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See also: LEARNING TO LEARN AND METACOGNITION; READING, *subentry on* COMPREHENSION.

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MYTHS, MYSTERIES, AND REALITIES

Why is it that people remember some things and forget others? How long do people remember things? What kinds of cues are likely to help a person remember a forgotten item? These are just a few of the many questions of interest to memory researchers. This entry reviews some of the important questions in the field of memory research and describes how psychologists use experimental methods to answer these questions. It also describes some of the major findings and rebuts some of the common myths about memory. This discussion is structured around the three stages of memory: encoding, storage, and retrieval.

Encoding refers to the intake of information and creation of a memory trace. In a typical memory experiment, the encoding phase involves presentation of the to-be-remembered stimuli, such as nonsense syllables, words, pictures, stories, films, or staged events. In real life, encoding includes all forms of perception, from watching a movie to having a conversation. Encoding may be *intentional* in that subjects are forewarned to memorize the items or *incidental* in that subjects learn the to-be-remembered material through performance of another task such as making a category judgment. In educational settings, encoding is intentional when students deliberately study the meanings of vocabulary words, learn facts for a test, or memorize a famous speech. In everyday life, however, most things are learned incidentally. Examples in the education domain include students learning about a historical period by watching films, role-playing, and reading memoirs.

Storage or *retention* refers to the maintenance of the memory trace over time. In most laboratory experiments, the retention interval is quite short and the subject does an unrelated task during that time. In the education domain, there may be a retention interval of several weeks between learning and testing; students may continue to practice the target information during the retention interval.

Retrieval involves later accessing that memory trace. There are many different ways to test memory. *Explicit tests* require subjects to consciously remember events from the study phase. Most educational tests are explicit; students know they are being tested and that they should remember facts from class and textbooks. Explicit educational tests include essay, short-answer, multiple-choice, and true-false tests; these roughly correspond to the laboratory tests of free recall, cued recall, forced choice, and old-new recognition. *Implicit tests* measure the effect of previous experience on a task that does not require the subject to consciously refer back to the study phase. In education, pure implicit tests are rare although many explicit tests may tap a student's implicit knowledge (e.g., essay tests implicitly test a student's knowledge of grammar). In the laboratory, there are many different implicit tests. For example, a subject who had recently seen a list that included the word *octopus* would complete the word stem "oct___" with "octopus" at a higher rate than subjects who had not seen the list.

In the following sections, some of the facts and myths associated with each of the three stages of memory are described.

Encoding

Key questions about encoding include what kinds of things are easily memorized and what study strategies can be employed to ensure later memory.

Not all materials are remembered equally well. Pictures are remembered better than words, and in general memory is better for distinctive items. Likewise, concrete words are better remembered than abstract words. Good teachers often apply this finding by using concrete analogies to explain abstract phenomena or theories, such as when the movement of gas molecules is compared to the movement of billiard balls on a pool table.

Not all study strategies are equal. In general, elaborative encoding yields the best memory. Elaboration involves going beyond the stimulus at hand to create a richer memory trace. For example, rather than simply repeating a to-be-memorized vocabulary word, a student might think of other words similar in sound and meaning, draw a picture that somehow represents the word and its definition, or write sentences using the word in context. In perhaps the most famous laboratory demonstration of this, Fergus I. M. Craik and Endel Tulving looked at subjects' memory for words after perceptual, phonemic, or semantic processing in a 1975 study. For example, if all subjects studied the word *EAGLE*, one group decided if the word was in uppercase letters (perceptual), the second group decided if it rhymed with legal (phonemic), and the third group decided if it was an animal (semantic). All of these questions would have been answered affirmatively, but memory was best following semantic processing, next best with phonemic processing, and worst after perceptual processing. This is the classic levels of processing effect. The educational implication is that incidental study can be just as effective as intentional memorization. If students are studying via a semantic or other elaborative task, the resulting memory can be just as strong even if they are not forewarned about the upcoming memory test.

