Gentner, D. (1995). Cognitive science. *Academic American Encyclopedia* (100th ed., pp. 97-99). Danbury, CT: Grolier.

Until about 1970 the cognitive approach had little impact outside the experimental laboratory. In the years since then, however, various cognitive theories of personality have been developed, as well as information-processing analyses of intelligence tests and a number of cognitively oriented therapies (see COGNITIVE THERAPY).

Cognitive psychology arose partly as a reaction to BEHAVIORISM. The behaviorist insistence that only stimuli and responses lay within the scope of science had long prevented the effective study of higher mental processes. The establishment of cognitive psychology broke this taboo.

Characteristic Methods. In cognitive psychology the human mind is conceived of as a structured system for handling information. According to most cognitive theories, information picked up by the senses is analyzed, stored, recoded, and subsequently used in various ways; these activities are called information processes. They need not be represented in consciousness; cognitive psychology relies very little on conscious introspection. Instead, experiments are designed to take advantage of various objective indicators of information processing: reaction-time measurement, response selection, performance in memory tests, and so on. Mathematical and logical analyses of such data are used to construct models of the underlying processes. These models are not intended to represent actual brain mechanisms. Although it is assumed that all mental activity has some physiological basis, that basis is of little concern to most cognitive psychologists. Just as the program of a computer can be described without knowledge of its physical construction, it is hoped that the program of mental information-processing can be understood without regard to the machinery of the brain.

The analogy between brain and computer, or mind and program, has influenced cognitive psychology in many ways. Concepts such as code, INFORMATION STORAGE AND RETRIEVAL, buffer, and executive routine frequently appear in cognitive theories. Moreover, some cognitive psychologists regard their field and ARTIFICIAL INTELLIGENCE as coordinate sciences that borrow concepts from one other (see COGNITIVE SCIENCE). Not all subscribe to this view, however. Some feel that the differences between human and artificial intelligence are so great that the analogy is misleading.

Topics of Investigation. Although the historical roots of cognitive psychology go back to introspective psychology and associationism, its modern form took shape in the 1950s. Donald Eric BROADBENT's *Perception and Communication* (1958) was the first book entirely devoted to human information processing. It introduced the notion of several distinct kinds of storage systems (memories) of limited capacity and of attention as a mechanism for filtering incoming information. A wide range of new techniques for the study of information processing was soon devised and led to a number of important discoveries. Using brief visual presentations of letters and numbers, for example, George Sperling demonstrated the existence of a special visual information store (subsequently called iconic memory) with almost unlimited capacity but very short duration. It is now supposed that recoding from iconic memory to more lasting forms of storage takes place by both verbal and nonverbal means.

Subsequent research resulted in the further division of memory into various parts or types. A short-term memory of sharply limited capacity, which is primarily verbal and shows rapid forgetting, has been distinguished from a long-term memory that shows little evidence of any limitations at all. Special kinds of memory for visual material have also been postulated, and techniques now permit the objective study of visual imagery. Recent research has dealt not only with episodic memory for personal experiences but also with semantic memory, which is essentially one's store of knowledge. Reaction-time methods have been used to explore the structure of semantic memory, and there have been a number of attempts to model that structure with computer programs. The success of these attempts remains controversial.

Several other areas of interest have concerned cognitive psychologists from the first. One of these is PATTERN RECOGNITION: how does the information-processing system categorize and distinguish among objects? Another is attention: how and at what level does the individual select among the available alternative sources of information? There has also been continued work on the higher mental processes: decision making, problem solving, and thinking. Much of the work has involved computer simulation as well as experiment.

At first, cognitive psychologists were primarily concerned with explaining the phenomena uncovered in their own laboratories. Their work soon brought them into contact with other intellectual traditions, however, and these contacts have led to new theoretical initiatives. The field of PSYCHOLINGUISTICS, for example, was created by applying experimental methods to the study of language. It has been heavily influenced by concurrent developments in linguistics itself, especially the work of Noam CHOMSKY.

