THE NATURE OF LONG-TERM MEMORY

The ability to remember the people, places, and things encountered in the course of daily life is a fundamental form of cognition that guides behavior. The frustration experienced in situations such as the hallway meeting described serves as a brief reminder of our dependence on memory, the internal repository of stored information. The kind of memory involved in these situations is long-term memory, information that is acquired in the course of an experience and that persists so that it can be retrieved long after the experience is past. William James (1890) described this kind of memory as "the knowledge of a former state of mind after it has once dropped from consciousness." By contrast, other forms of long-term memory influence our present thinking and behavior while operating outside awareness. In such instances, past experience unconsciously affects the present. Progress in understanding longterm memory has come from behavioral investigations of people with intact memories as well as of patients with memory deficits. Insights into the operation of memory also have come from lesion and recording studies in animals and neuroimaging studies in humans.

FORMS OF LONG TERM MEMORY

Theorists believe that there are multiple forms of long-term memory that differ in their basic information processing properties and in the brain structures that support them (Figure 5–1). These various forms of memory are thought to fall into two general classes, described as declarative and nondeclarative. Declarative memory (also known as explicit memory) refers to forms of long-term memory that can ordinarily be consciously recollected and "declared," or described to other people, such as memory for facts, ideas, and events. Declarative memory encompasses episodic memory, the memory of events in our own personal past, and semantic memory, our general knowledge about things in the world and their meaning, a distinction proposed by Endel Tulving in 1972. Tulving defined episodic memory as the conscious knowledge of temporally dated, spatially located, and personally experienced events or episodes.

He defined semantic memory as knowledge about words and concepts, their properties, and interrelations (Tulving, 1972). We are aware of the contents of both kinds of memory, but a difference between them is context, or the lack thereof. Episodic memory, which supports memory for individual life events, has a context: when you recollected details about one of the people you met in the hall—her political views, her tastes in cuisine—you engaged in a kind of "mental time travel" to your earlier meeting, and you were aware that the information you possessed about her was bound to that particular autobiographical experience. But when you retrieve your semantic memory of, say, the main ingredients of Italian cuisine, that memory is

not bound to the specific context in which you acquired that knowledge because you likely accumulated the knowledge across multiple experiences in a variety of contexts. Tests that assess declarative memory are termed explicit memory tests because they require the retrieval of an explicit description or report of knowledge from memory.

Declarative memory is highly flexible, involving the association of multiple pieces of information into a unified memory representation; thus, we may have different routes to retrieval of a given memory. Both forms of declarative memory, episodic and semantic, depend on the operation of the medial temporal lobes.

Nondeclarative memory (also known as implicit memory) refers to nonconscious forms of long-term memory that are expressed as a change in behavior without any conscious recollection. Tests of nondeclarative memory—termed implicit memory tests—do not require description of the contents of memory, but rather reveal memory implicitly through observed changes in performance, such as the gradual acquisition of a motor skill. In comparison to declarative memory, nondeclarative memory tends to be more restricted in the ways that this knowledge can be retrieved. The various forms of nondeclarative memory do not depend on the medial temporal lobe structures that are important for declarative memory. Rather, the various forms of nondeclarative memory are implemented in different brain regions (see Figure 5–1).

ENCODING: HOW EPISODIC MEMORIES ARE FORMED?

Some of life's episodes, central or trivial, may be remembered so well that we can accurately bring back to mind tremendous detail, even after considerable time has elapsed—you remember with pleasure an Italian dinner you shared with the friend you just met again in the hall. Other experiences may be poorly remembered or, worse yet, irretrievably lost—what is that guy's name? He's not in my physics section, is he? What determines whether an experience will be remembered or forgotten? Early experimental studies of human memory in the late 1800s investigated this puzzle. Research during the past century has demonstrated that a complete understanding of how memories are formed requires appreciation of the many cognitive and neurobiological processes that constitute the three stages of memory processing—encoding, consolidation (the modification of representations in memory so that they become stable), and retrieval—and the interactions among these different stages.