Encoding is not like taking pictures with a camera; not everything is recorded. Instead, encoding is selective. The levels of processing effect is an example of this; depending on the instructions, subjects directed their attention to different features of the target word. More generally, what students encode will be a function of what they already know and how well they can understand and link the incoming information to their prior knowledge. A *schema* is the term for a person's knowledge representation of a concept or domain. Without a schema, the understanding and interpretation of incoming information is difficult. For example, in a 1977 study by D. James Dooling and Robert E. Christiaansen, subjects had poor memories for such passages as "With hocked gems financing him / our hero bravely defied all scornful laughter that tried to defy his scheme / Your eyes deceive, he said—an egg not a table correctly typifies this unexplored planet." Good memory required knowledge that the upcoming passage would be about Christopher Columbus. Schemas also serve to direct a subject's attention to particular schema-relevant details and to allow for inferences. For example, according to a 1977 study conducted by James Pichert and Richard Anderson, students who read a story about two boys playing hooky and

spending the day at home remembered different things depending on which of two perspectives had been instantiated at encoding: home buyer or burglar. Subjects who read the story with the perspective of a burglar attended to and remembered better such details as that the house's side door was unlocked, a fact unlikely to be relevant to a home buyer.

Another fact about encoding is that more is not necessarily better; massed study is not a good idea. While many students choose to cram for exams the night before, the data clearly suggest that spaced study opportunities are preferable. The same holds true for rehearsal of to-be-remembered information, which is described in the next section on activities during the retention interval.

Storage

Encoding is a necessary but not sufficient condition for later memory. As time passes, it becomes less and less likely that a person will be able to retrieve the target event. In 1985 Herman Ebbinghaus first documented the now classic forgetting function; he taught himself series of consonant-vowel-consonant trigams and tested his memory after varying time lags. Memory dropped off quickly at first, but eventually forgetting leveled out over time to a fairly stable level. Most laboratory studies involve fairly short retention intervals; in 1984, however, Harry P. Bahrick examined knowledge of Spanish following retention intervals of up to fifty years (participants reported very little use of Spanish during that time). Again, there was a sharp drop in knowledge by three to six years poststudy, but after that initial drop, knowledge was surprisingly stable over the next twenty-five years. Bahrick termed this long-term retention the *permastore.*

Rehearsal during the retention interval aids memory; not all forms of rehearsal, however, are equal. Simply repeating a to-be-remembered item will not necessarily lead to enhanced memory. A student who writes a fact over and over will not remember that fact as well as a student who takes a more active approach to rehearsal. One of the best strategies is that of expanding rehearsal combined with self-testing. For example, the student who wants to learn a vocabulary word should not simply stare at the word paired with its definition. Rather, she should test herself and produce the definition of the word from memory; after a short delay she should repeat the process, and so on, incrementally increasing the delay until the retention interval is at the desired length.

Memories do not lie dormant during the retention interval but are affected by the new information that continues to enter the system. In one classic demonstration of *interference,* subjects saw a slide show of a traffic accident involving a car passing a stop sign. In the next phase of the experiment, subjects in the experimental condition read a narrative description of the slide show that included a misleading reference to a yield sign. Control subjects also read a narrative, but it did not contain the misinformation. All subjects were later asked whether they had seen a stop sign or a yield sign. Subjects who had been exposed to the misleading post-event information were more likely to mistakenly say they had seen a yield sign than the control group. Although the exact mechanisms underlying the misinformation effect are still under debate, in at least some circumstances the misinformation works to block or interfere with access to the original memory.

Retrieval

No single test of memory is perfect. No one test yields an absolute measure of what is in memory; rather, one can ascertain what is accessible only under a particular set of test conditions. The failure to recall part of a list is not necessarily synonymous with forgetting those words. Rather, they may be *available* in memory but not *accessible* given the current retrieval cues. When asked to write down all the words from a studied list, a subject may not be able to recall studying the word *robin.* This allegedly forgotten word, however, may be recalled in response to the category cue "birds" or correctly labeled as "old" on a test that re-presents the word *robin* for an old-new decision. Similarly, a student who is unable to produce an answer on an essay test may recognize it on a multiple-choice test.

Conclusions about memory may vary across tests. Take, for example, the effects of word frequency on memory. Following study of a word list, words that occur with high frequency in the language (e.g., *tree*) are recalled with a higher probability than are words that occur with low frequency in the language (e.g., *ecru*). The opposite result, however, is obtained on recognition memory tests. When subjects are asked to label words as "old" or "new," they do a better job with low frequency than high frequency

words. This paradox is one that continues to interest researchers.