The development of cognitive processes in the growing child has also become a subfield in its own right, strongly affected by the work of Jean PIAGET and his students. The perceptual theories of Eleanor and James GIBSON use a different definition of information and reject the concept of information processing entirely. Although these developments have given rise to new theoretical disagreements among cognitive psychologists, they have also given a renewed impetus to the field as a whole.

ULRIC NEISSER

Bibliography: Altarriba, J., ed., *Cognition and Culture* (1993); Galotti, K., *Cognitive Psychology In and Out of the Laboratory* (1994); Honeck, R., ed., *Introductory Readings in Cognitive Psychology* (1994); Neisser, U., *Cognition and Reality* (1976); Strube, G., and Wonder, K., eds., *The Cognitive Psychology of Knowledge* (1993).

cognitive science

Cognitive science is the interdisciplinary study of the mind. Its focus is on the nature of cognition: thinking, learning, problem solving, language and its interactions with conceptual structure, and other aspects of mental life. It embodies a convergence of cognitive psychology with computer science, developmental studies, and work in LINGUISTICS, ARTIFICIAL INTELLIGENCE, anthropology, neuroscience, and philosophy. What brings these disciplines together is the central tenet that a broad range of mental processes are computational in nature and that these processes operate on mental representations.

There is a considerable overlap in topic matter between cognitive science and cognitive psychology. Both disciplines aim to model human mental processes and the nature of cognition. Cognitive science, however, is more inclusive in the methodologies it brings to bear on these issues. In addition to the experimental work traditionally done in cognitive psychology, cognitive science draws on other models of representation and processing. From linguistics it takes analyses of the structure of language. It employs the investigations of neuroscience into how the brain connects with the mind. From anthropology it takes ethnographies that reveal the variety of systems of belief. Finally, it draws on philosophical arguments as to how all these currents link with one another and with the great issues of human thought.

There is also a subtle difference in focus, in that cognitive science centers mainly on higher-order processes such as causal reasoning, planning, and analogical mapping. It is less concerned than cognitive psychology with the nature of lower-level mental processes.

GROWTH OF COGNITIVE SCIENCE

Questions about the nature of mentality have been asked throughout human existence. How are ideas represented in the mind? Are different kinds of concepts stored in different parts of the brain? Is the capacity for language innate or learned? How are language, perception, and thought interrelated? For a long while these and other such questions remained in the province of philosophy. The empirical study of cognition did not really become established as a field until the 19th century. Perhaps paradoxically, however, the first stage in the development of this science was a divisive one. Around the beginning of the 20th century, the study of cognition in terms of psychology, linguistics, neuroscience and so on each developed into a distinct and separate area of inquiry. A general hiatus in cognitive science as a whole then followed, during the period when BEHAVIORISM came to dominate psychology—roughly, from 1920 to 1950.

During this period, nonetheless, certain events and ideas interacted to form the foundations on which modern cognitive science is built. One of these was the growth of computer science, along with the development of INFORMATION THEORY by Claude SHANNON and of CYBERNETICS by Norbert WEINER and John VON NEUMANN. Another contributing idea was the central concept set out by Alan TURING: that a finite machine can carry out any conceivable calculation if it goes through a sufficient number of steps. Turing also proposed what is now called the Turing test to judge whether a computer can be said to think. If a human interviewer is allowed to question the computer at will and cannot then distinguish it from a human on the basis of the answers, the computer has passed the Turing test.

The field of artificial intelligence developed from these roots, with scientists such as John McCarthy, Marvin Minsky, Allen Newell, and Herbert SIMON as its early leaders. The importance of artificial intelligence to cognitive science lay not only in the idea that machines could conceivably be programmed to think like humans, but also in the equally bold idea that by explicitly describing the processes of thinking, those processes could be made available to empirical study.