Encoding is the term used for the various processes by which information is transformed into a memory representation. These processes are set in motion at the time of the experience, forming a mental representation that records some aspect or aspects of it. All forms

of memory, declarative and nondeclarative, begin with encoding. But because episodic memory records the unique history of each person's life, it seems a suitable starting point for our discussion of how encoding works. One way to uncover the fundamental properties of encoding is to try to determine what strengthens the process. This approach has revealed that encoding is influenced by a number of factors, including the degree to which we attend to information and the extent to which we "elaborate" on its meaning.

Elaboration involves interpreting information, connecting it with other information, and mulling it over. Other influences that strengthen encoding are conscious retrieval of the information, and practice that is "distributed," or spaced out, in time. As suggested by studies of patients with amnesia, the medial temporal lobes play a critical role in episodic encoding. Neuroimaging and clinical data also indicate that the frontal lobes contribute to attention and elaborative processing and thus affect encoding.

THE IMPORTANCE OF ATTENTION

One of the more obvious and consequential reasons for poor encoding is failure to attend to an event while it is happening. When your attention to information is divided, for example because you are distracted, encoding is weaker and later attempts to remember are likely to fail. You may have forgotten where you put your glasses because you're still trying to remember the name of the physics student you saw in the hall. And you may have forgotten his name because when you met the first time your attention was focused on the impending physics exam. The role of attention in encoding has been explored in the laboratory. In one set of experiments (Craik et al., 1996) participants were instructed to try to remember 15 auditorily presented words under one of two conditions. In the full-attention condition, participants were not given any task other than to try to remember the words. In the divided-attention condition, during word presentation participants were also instructed to monitor the position of an asterisk on a computer screen and press one of four buttons as the location changed. Participants remembered on average 9 of the 15 words when encoding was performed under full attention, but only 5 words when encoding was performed along with the secondary task.

LEVELS OF PROCESSING AND ELABORATIVE ENCODING

Evidence that attention is central to encoding might seem to suggest the conclusion that intent is required for effective memory formation. But not so fast: although intent to encode can motivate attention, intention per se is not required for effective encoding. Encoding is an automatic by-product of attending to and processing a stimulus (Craik & Lockhart, 1972). What influences encoding efficacy is the way the stimulus is processed, not the reason that processing was performed.

Levels of Processing theory:

Consider the various kinds of cognitive operations you could perform when meeting someone for the first time. Looking at that person's face, you might observe some aspect of the structure of its appearance. Or you might note the phonology—the speech sounds—of the person's name. Or you might elaborate on conceptual details you learn at this first meeting, a political viewpoint, for example, relating it to your own. In this sense, elaboration consists of generating additional information. Levels-of-processing theory draws on the fact that there are various aspects of any given stimulus that can be attended and processed. In this view, encoding is seen as a direct by-product of stimulus processing, the processing of particular aspects of a stimulus leaving a corresponding residue in the system that can guide later remembering. Different aspects of stimulus processing are thought to correspond to different levels of analysis that range from a "shallow" or superficial level of perceptual analysis to a "deep" (i.e., elaborative level) of semantic (i.e., meaning-based) analysis that actively relates incoming information to knowledge already stored in memory

According to the theory, encoding efficacy heavily depends on the level of processing performed on a stimulus, with deeper processing producing a stronger, more durable representation and thus increasing the likelihood that the stimulus will be remembered. Many behavioral studies have supported the hypothesis that episodic memory benefits from "deep" (i.e., elaborative) processing. In one of these studies (Craik & Tulving, 1975), participants viewed words and made one of three decisions about each word. For some words, participants were to say whether the words were in uppercase or lowercase letters—a "shallow" structural condition. For a second set of words, participants were asked whether each rhymed with a target word—an "intermediate" phonological condition. For words in a third set, participants were to decide whether each was a member of a particular category—a "deep" semantic condition.

