Encyclopedia of Learning and Memory

Larry R. Squire
Editor in Chief

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and for the messages of common advertisements.

Additional examples of ineffective rehearsal have come from experiments on rote rehearsal (e.g., Glenberg, Smith, and Green, 1977; Rundus, 1977). In these studies, subjects have repeated words aloud over and over. An unexpected memory test on the words is later given to the subjects. Memory performance is usually only slightly affected by the number of times that a person read each word aloud. On the other hand, if people are encouraged to carry out more active, effortful processing on the words, memory improves dramatically as study time is increased.

Thus, repetition need not lead to improved learning. Rather, repetition leads to increased opportunities for learning to occur. Whether such learning takes place will depend on the amount and nature of processing that a person carries out.

(See also ATTENTION AND MEMORY; DISTRIBUTED PRACTICE EFFECTS.)

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Robert L. Greene

RETRIEVAL PROCESSES IN MEMORY

The processes of learning and memory are often subdivided into stages of *encoding* (initial learning of information; see CODING PROCESSES), *storage* (maintaining information over time), and *retrieval* (using stored information). Processes of encoding establish some representation of experience in the nervous system, which is referred to as a *memory trace.* Memory traces certainly have physiological underpinnings, but cognitive psychologists use the construct as an abstraction to refer to the changed state of the cognitive system before and after some experience. *Retrieval processes* refers to the means of accessing stored information and can be affected by a variety of factors.

The division of processes into those affecting encoding, storage, or retrieval seems simple in concept but cannot be readily defended in practice. One reason is that it is impossible to distinguish cleanly between encoding and storage processes, because the two are inextricably connected. When does initial learning (encoding) end and maintenance of information over time (storage) begin? There is no clear answer to this question; suggestions provided by some theorists to cut this Gordian knot are relatively arbitrary. However, separation between the bundle of processes referred to as encoding and storage, on the one hand, and those involving retrieval, on the other, can be accomplished more directly.

The general logic of this separation is to hold conditions of encoding and storage constant and to manipulate only conditions of retrieval. For example, two groups of people could be presented with material (lists of words or sets of stories) to remember and could be treated identically until the time they are tested. Then one group of people might simply be given a blank sheet of paper and asked to recall all that they can of the material. Imagine that they recall 40 percent of the material under these *free recall* conditions (so called because they are given no external cues to aid recall and are free to recall material in any order). This measure might be thought to reflect the amount of information that people have encoded and stored—the amount they know—but this conclusion would ignore the possibility that the bottleneck in performance is at the retrieval stage. Perhaps the people really have encoded and stored much more, but have simply failed to retrieve the extra material. This possibility can be examined by testing another group of subjects who are given retrieval cues to prompt recall of the material. Often appropriate cues can produce great benefits relative to free recall (Mantylä, 1986).

The advantage of cued recall over free recall indicates that more information is *available* (or is stored) in memory than is *accessible* (retrievable) on a particular test such as free recall (Tulving and Pearlstone, 1966). More generally, no test of memory provides a perfect measure of information stored in memory; the retrieval processes involved in any test filter the information. At best, we study the information that can be produced under a particular set of retrieval conditions. Although no test or set of retrieval conditions can ever provide a perfect window on the contents of memory, study of retrieval processes can proceed meaningfully in many different ways.

Repeated Testing

One straightforward way to study retrieval processes is to test people repeatedly on the same material, under the same or differing conditions. For example, people might study sixty pictures of easily named objects and then be tested on the names of those objects under conditions of free recall. After a first test, they would be given a second and then a third test under identical conditions without intervening study of the material. An almost universal finding in such experiments is that people will recall items on the second and third tests that they did not recall on the earlier tests, a phenomenon called *reminiscence* (Ballard, 1913). Of course, some pictures recalled on the first test might be forgotten on later tests, but surprisingly the reminiscence or recovery between tests often outweighs the interest forgetting. When total recall improves over tests, this phenomenon is called *hypermnesia* (Erdelyi and Becker, 1974). Whereas reminiscence (recall of items on a later test that could not be recalled on an earlier test) almost always occurs in experiments, hypermnesia is observed more rarely and usually under conditions where no retrieval cues are given. Under certain conditions the phenomenon is quite reliable, so the challenge is to specify the necessary conditions for its observation. It may be that hypermnesia occurs more regularly with materials that involve imagery (such as pictures); another proposal is that hypermnesia depends on the level of retention (regardless of type of material) and on retrieval dynamics across tests (Roediger and Challis, 1989). Whichever is the case—and some argue for a hybrid theory—the phenomena of reminiscence and hypermnesia point up again that a single test of retention provides a faulty assessment of the amount of information stored in memory (Payne, 1987).

