Long-Term Memory: Processes

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Long-term memory refers to the permanent retention of information in the human memory system that can last from several minutes to a lifetime. An influential model of the organization of long-term memory proposed by Larry Squire (and subsequently corroborated by cognitive neuroscience research) suggests that long-term memories can be classified in either of two distinct systems: (a) a *declarative system*, specializing in the processing of memories for facts *(semantic memory)* and events *(episodic or autobiographical memory)*, and (b) a *nondeclarative system*, specializing in the processing of procedural skills, habits, and different kinds of learning. This entry focuses on the theories surrounding two interdependent processes that largely determine the successful functioning of long-term memory: memory encoding and memory retrieval.

Although the capacity for long-term memory is theoretically unlimited, its effectiveness depends on whether the right kind of information is accessible at the right time and in the right context and on whether the information is sufficient by itself or requires amplification from other memories. For example, remembering that Paris is the capital of France (a fact) is relevant during a geography test, but not during a chemistry exam, and remembering how to swim (a procedural skill) is critical when one is in the pool, but not when riding a bike.

Similarly, remembering to bring a dessert to a friend's dinner party (an event) might be supplemented by the memory that one is allergic to peanuts (an autobiographical memory). Viewed in this context, long-term memory encompasses a set of dynamic processes that underlie its remarkable flexibility.

Memory Encoding

The process of encoding pertains to the active translation of information about the world into long-term memory in a manner that allows access of this information in a useful way. Fergus I. M. Craik and Robert S. Lockhart proposed one of the early theories of encoding that focused on the influence of the level of processing of the presented information on later memory retrieval.

According to the *depth-of-processing* approach, information can be experienced at different levels of specificity, ranging from superficial processing of the physical characteristics of a stimulus (e.g., the color of the font in which a word appears or how it sounds) to "deeper" features pertaining to stimulus identity (e.g., the meaning of the word) or its personal relevance to the participant (e.g., whether the word describes him or her). Evidence from studies involving both intentional learning paradigms (wherein participants are aware that their memory for the studied material will be assessed following learning) and incidental learning paradigms (wherein participants are unaware that memory will later be tested) have shown that the deeper the level of processing of the experienced information, the higher the likelihood this information will be remembered easily and accurately.

Although the depth-of-processing theory helped shape early thinking about long-term memory function, it is frequently difficult to define a priori **[Page 520]** what the processing level of a given stimulus feature should be unless memory for that feature has already been assessed. In addition, whether the level of processing of a feature leads to better memory appears to depend on how the memory is tested. This has called into question the broad applicability of this approach to long-term memory phenomena.

Beyond any influences of processing depth, long-term memory encoding can be affected by the context in which to-be-remembered information is presented. According to the *encoding specificity principle*, memory performance is better when the context of memory retrieval matches the context of memory encoding.

For instance, English–Spanish bilinguals presented with different kinds of information in English and Spanish remembered that information better when their memory was assessed in the language in which the stimuli were originally presented than when assessed in the other language. Similarly, participants who learned lists of words either on land or underwater recalled the words better when the retrieval context matched the original learning environment.

Changes in physical context are typically weaker than changes in mental context, and they depend on the extent to which physical context was attended to during encoding. In a related phenomenon, known as *state-dependent recall*, changes in the internal context (e.g., due to drugs or alcohol) can also introduce measurable, but modest, effects on memory retrieval. Overall, these effects are stronger in more naturalistic, as opposed to experimental, settings. Nevertheless, the exact circumstances under which changes in context influence memory remain controversial and are not yet fully understood.

Long-term memory is further influenced by emotional context. People tend to remember pleasant events better than unpleasant events and positively judged stimuli better than negatively judged stimuli, with neutral stimuli associated with poorer memory, overall. Several studies have demonstrated that people tend to recall more accurately information that is aligned with their current mood, a phenomenon known as the *mood congruency effect.* This finding can have certain clinical implications; it suggests that people diagnosed with depression might remember negative events better than positive events, which could perpetuate their depressive symptoms.

Aside from context effects, memory performance is significantly enhanced when materials are organized in a meaningful and intuitive way during encoding. For example, remembering one's grocery list will improve if the items on the list are not presented randomly but rather are organized according to grocery store sections (e.g., produce, dairy, personal care, etc.). The level of *distinctiveness* in the encoding of new stimuli relative to one's past memories can further determine later retrieval.

For instance, remembering, among all other new acquaintances, the name of a particularly interesting person one has met at a party requires additional time and depth of processing. Actively integrating new information with one's prior knowledge, a process known as *elaboration*, can likewise facilitate memory encoding, although it is also possible for new memories to become distorted so as to conform to past experience.

In addition, research has shown that *spacing* learning over longer periods of time is associated with better memory, an effect attributed to multiple encodings and repeated elaboration of the new information. The benefits of elaboration are further augmented by self-referential strategies—namely, processing new information in ways that relate to the self (e.g., visualizing oneself using a novel object as opposed to visualizing the object alone). Several studies have shown that not only are cues related to the self richer, more highly interconnected, and more distinctive, but they also tend to be rehearsed more frequently, leading to successful memory retrieval.