So, how then to get the best performance possible on a memory test? The general rule is that the test should match study as much as possible. Returning to the levels of processing effect described earlier, semantic processing leads to better memory in part because most memory tests are semantic in nature. When subjects are given a phonological test (e.g., did you study a word that rhymes with *beagle*?), performance is better when words are encoded as rhymes than when they are categorized. Effects of test expectancy are nicely explained within this framework. Performance on an open-ended (essay or free recall) test suffers if students are incorrectly led to expect a multiple-choice test. Depending on which test is expected, students study differently. Students expecting a multiple-choice test focus less on relations between items and spend less time preparing than do students expecting a more open-ended test. The way students study for multiple-choice tests does not match the demands of the recall test; hence, performance suffers when students are surprised with the unexpected version of the test. A good educator will make clear the test demands early in a course so that students will tailor their study strategies appropriately.

Memory is not like a tape that can be played back perfectly at test. Rather, memory is reconstructive. In one example of this, from the 1977 study of Dooling and Christiansen, subjects read a paragraph that began "Carol Harris was a problem child from birth. She was wild, stubborn and violent." Right before the test phase, some of the subjects were told that Carol Harris was really Helen Keller. These informed subjects were much more likely to incorrectly identify the statement "She was deaf, dumb, and blind" as having been in the original paragraph than subjects who were not informed of Harris's true identity. Subjects made use of their knowledge at test to reconstruct what they read during the first part of the experiment. Schemas are as active during test taking as they are during encoding, and they provide retrieval cues and allow for reconstruction.

Conclusions

There are two very general requirements for effective memory: quality encoding and appropriate retrieval cues. These principles are exemplified in a classic study method, the SQ3R method, which Francis P. Robinson described in 1970. SQ3R stands for: survey, question, read, rehearse, and review. Students begin by surveying the textbook chapter before reading it, to become familiar with its organization. As they read the chapter, they form questions that they then answer. Finally, they rehearse and test themselves on what they have just read, and review all the material repeatedly. Each of these activities links to basic memory processes. The initial survey of the chapter leads students to set up a schema for the chapter that guides both encoding and later retrieval. The questions students create serve as retrieval cues later on. Answering these questions, repeated rehearsing, self-testing, and reviewing the material are all forms of retrieval practice that will aid memory. Studying a textbook chapter need not be a mystery to students.

See also: MEMORY, *subentries on* AUTOBIOGRAPHICAL MEMORY, IMPLICIT MEMORY, METAMEMORY, STRUCTURES AND FUNCTIONS.

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STRUCTURES AND FUNCTIONS

In the study of memory there have been many metaphors adopted in the search for an explanation of the memory process. The fourth century B.C.E. Greek philosopher Aristotle compared memorizing to making impressions in wax, and the idea that memories are copies of reality that a person stores and later retrieves has been widespread. This is sometimes called the storehouse metaphor, and many of the ways in which people talk about memory (searching for memories, bringing them back from the recesses of one's mind) assume such a metaphor. The computer metaphor that has been popular with psychologists researching memory is a version of the storehouse view. It conceptualizes the stages involved in remembering in terms of encoding, storage, and retrieval in which information is entered into memory, retained, and then found again at a later time. Thinking about remembering in this way can be valuable, but it can lead to the incorrect assumption that what is remembered is a simple copy of what was originally experienced. In reality, much that is remembered captures the gist rather than the details of the original experience, and remembering is often a process of reconstruction. Examples of constructive remembering can be found in research on false memories. Elaborate and detailed false memories of events from an individual's past can be easily created. More mundanely, hearing a list of close associates to a particular word leads to recall of the word itself even though it was not presented. One alternative to the storehouse metaphor is the correspondence metaphor that emphasizes the deviation between the memory and the original experience.

Memory Structure

Researchers who study memory use a number of terms to subdivide the enormous field. One major distinction is that between explicit and implicit memory. Explicit memory refers to the conscious recall of information. Conscious awareness of past experiences involves explicit memories. Often, however, people are influenced by experiences that are not consciously recallable. For example, the ease and speed with which a person solves the anagram *rbocoilc* depends upon how recently the person has encountered the word *broccoli.* This facilitation reflects implicit memory. Processing of new information is primed by past experiences without conscious awareness. The distinction between explicit and im-