Testing with Retrieval Cues

The most popular method of studying retrieval processes is by manipulating the nature of the testing conditions, particularly the types of cues given to aid recollection. In a typical paradigm, people are given a list of words to remember that belong to common categories. The list might be composed of words such as *zebra, ocelot, sheep, beaver, desk, dresser, couch,* and *footstool,* representing the categories *four-footed animals* and *articles of furniture.* After receiving a long list, some people are tested under conditions of free recall (recall the words in any order) and some under conditions of cued recall (the same instruction, but now the names of the categories are provided as retrieval cues). The typical finding is that people tested with category names as retrieval cues recall many more items than those tested without cues, showing again the disparity between information that might be available in memory and that accessible on a particular test. The gains from cues are genuine and not due merely to guessing items belonging to the categories, because the items used are typically not the most likely to be guessed (*horse* and *dog* are avoided as study materials in favor of *ocelot* and *beaver*).

What causes retrieval cues to be effective? A primary consideration is what type of information was learned and how it was encoded—what information is stored in memory. The general principle governing retrieval of such stored information is called the *encoding specificity principle:* retrieval cues are effective to the extent that they help reinstate or re-create processes involved in original learning (Tulving, 1983). The idea is that events are encoded in specific ways—we retain specific coded features of our experiences that may comprise the memory traces of these experiences. Retrieval cues are then effective to the extent that they match or overlap the specific encoded features.

Consider a thought experiment to illustrate this point: You are asked to recall all the experiences you can from your year in the fifth grade, and are given half an hour to do so. You should include the names of your classmates and, if possible, the seating arrangement in your classroom. Presumably you could accomplish this task with a certain (low) level of performance. Now imagine a second phase to the experiment wherein you are actually taken to your elementary school, reenter your classroom, and squeeze into your little desk, to perform the task again under these new conditions. We might now assume (and experiments confirm) that powerful retrieval cues, such as the place in which an event occurred, would greatly increase your memory of your fifth grade year (Bjork and Richardson-Klavehn, 1989). The sights, sounds, and smells of your classroom would revive dormant memories that would otherwise be inaccessible.

Numerous laboratory experiments have confirmed the essence of the encoding specificity principle by showing that retrieval cues that match, or re-create, the original features of the learning experience promote better memory. This is not to say that all retrieval phenomena are well accounted for, because some empirical problems do exist. For example, certain types of cues that seem as if they should be effective are not; in some cases, seemingly "good" retrieval cues actually hinder rather than help recall. One example is the *part-list cuing phenomenon,* wherein giving people part of a list of items hurts recall relative to control conditions (Slamecka, 1968). For example, if people are given lists of words belonging to common categories (such as the examples used above) and then at test either are given only category names as cues or are given category names plus two items from the categories, recall of the remaining items from the categories will be better when only category names are given as cues. Providing some items from the category in addition to the category names will re-create the learning situation better than just giving the category names, but in fact such item cues hurt recall.

Explaining this retrieval inhibition has proved to be a challenge; much research has established the validity of the finding and eliminated many artifactual possibilities for the results (Nickerson, 1984). One interpretation links the part-list cuing effect to a *cue-overload principle:* a retrieval cue becomes less effective as more events are subsumed under the cue (Watkins, 1975). So, for example, a category name retrieval cue provides better recall of the studied members of a category if two items were given in each category of the list rather than six items. In the case of part-list cues, it may be assumed that presentation of the category members at test somehow adds to the number of items subsumed under the category name cue and thereby reduces recall. Numerous observations accord with the cue overload principle's interpretation of the part-list cuing effect, although other theories exist as well. The cue overload principle complements the encoding specificity principle in making sense of the variable effectiveness of retrieval cues.

State-Dependent Retrieval

Alcohol and other drugs having a depressing effect on the central nervous system are known to impair retention of information. The usual interpretation is that alcohol interferes with the neural processes which underlie encoding and storage of information, or the consolidation of information. This is likely true, but may not represent the whole story of drug-induced amnesia. Retrieval factors are at work, too. Clinicians working with alcoholic patients have observed that the patient may, for instance, hide a bottle while drunk and then not be able to remember where it is hidden when sober. However, the next time the patient gets drunk, the bottle may be recovered. The phenomenon suggests that successful retrieval of memories may depend on matching the pharmacological states in which information is learned and used.

This phenomenon of *state-dependent retrieval* (better recall when pharmacological states of learning and testing match rather than mismatch) has been verified in laboratory experiments. In one case (Eich et al., 1975) volunteer students smoked marijuana or a placebo cigarette before being exposed to a categorized word list. Four hours later the subjects again smoked either a marijuana cigarette or a placebo and then were tested on the material, first by free recall and then by cued recall in which category names served as the retrieval cues.