Cognitive psychology emerged as a subfield of psychology in the late 1960s. It operated on the concept that human thinking can be modeled as a program, in a symbolic language, to be carried out on a computational device. The linguist Noam CHOMSKY, applying this concept in his own field, demonstrated that models that might have been compatible with behaviorism's chains of stimulus-response could not account for the generative nature of human language. Psychologists such as George Armitage MILLER and Ulric Neisser also applied these insights to their descriptions of cognition. While linguistics and psychology and other disciplines continued for some time to progress along separate tracks in these efforts, the feeling was growing among many researchers that no single discipline was adequate to the problem—that understanding the complexity of the human mind required a combination of different methods of study.

Cognitive science was the result. It is by now well-established internationally as a field of its own, with societies and centers scattered around the world. While most researchers do not consider cognitive science as a whole to be a replacement for its subdisciplines, the cognitive-science approach of interdisciplinary collaboration is leading to fruitful interpenetrations among those disciplines. Cognitive science also has applications in education and in the workplace. In education, researchers such as Jerome BRUNER have stressed the social construction of cognitive models and have proposed methods for making classrooms more effective in promoting optimal ways of thinking about the world. In the workplace, the field of engineering psychology draws on research in cognitive science to identify people's typical mental models of devices and processes. It has been found that people can learn to use a new device more quickly and with fewer errors if it fits the causal pattern they expect, and cognitive scientists such as Donald Norman have set forth design principles that fit people's normal cognitive models.

MAJOR THEMES AND TOPICS OF STUDY

The assumption that there are mental representations and computational processes that operate over them is nearly a universal tenet in cognitive science. The analogy between humans and computers has been very influential and has served to establish certain ground assumptions. One of these is that, while knowledge of the brain may prove highly informative for gaining understanding of the mind, such knowledge is not strictly necessary. Explanations that exist at the level of representations and of the processes acting on them are sufficiently legitimate descriptions of cognitive phenomena. Further, the representational paradigm allows a rich vocabulary of these internal processes: for example, *accessing* mental representations, as in memory retrieval; *transforming* a representation, as in problem solving; *aligning* representations, as in analogy and similarity; and so on.

This common vocabulary facilitates cross-disciplinary interaction. Such interaction often takes the form of applying converging methodologies, with the goal of decoding the representations and processes that characterize a particular cognitive domain.

The Nature of Representation. Because the topic of mental representation is central in cognitive science, debates about its exact nature continue to occur. Early debates concerned issues such as whether the storage of visual information takes place in terms of holistic images or of propositional networks. Another kind of distinction to be made—one imported from the field of artificial intelligence—is the one between declarative knowledge and procedural knowledge. That is, early in training on a complex task, people can often describe the rules they are using in fairly explicit terms. With extensive practice, however, "proceduralization" may occur: the ability to state the rules and to reason explicitly about them diminishes even as performance improves.

Different kinds of representational structures have been proposed, such as *schemas* (networks of related information, such as the contractual structure of a business agreement), *scripts* (expected sequences of activities, such as the events that take place in a restaurant or a dentist's office), and *naive physics models* (systems of belief about phenomena in the world, such as people's folk models of how evaporation causes cooling). Researchers have found that these kinds of representations are useful in predicting how people will respond to a given situation. For example, people tend to remember well those elements of a story that fit their schema for a situation, and they often distort inconsistent details so as to make them match better with their long-term-memory representation. There are also larger knowledge structures, such as *semantic networks* that embody knowledge about interconnected categories. An example of semantic networks would be taxonomies of knowledge about animals and plants. Some aspects of these taxonomic category structures appear to be cross-cultural.

Development and Learning. Study of cognitive development is also an important area of cognitive science. Beginning with the work of Jean PIAGET and Lev VYGOTSKY, researchers have examined the ways in which children acquire understanding of the physical world and of conceptual structures. Researchers have found that in many cases there is considerable similarity between children's early performance and the performance of adults who are novices in a given domain. For example, when grouping physics problems, adults who know very little science show a classification pattern similar to that found for young children by grouping the problems according to their surface characteristics rather than according to underlying physical principles.

Such results have led many researchers to take a "child as universal novice" approach to cognitive development. According to this view, the striking differences between thinking in children and adults can best be explained in terms of gains in knowledge, rather than in terms of changing the fundamental logic of the child's thought processes.

