episodic memory The kind of memory that renders possible the conscious recollection of personal happenings and events dated in the rememberer's past. The concept has undergone considerable changes since its introduction (Tulving, 1972) and is now used in different senses by different writers and in different contexts. Two principal senses of the term are discussed here.

The first one, almost universally accepted now, is that of episodic memory as a type of memory performance. Episodic memory in this sense refers to the acquisition of symbolically representable information on one occasion and its reproduction on a subsequent occasion. The prototypical laboratory experiment, in which subjects are exposed to a collection of verbal items and then tested for their knowledge of some aspect of what they perceived, can be regarded an episodic memory experiment in this first sense of the term: the subjects' recollection of miniature laboratory events from their personal past is the object of interest.

In an episodic memory experiment, the subject is given a task consisting of two parts: (1) she or he observes or studies a set of materials presented by the experimenter, and (2) takes a test for her or his knowledge of the studied material. A large number of different test questions has been used, including the following: (1) What were the items in the study set or list? (free recall task). (2) In what order were they presented? (serial recall, or serial reproduction, task). (3) What item appeared together with Item X? (paired-associate task). (4) What item in the study list was the name of a four-legged animal? (cued recall task). (5) Did Item X appear in the study set? (yes/no recognition task). (6) Which of these two items, X or Y, appeared in the study set? (two-alternative forced choice recognition). (7) Which of these two items, X or Y, appeared earlier in the study list? (relative recency judgement) (*see* RECALL; RECOGNITION MEMORY). Each of these questions is designed to elicit the subject's recollection of an event that the subject has personally observed or witnessed. Each question, therefore, can be paraphrased in these terms; for example: Which items do *you* remember *seeing* in the list? Do *you* remember *hearing* Word X in the list? Which of these two items, X or Y, did *you encounter* earlier in the list? – hence the designation of these tasks as episodic memory tasks.

In the first sense, much of the research on verbal learning and memory that has been

carried out in psychological laboratories since Hermann Ebbinghaus could be classified as research on episodic memory. Different measures of memory performance in this kind of research – such as free recall, cued recall, and recognition – can be regarded as measures of episodic memory. They reflect the extent to which the learner has retained the information that was presented during a particular study episode. As a result of many decades of research, the effect of many variables on episodic recall and recognition is now known. Major determinants of the accuracy of reproduction of materials studied in episodic memory experiments include ENCODING OPERATIONS IN MEMORY and relations between encoding and retrieval conditions subsumed under the ENCODING SPECIFICITY PRINCIPLE. An explanation of the findings and phenomena of episodic memory in terms of underlying psychological processes has been the major objective of many cognitive theories of memory.

Only a small part of human memory is episodic. Most of the knowledge that people learn, retain, and make use of in the course of their daily lives has to do with things other than the recollection of particular personal events. The ability to comprehend and speak one or more languages, to read, to write, to recognize objects in the environment, to know their properties and function, to know how to classify these objects into categories according to criteria such as their nature or value, the ability to answer questions about geography or history, the ability to appreciate literature or art, to understand problems of economy and politics, and a myriad other skills and knowledges, have developed through learning and depend on memory. But they do not entail the remembering of particular occasions from one's past. They represent capabilities other than episodic memory.

The second sense of the term "episodic memory" is that of a hypothetical memory system that differs from two other major hypothetical memory systems, SEMANTIC MEMORY and procedural memory (*see* DECLARATIVE AND PROCEDURAL KNOWLEDGE; MEMORY SYSTEMS). According to the hypothesis, the ability of the individual to *remember* personally experienced past events – that is, to become consciously aware again of a previous experience – is possible only by virtue of an intact brain system specialized for that purpose. The retrieval of a great variety of general information about the world, including some purely factual information about one's own past, can be accomplished by the semantic memory system alone, but such retrieval, according to the current hypothesis, differs from episodic remembering in terms of the brain mechanisms that subserve it, in terms of operating principles, and in terms of the qualitative nature of the accompanying conscious experience.