The results are shown in Table 1; first consider the free recall results, where the number of words recalled from the set of 48 are shown. If people were sober both when they studied the words and when they were tested on them, they performed best (11.5 words recalled). If they were under the influence of marijuana at study but sober at test, they recalled fewest (6.7). This condition represents the usual case of drug-induced amnesia, when people experience events under the drug

Table 1. Results of the Experiment on State-Dependent Retrieval

Condition		Average Number of Words Recalled	
Study	Test	Free Recall	Cued Recall
Placebo	Placebo	11.5	24.0
Placebo	Drug	9.9	23.7
Drug	Placebo	6.7	22.6
Drug	Drug	10.5	22.3

but are sober when tested. Is this effect due only to encoding and storage factors, or are retrieval factors at work, too? This question can be answered by examining the last row: when people were drugged at both study and test, they recalled more words (10.5) than when they were drugged only during study (6.7). Just as in the anecdote about the alcoholics related above, retention improved when the pharmacological state at test matched that at study. Do not conclude from this experiment that drugs improve memory, because they usually do not. (When people learned the information sober but were tested under marijuana, they performed worse than when tested sober.)

Although state-dependent retrieval is a real phenomenon, it usually occurs only under free recall conditions, as can be verified by examining the cued recall results. The category names served as good retrieval cues, because cued recall was better than free recall in all four conditions. However, the state-dependent retrieval effect (better recall in the drug-drug study and test condition compared with the drug-sober condition) has vanished. These results are broadly consistent with the encoding specificity hypothesis. Under conditions of free recall, a person's pharmacological state can serve as a retrieval cue, and if the cues match between study and test conditions, performance is enhanced. However, when powerful external retrieval cues are provided, they overshadow the weak "state" cues and render them ineffective. This account explains the common finding that state-dependent retrieval effects are rarely found on tests employing cued recall (Eich, 1989). (See also DRUGS AND MEMORY.)

Do state-dependent retrieval phenomena exist with states other than drug states? The conditions most often investigated are moods, in studies where researchers induce happy or depressed moods in people by various means prior to study or test of material. The expected finding is that congruence of mood at study and test should produce better retention than when moods mismatch. This result has been reported in some studies, but there have been numerous failures to replicate it and the reasons for this state of affairs are not well understood at this point. (See also EMOTION, MOOD, AND MEMORY.)

Transfer-Appropriate Processing

A viewpoint related to the encoding specificity hypothesis, *transfer-appropriate processing*, emphasizes that all retention tests can be considered as cases of transfer of prior experience to the test situation. Depending on the nature of the task used to assess memory, some experiences will provide good transfer and others will provide poor transfer. Further, this approach emphasizes the relativity of memory tests: some methods of learning may prove superior for one type of test but disastrous for another. The phrase *transfer-appropriate processing* was first used to explain some results obtained in the *levels of processing* tradition (Morris, Bransford, and Franks, 1977). Under many conditions, if people study events while focusing on their meaning, they retain the events better later than if they had focused on other aspects of the events, such as what they look or sound like, while studying them. For words, retention is better on many tests after people have generated meaningful associations for the words (thus forcing attention to their meaning) than when rhyming words have been generated (causing attention to sounds or phonemes).

Most of the tests showing the superiority of meaningful encodings have been those, such as recall or recognition, that are thought to rely heavily on meaning (Craik and Tulving, 1975). But suppose a test were given for the sound of words following study experiences encouraging attention to either the meaning or the sound of words. When such tests were constructed, the results came out largely as expected: having people think about the rhyming aspects of words during study produced better performance on tests requiring knowledge of the sound of the words than did study experiences emphasizing the meaning of words. Therefore, the ways in which one studies events are not inherently good or bad for later retention; instead, whether study strategies are good or bad depends on their relation to the nature of the test. Learning experiences transfer well or poorly depending on the nature of the test and the type of knowledge it requires.

The ideas of transfer-appropriate processing have been applied to several different problems. One is the explanation of differences between explicit tests of memory (those in which people are told that their memories are being tested) and implicit tests of memory (those in which people are simply given a new task and retention is measured by how prior experiences transfer to the new task). Many implicit memory tests seem to involve perceptual components and to benefit from appropriate perceptual processing, whereas many explicit tests depend upon meaningful processing. Numerous experiments have confirmed that these two broad areas of experience (perceptual, conceptual) differentially affect certain tests in the predicted manner (Roediger, 1990). (See also IMPLICIT MEMORY.)