Consistent with the levels-of-processing hypothesis, a later memory test revealed that the percentage of words from each set that was subsequently recognized as having been studied differed markedly for the three sets: 78 percent of the words were recognized following "deep" encoding, 57 percent following "intermediate" encoding, and just 16 percent following "shallow" encoding. Episodic memory substantially benefits from elaboration of the meaning of a stimulus or event at the time it is encountered. Levels-of-processing theory suggests that the stimuli and events that we are likely to remember best are those that we actively process for meaning. Your recollection of meeting someone who also grew up in Des Moines, likes the same kind of food you do, and is a supporter of the Republican party is clear and detailed

because of the elaboration provided by links to other representations of information already in memory and shared in conversation.

As in the Craik and Tulving (1975) experiment, most studies testing levels-ofprocessing theory have used instructions that reveal incidental learning, learning that occurs not as the result of a purposeful attempt but as a by-product of performing a task. In these instructions participants are not explicitly directed to learn, but rather are asked to perform a particular task with stimuli. Because participants are unaware that memory for the stimuli will be tested, they do not intentionally try to learn, and learning is incidental to performance of the task. The phenomenon of incidental learning helps us understand just how it is that we can remember our everyday experiences, which, after all, we don't usually deliberately attempt to encode into memory. It is unlikely that you tried to encode your meeting with your political bedfellow when it first occurred. Nonetheless, you do remember it, because encoding occurs whenever we process or attend to a stimulus or event while it occurs. (You didn't try to encode your first meeting with the physics student, either—but more to the point, you didn't particularly attend to it, so the encounter left only a weak memory, and you had difficulty remembering the event.) Levels-of-processing theory has provided much insight into the processes that lead to episodic encoding, and thus it has considerable explanatory power. But the theory has a number of limitations. There is no way of measuring the "depth" or quantifying the "level" of processing required by a particular encoding task other than its impact on memory. The lack of an independent measure of depth makes it difficult to test the theory.

A more central question concerns interpretation: do levels-of-processing effects reflect differences in the strength and durability of encoding, or differences in which aspects of a stimulus are selected for encoding and the correspondence between the kind of processing performed at encoding and that performed at retrieval? Some investigators believe that the question is not one of level but of match between what is encoded and what is tested at retrieval. If retrieval demands recovery of semantic details about a past experience, then semantic processing at encoding will be more effective because it increases the likelihood that semantic aspects of the stimulus or event will be stored in memory; but if retrieval demands recovery of perceptual details, then perceptual processing at encoding will be more effective for the complementary reason. This principle—that processing at encoding is most effective to the extent that that processing overlaps with the processing to be performed at retrieval—is known as transfer appropriate processing (Morris et al., 1977).

In an important study testing the levels-of-processing and transfer-appropriateprocessing perspectives, Morris and colleagues (1977) had participants encode

words by making a rhyme decision or a semantic decision about each word. During retrieval, memory was probed in one of two ways. A task requiring recognition of words that had been previously studied revealed the standard levels-of-processing effect (superior memory following semantic encoding). By contrast, a task requiring recognition of words that rhymed with previously studied words revealed superior memory following rhyme encoding. The level of processing does not necessarily affect the strength or durability of the encoded memory, but rather influences what is encoded.

Encoding processes yield superior memory to the degree that the features attended and processed during encoding overlap with those being sought at retrieval. For a more detailed discussion of this landmark work, see the accompanying A Closer Look box. A related idea, proposed by Tulving and Thompson (1973) and referred to as the encoding specificity principle, states that our ability to remember a stimulus depends on the similarity between the way the stimulus is processed at encoding and the way it is processed at test. For example, if the word bank is interpreted as meaning "the side of a river" rather than "a financial institution" at encoding, then remembering will be superior if at retrieval bank is interpreted as "the side of a river."

RETRIEVAL: HOW WE RECALL THE PAST FROM EPISODIC MEMORY

Our individual remembrances of times past depend on episodic retrieval, the processes by which stored memory traces are subsequently reactivated. It is the phenomenon of retrieval that produces the subjective experience of consciously remembering the past. Episodic retrieval depends on medial temporal lobe processes that support pattern completion, and frontal lobe processes that support strategic retrieval mechanisms.