The postulation of episodic memory as a separable memory system is part of the enterprise of the *classification* of natural phenomena of memory; it does not imply any hypotheses concerning the processes underlying such phenomena in the specified domain. The evidence in support of such a separable system is still fragmentary, and the whole issue is being widely debated. The principal observations of interest have been provided by the study of brain-damaged patients suffering from AMNESIA. It has been observed that amnesic patients are capable of acquiring and retaining *some* new general factual information even though they are completely incapable of remembering the learning episodes or any other recent happenings in their lives. For instance, even the world's best known and most thoroughly studied amnesic patient HM (q.v.) can perform quite adequately in an episodic (in the first sense of the term) picture recognition task, displaying a forgetting rate indistinguishable from that of normal control subjects, provided that he is given a great deal of study time (Freed, Corkin, & Cohen, 1987). But no amount of "study time" will enable him to remember that he participated in such a recognition experiment. Such a dissociation between the ability to identify recently seen pictures and the ability to remember equally recent personal happenings can be seen as supportive of the hypothesis of a distinct episodic memory system.

Another kind of evidence is that of "source amnesia": amnesic patients can recall recently learned facts as well as normal people can, if

the retention intervals for the two groups are appropriately adjusted, but they cannot recollect the learning episode as such nearly as well as normal subjects do (Shimamura & Squire, 1987).

Although the two senses of episodic memory – type of memory performance and type of memory system – are related, they cannot be equated. On the one hand, an individual's ability to reproduce material presented in an episodic memory task, such as the recall of a list of words, obviously depends on his or her episodic memory system. On the other hand, however, evidence now exists that even people without functioning episodic systems, such as HM and other densely amnesic patients, can perform at higher than chance levels in episodic memory tasks. Moreover, there are good reasons to believe that the performance of normal subjects, too, on episodic memory tasks depends not only on their episodic memory system, but also on some other system. For instance, many students of memory now accept the idea that episodic (in the first sense) *recognition* of previously studied items involves two different sets of processes, one of which can be hypothetically identified with episodic retrieval of information about the study episode, and the other with processes that seem to be related to those underlying implicit memory (Mandler, 1980) (*see* IMPLICIT AND EXPLICIT MEMORY).

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ENDEL TULVING

ergonomics *See* HUMAN FACTORS.

expertise Attempts to develop a scientific account of the nature of expertise have recently produced an integrated body of results. In the late 1960s and early 1970s, efforts to describe and simulate complex reasoning in cognitive science and ARTIFICIAL INTELLIGENCE research demonstrated that models of the well defined rule systems of symbolic logic or chess and powerful heuristics or general problem-solving processes did not capture the speed and insightfulness of human experts' performance. Simulations of chess playing, which were key in this work, showed that a machine with a knowledge base of chess rules, search heuristics, and a nearly unlimited capability to search for the best moves was slow and ineffective by comparison to a proficient chessplayer. Studies of grand masters' performances indicated that their strategies depended on knowledge of an array of patterns more diverse than even they realized and that this knowledge somehow yielded rapid perception of the ramifications of a chess board's layout (Chase & Simon, 1973; de Groot, 1978) (*see* PATTERN PERCEPTION).

As research on other forms of performance, particularly in semantic information processing and symbolic integration tasks, sharpened the sense that the apparently intuitive understanding displayed in expertise rests on extensive specialized knowledge, cognitive science and artificial intelligence became increasingly occupied with exploring knowledge's role in problem solving (Feigenbaum, 1989). It became clear that the fundamental problem in accounting for expert performance was representing specific structured knowledge rather than the domain-independent heuristics that interact with it. This shift from a generalized power-based to a knowledge-based paradigm encouraged the design of knowledge engineering approaches; major empirical efforts were redirected to assay competence through sophisticated task analyses. Studies of experts' PROBLEM SOLVING, in domains ranging from physics, medical diagnosis, computer programing, skilled

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