Related Topics

Retrieval processes play a role in all memory phenomena, so the coverage here has perforce been selective. For example, the fact that distinctive events are well remembered may be interpreted in terms of the cue overload principle; the inhibition from part-list cues may be related to the TIP-OF-THE-TONGUE PHENOMENON wherein people are blocked from recalling well-known information by intrusion of related information. All memories depend not just on conditions of encoding and storage, but on myriad retrieval factors. Some retrieval processes seem reasonably well understood at this point, albeit at a general level, but others present problems whose solutions have not yet been attempted.

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Henry L. Roediger III

RIBOT, THÉODULE

Théodule Armand Ribot (1839–1916) was born in Guingamp, Brittany. After attending lycée in Saint-Brieuc, he entered the Ecole Normale Supérieure at Paris in 1862. He received his degree in philosophy in 1865, and until 1872 he taught philosophy in the secondary schools of Vesoul and Laval. In 1870 Ribot published his first work, *La psychologie anglaise contemporaine.* Seven years later he gave up teaching so that he could concentrate on writing. He also attended clinical courses in psychiatry given by Valentin Magnan, Benjamin Ball, Jules Luys, Félix Voisin, and Jean-Martin Charcot, then defended his thesis, "L'hérédité psychologique." In 1876 Ribot and Hippolyte Taine founded the journal *Revue Philosophique*, which is still published.

In 1885, Ribot started a course in experimental psychology at the Sorbonne, and in 1888, through the influence of Ernest Renan, a chair of experimental and comparative psychology was created at the Collège de France that Ribot occupied until his retirement in 1901. Among Ribot's honors was his election to the Académie des Sciences Morales et Politiques (Section of Philosophy) in 1899.

Ribot was responsible for creating in France "scientific" psychology, rejecting a psychology that depended on spiritualism and introspection in favor of one that depends on facts and has to agree with known physiological and biological data. Ribot was interested in pathological psychology because it enabled one to understand normal psychological mechanisms by discovering the laws that govern facts. Influenced by Herbert Spencer's evolutionism, Ribot described, as did Hughlings Jackson, the law of regression (or of dissolution) that controls pathological mental phenomena, such as the amnesias. It is important to point out that Ribot was neither an experimenter nor a clinical observer. His contributions were purely intellectual and the result of personal reflection upon the

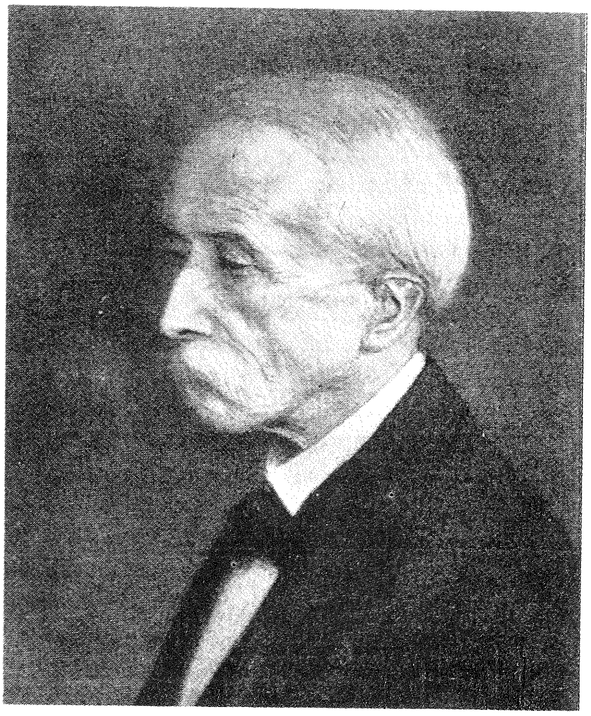

Figure 1. Théodule Ribot. *Photo by Harlingue-Viollet.*

events reported by others, which he categorized and regrouped. He never attempted to construct models. His work was empirical and rational rather than experimental.

Ribot is probably best known today for his law of regression in the amnesias, Ribot's Law. The law outlines in a logical fashion the progressive dysfunction of memory in disease. First to be affected are recent memories. Second, personal memories disappear, "going downward to the past." Third, things acquired intellectually are lost bit by bit; last to disappear are habits and emotional memories. Thus, Ribot's Law refers to progressive amnesia as a temporal gradient going from the most recent to the oldest memories. For Ribot this law implied that memory depends upon permanent modifications and organization of neurons, and it is their disorganization that leads to amnesia. Ribot's Law considers only one type of memory, defined by a double capacity of conservation and of reproduction of certain states (for example, a skill); the recognition and localization in the past that are carried by consciousness are exclusively psychological and do not constitute memory. Ribot applied his law to aphasias, which he regarded as partial amnesias.