One area in which many other researchers have challenged this idea of a general-purpose learning system, however, is that of language. They argue that ordinary learning processes, in which adults do better than children, cannot capture the well-proved ability of children to learn languages. This ability suggests that human infants innately possess it but that it tends to disappear over time. More indirect evidence that language may have a special status in human cognition comes from neurophysiological studies suggesting that certain parts of the brain's left hemisphere are dedicated to language. Because still other researchers emphasize the commonalities between language learning and other kinds of learning, the degree to which language should be considered separately from other aspects of cognition remains an active question.

Computational Models. The dominant computational model for most of cognitive science's history has been symbolic processing, in which structural descriptions involving symbols are the medium of representation. In the classical approach, the assumption was that human thinking could be described using the same kind of abstract language as is used to describe symbolic computer programs. In particular, such a language includes symbols that correspond to psychologically relevant concepts and rules for combining and reasoning about symbolic descriptions. More recently, with the rise of the concept of neural nets (abstract mathematical models of the human nervous system; see AUTOMATA, THEORY OF), genetic algorithms, and connectionist systems, new kinds of computational models have been applied to various aspects of human cognition.

Connectionist models of PATTERN RECOGNITION have been able to combine top-down knowledge (constraints from the set of known patterns to the elements that make up the patterns) with bottom-up knowledge (constraints from the perceptual features to the global pattern to be recognized). Such models have shown humanlike behavior in such areas as word recognition and word pronunciation, including making psychologically plausible errors.

These models have had considerable success in some areas, notably PERCEPTION and pattern recognition, and have also been applied to topics such as language learning, analogical mapping, and categorization. This research has led some workers to challenge the idea of rules operating over symbolic representations. They maintain that human knowledge is expressed in terms of networks of positive and negative connections between large numbers of subconceptual elements. Debate continues on the merits of connectionist modeling. Cognitive scientists such as David Rumelhart and James McClelland argue that symbolic representations are often unnecessary, while others such as Jerry Fodor and Xenon Pylyshyn argue that the generativity and systematicity of mental processing could not be achieved without a true representational level. Currently many researchers favor a hybrid approach that combines a neural net (for modeling low-level, perceptually driven phenomena such as pattern recognition) with a symbolic level (for modeling higher-order knowledge and reasoning).

DEDRE GENTNER

Bibliography: Collins, A., and Smith, E. E., eds., *Readings in Cognitive Science* (1988); Gardner, H., *The Mind's New Science* (1985); Johnson-Laird, P. N., *The Computer and the Mind: An Invitation to Cognitive Science* (1988); Luger, G. F., *Cognitive Science: The Study of Intelligent Systems* (1994); Osherson, D. N., and Smith, E. E., eds., *Thinking: An Introduction to Cognitive Science* (1990).

cognitive therapy

Cognitive therapy is a form of PSYCHOTHERAPY that pays primary attention to cognition in seeking the causes of a person's mental disorder and the possible route to its remedy. That is, the way in which a person construes the world—the set of perceptions and belief systems involved in the patient's efforts to understand and deal with life's problems—is taken to be the underlying determinant of the emotions and behaviors exhibited in the process.

The idea that a person's beliefs and manner of thinking are important influences on behavior is hardly unique to cognitive therapy. Its difference from other therapeutic programs such as client-centered therapy and psychoanalysis lies in its emphasis on the primary importance of cognition. What might lie buried in the unconscious is of secondary or perhaps no real interest to the therapist, who instead tries to attack thought and belief systems that are found to be faulty and to help the patient to develop better cognitive processes.

Important precedents to the cognitive approach include the work of such figures as Alfred ADLER and Jean PIAGET, who emphasized the importance to behavior of faulty belief systems and other cognitive factors. Various nonpsychologists have also long advocated self-improvement programs based on one form of self-programming or another. The various current forms of cognitive therapy, however, mainly evolved during the 1970s. Among the leading practitioners are Aaron Beck, Albert Ellis (who calls his process rational-emotive therapy), and Donald Meichenbaum (who calls his process self-instructional therapy). The major criticism of any of these approaches—as of all approaches to mental disorders—is that their procedures, to be most fully effective, should try to exhibit as broad and profound an appreciation as possible of the complexities of human mentality.