Memory Retrieval

Long-term memory retrieval refers to the process of accessing existing memories in a useful way. Successful memory retrieval is directly linked to the process of memory encoding in that access to long-term memories depends on the similarity between the cues used during retrieval and those present during encoding, as discussed earlier. Memory retrieval can be intentional (or explicit) and typically involves the *recall* (i.e., reproduction) of learned material as a response to a question or a cue or the *recognition* of whether a particular item has been encountered before.

[Page 521] For example, responding with the definition of the mood congruency effect on an essay exam question would rely on *recall* processes, whereas answering a multiple-choice question on the topic would rely on *recognition* processes. In contrast, implicit memory retrieval occurs when there are no explicit memory prompts, and it typically involves access to long-term memories outside one's awareness. For example, in *repetition priming*, exposure to a particular story increases the likelihood that words from that story will be recognized faster in a seemingly unrelated follow-up task.

As Squire's taxonomy of memory suggests, explicit and implicit memory retrieval depend on dissociable cognitive and neural systems, such that information that cannot be retrieved explicitly can nonetheless influence performance on implicit memory tasks. This distinction becomes evident in certain cases of *amnesia* or memory loss. Patients with *retrograde amnesia* have difficulty remembering information that occurred prior to their injury, whereas patients with *anterograde amnesia* have difficulty forming new memories following their injury. Interestingly, these deficits are observed only in explicit memory but not implicit memory tasks. In the latter, a patient's performance typically remains intact.

Models of Long-Term Memory Retrieval

An early, influential model of long-term memory was proposed by Allan M. Collins and M. Ross Quillian and focused primarily on the retrieval of semantic knowledge (i.e., one's memory for facts). The model proposed that one's knowledge of the world is organized *hierarchically*, forming a network of associations composed of nodes that represent ideas or concepts (structured from broad to specific) and links between those nodes indicating the relationship between them (e.g., *dog* is an *animal).*

According to this model, memories are activated from node to node following this organizational hierarchy until an answer has been reached (e.g., the answer to the question Is a *dog* an animal?). Experiments measuring how long participants took to answer such questions provided some verification for this model. However, variability in memory retrieval across different items in a category (e.g., due to how typical an item is of the category), in addition to the difficulty the hierarchical model has in accounting for complex (i.e., not simple inclusion) relationships or false responses, limits its explanatory potential.

An extension of the hierarchical model was proposed by John R. Anderson in the context of his *adaptive control of thought* (ACT) theory and its revision ACT*. According to this approach, activation spreads across networks of nodes and links. However, these are organized into more complex units of meaning or *propositions* that can account for a wide variety of memory phenomena, including facts and events.

The model has largely been supported experimentally, with its main strength being its ability to address the retrieval of knowledge that is *relevant* to a given task. The *parallel distributed processing* (PDP) model of memory introduced by James L. McClelland and David E. Rumelhart offers a very different view of memory in that concept representations that pertain to both semantic and episodic information are distributed across multiple nodes, with the strength of the connections between them varying depending on context. The appeal of PDP models has increased because of their ability to capture complex cognitive phenomena and their compatibility with models of human brain function.

Prospective Memory

Long-term memory processes do not pertain exclusively to the formation of and access to a record of past events. Indeed, one of the most fundamental aspects of memory is that it allows people to think about events in the future. This mental time travel toward planned future events is known as *prospective memory.* Prospective remembering is prevalent in everyday life—remembering a doctor's appointment, picking up a friend at the airport, or remembering to take one's high blood pressure medication are all instances of prospective memory.

This aspect of memory has become the subject of experimental investigation. Contrary to retrospective retrieval processes that are typically achieved in response to an explicit memory cue, prospective retrieval can be achieved as a result of multiple mechanisms, including active monitoring and spontaneous retrieval, both of which **[Page 522]** emphasize the timing of a particular future event in addition to its content. These processes are the focus of current research, due to the potential detrimental consequences of prospective memory failures (e.g., for a patient's health or for transportation safety).

See alsoFailure of Memory (/reference/the-sage-encyclopedia-of-theory-in-psychology/i2921.xml); Knowledge (/reference/the-sage-encyclopedia-of-theory-in-psychology/i4028.xml); Long-Term Memory: Structures (/reference/the-sage-encyclopedia-of-theory-in-psychology/i4266.xml); Memory as Reconstructive (/reference/the-sage-encyclopedia-of-theory-in-psychology/i4415.xml); Short-Term and Working Memory (/reference/the-sage-encyclopedia-of-theory-in-psychology/i6524.xml); Working Memory, Improvement of (/reference/the-sage-encyclopedia-of-theory-in-psychology/i7415.xml)

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Further Readings

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