 1981). According to Chomsky, individuals possess innate structures that determine a universal language. This concept accounts for the "spontaneous, uniform, and complex character of the rules of sentence production and comprehension (Piattelli-Palmarini,1980, p. 53). Individuals, thus, can comprehend an unlimited number of sentences that are linguistically correct (i.e., that fit into the universal language). Chomsky relates language to two types of elements: surface structures and deep structures (Hayes, 1970). Surface structures of grammar determine obvious details such as word order within a sentence. For example, the sentence *The cat bit the dog* is obviously different from *The dog bit the cat* on a superficial level. When examining the deep structures of these sentences, however, they are actually quite similar in linguistic construction. Surface structures affect our immediate understanding and retention of sentences while deep structures often account for the psychologically meaningful aspects of language (Hayes, 1970). In cognitive theory, Chomsky's work benefited verbal network models that are based on the concept of a verbal storage system within cognition (Bell-Gredler, 1986).

Perhaps the most important contribution to cognitive psychology involved the emergence of the computer in the 1950s. The computer functions of storage, retrieval, manipulation, and problem solving were deemed to be analogous to human cognition. The mind of the learner was seen as an intricate representation of computer-like processing (Friedman, et al., 1986). As an increasing number of theorists embraced this concept, the information processing model became dominant within cognitive psychology.

Donald Broadbent was one of the first proponents to regard human memory as a type of processor. Broadbent viewed memory as an active and organized multistage system. His proposals of sensory buffers, short-term memory, and long-term memory each played substantial roles in the theory (Bell-Gredler, 1986).

Another eminent theorist, Ulric Neisser, impacted the field with his formal information processing model that dealt with specific cognitive structures, mental processes, and perception (Mayer, 1981). In his landmark text, Cognitive Psychology (1967), Neisser discussed the storage and retrieval of information. According to Neisser, information is stored in long-term memory as summary codes that are used to construct relationships during recall (Bell-Gredler, 1986). An excellent parallel to these processes can be observed in detective work. For example, police officers often use a few shreds of evidence to construct a complete description of a crime. Another of Neisser's concepts, the executive program, offered an analogy for the sequential nature of thinking (Neisser, 1967). Neisser's comprehensive work provided the basis for integrated research of human cognitive processes (Mayer, 1981).

Other proponents examined information processing from the perspective of language. For example, John Bransford and J.J. Franks emphasized the constructive process of providing meaning for sentences. By conducting sentence recognition experiments, Bransford and Franks discovered that individuals tend to integrate separate ideas into unified representations of the concepts. This process, input synthesis, involves one's use of internal knowledge to help formulate meaning for the sentences. Thus, the learner constructs these personal meanings based on relevant schemata as well as on the external environment (Jones & Idol, 1990).

Among information processing proponents, Allen Newell and Herbert Simon were the first to apply problem-solving processes directly to computer operations. Newell and Simon comprehensively researched, analyzed, and tested problem-solving strategies in the attempt to formulate a parallel within computers (Mayer, 1981). The process of strategizing generally involves three steps. First, the issue is presented to the individual as part of a problem space, which includes the stated problem, the givens, and all possible operations. Secondly, the person develops specific goals and subgoals and begins to search for answers to the subgoals. Finally, the individual employs means-end analysis in order to selectively test the various operations, to alter or create new subgoals if needed, and to assess progress (Mayer, 1981). One only works on one subgoal at at time in the methodical attempt to satisfy the goals within the strategy (Mayer, 1981). In the late 1960s, Newell's and Simon's research resulted in their development of the monumental General Problem Solver, a computer program that simulated a variety of human problem-solving capabilities (Bell-Gredler, 1986). The theorists had opened the floodgates for the exploration of artificial intelligence, a concept based on the premise that computers can be programmed to think. By encouraging distinct conceptual analyses of mental functions, Newell's and Simon's work contributed to cognitive process models, which involve the use of flowcharts and programs to represent and predict problem-solving strategies (Mayer, 1981).

Conclusion

Cognitive learning theories hold a unique place in history--they explore the captivating depths of the mind from the perspective of process. According to these theories, one's ability to learn stems from the way one perceives, organizes, stores, and retrieves information. Cognitive approaches can be applied to any discipline. Primary emphases involve problem-solving and the facilitation of storage and retrieval of information for application. The ongoing study and enhancement of these processes can only benefit our ability to learn more efficiently and effectively.

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