Bibliography: Beck, Aaron T., *Cognitive Therapy and the Emotional Disorders* (1988); Craighead, Linda, et al., eds., *Cognitive and Behavioral Interventions* (1993); Ellis, Albert, *Reason and Emotion in Psychotherapy* (1994); Freeman, Arthur, and Dattilio, F. M., eds., *Comprehensive Casebook of Cognitive Therapy* (1992); Schuyler, Dean, *A Practical Guide to Cognitive Therapy* (1991).

Cohan, George M.

George Michael Cohan, b. Providence, R.I., July 3, 1878, d. Nov. 5, 1942, was an actor, singer, dancer, playwright, composer, director, and producer. He dominated the American theater at the beginning of the 20th century.

As a child he appeared in his family's vaudeville act, the Four Cohans. At age 17 he was managing the act and writing vaudeville sketches and songs. His first full-length play, *The Governor's Son,* opened in New York in 1901. This fast-paced mixture of popular song, comedy, and melodrama set the standard for subsequent Cohan productions. *Little Johnny Jones* (1904) introduced two of Cohan's most enduring songs, "I'm a Yankee Doodle Dandy" and "Give My Regards to Broadway." Cohan was a patriot; his tunes "You're a Grand Old Flag" and "Over There" were World War I favorites.

In 1923, Cohan took on a serious role as a second-rate variety performer in *The Song and Dance Man.* Ten years later he gave what many critics considered the finest performance of his career as Nat Miller in Eugene O'Neill's *Ah, Wilderness!* Cohan also appeared as Franklin Roosevelt in *I'd Rather Be Right* (1937). His autobiography, *Twenty Years on Broadway and the Years It Took to Get There,* appeared in 1925. A film (*Yankee Doodle Dandy,* 1942) and a Broadway musical (*George M!,* 1968) were based on his life.

ANDREW KELLY

Bibliography: Ewen, David, *Great Men of American Popular Song* (1970); McCabe, John, *George M. Cohan* (1973; repr. 1980); Morehouse, Ward, *George M. Cohan* (1943; repr. 1972).

Cohen, Morris Raphael

Morris Raphael Cohen, b. July 25, 1880, d. Jan. 28, 1947, was a Russian-born philosopher. He immigrated to the United States in 1892 and studied at the City College of New York and Harvard University. He taught at City College (1912–38) and at the University of Chicago (until 1942). A proponent of both rationalism and naturalism, Cohen believed that there is a logical order to the universe independent of any mind, but since the universe also has an irrational aspect, our knowledge of facts is only probable. He considered law as a social system that embodies both the logical use of ideas and continuing reference to facts. His books include *Reason and Nature* (1931), *Law and the Social Order* (1933), *An Introduction to Logic and Scientific Method,* with Ernest Nagel (1934), *A Preface to Logic* (1945), *The Meaning of Human History* (1947), and *Reason and Law* (1950).

E. DARNELL RUCKER

Bibliography: Bender, Thomas, *New York Intellect* (1987); Delany, C. F., *Mind and Nature* (1969); Hollinger, D. A., *Morris R. Cohen and the Scientific Ideal* (1975).

Cohens v. Virginia

The case of *Cohens* v. *Virginia* (1821) resulted in a famous ruling by U.S. Chief Justice John MARSHALL, which established the principle that the federal judiciary must prevail over state courts on all questions of national law. In 1802, Congress established a lottery in order to finance municipal improvements in the District of Columbia. Two brothers, P. J. and M. J. Cohen, were arrested in Norfolk, Va., for selling tickets to the lottery in violation of Virginia's laws. Convicted and fined in a Virginia court, the brothers appealed to the Supreme Court, asserting that the act of Congress creating the lottery took precedence over Virginia's antilottery statutes. In response the Commonwealth of Virginia maintained that the Supreme Court had no jurisdiction in the matter.