Pattern completion and Recapitulation

Episodic retrieval is a powerful cognitive event that transforms our current mental state such that the present makes contact with and reinstates aspects of the past. Before you unexpectedly saw those people in the hall, it's perfectly likely you weren't thinking about either of them. For reasons we've discussed, you didn't remember one of them very well at all. But simply upon perceiving the face of the other person, your mental state was transformed. The sight of her face was a cue that initiated a cascade of processes that brought back to mind a host of details about your earlier encounter. Moreover, you were aware that these retrieved details pertained to a particular moment in your personal past. In essence, it is as if episodic retrieval launched you back in time, to an earlier moment in your life (Tulving, 1983).

How does a retrieval cue—such as the appearance of a face—serve to bring back details about the past? Episodic memories are encoded by binding together the various features of a

stimulus or event into an integrated representation, so an episodic memory consists of a conjunction of linked features. Why is this important to retrieval? For two reasons: (1) because any of those features is a possible route to the memory, multiplying the "ways in" to recollection, and (2) because it means we have access to our memories even when we have limited information. When a retrieval cue that corresponds to part of the encoded information, such as sight of a particular face, homes in on the stored representation, other features bound to the representation—a name, a restaurant sign, a conversation—are reactivated (see Figure 5–10). Because in this way a whole is built from linked parts, this retrieval process is known as pattern completion (McClelland et al., 1995; Nakazawa et al., 2002).

The notion that episodic retrieval depends on pattern completion has led to the additional hypothesis that retrieval entails recapitulation, a reinstatement of the pattern of activations that was present during encoding. Recapitulation is a reversal of the direction of information processing between lateral cortex (where disparate types of information are processed) and the hippocampus (where this information is integrated). During encoding, cortical processing provides inputs to the hippocampus, which binds the inputs into an integrated memory. In retrieval, a partial cue to the hippocampus triggers pattern completion, and the hippocampus projects back to cortical areas and replays the pattern of activation that was present during encoding.

The pattern completion and recapitulation hypotheses make two predictions. First, if pattern completion occurs in the medial temporal lobes and serves to recapitulate activation patterns, redirecting them to the lateral cortices, then medial temporal lobe retrieval activation should precede the recovery of episodic knowledge. Such retrieval signals preceding knowledge recovery in lateral cortical neurons have been observed in nonhuman primates (Naya et al., 2001). Further, it has been demonstrated that medial temporal lobe lesions in nonhuman primates eliminate cortical knowledge recovery, indicating that medial temporal processes precede and are necessary for reactivating cortical representations (Higuchi & Miyashita, 1996).

The second prediction is that, if episodic retrieval in fact entails the recapitulation of representations that were present during encoding, the pattern of cortical activation during retrieval should resemble that seen at the time of encoding. Neuroimaging studies with human participants have shown patterns of activation in visual and auditory association cortices during the encoding of pictures and sounds that were strikingly similar to those observed during the retrieval of such episodes (Figure 5–12 on Color Insert E) (Nyberg et al., 2000; Wheeler et al., 2000). It seems clear that retrieval entails the recapitulation of encoding patterns. However,

what is recapitulated is typically not an identical copy of the information that was present at encoding; memory, as we all have had occasion to know, is subject to distortion.

Cues for retrieval:

As with the investigation of encoding, researchers have gained insight into the mechanisms underlying episodic retrieval by noting the factors present on occasions when retrieval is successful. One of the fundamental conclusions reached as a result of this approach is that retrieval is cue dependent, that is, it is stimulated by hints and clues from the external and the internal environment—from the state of the world and the state of ourselves. When cues are not available or are not used, attempts at retrieval are less likely to produce pattern completion. Many instances of forgetting occur not because the information sought has been lost from memory but because the cues used to probe memory are ineffective.

Context provides particularly strong retrieval cues, a phenomenon you may have experienced in visiting your old elementary school or standing in the room you had as a child or for old times' sake having a snack at a deli that was a high school hangout. The memories thus produced are stronger and more detailed in such circumstances than when you simply reminisce without cues. This phenomenon reveals a context-dependent effect on retrieval: retrieval is typically better when the physical environment at retrieval matches that at encoding (this is similar to the encoding specificity principle). In a particularly creative experiment, the context dependency of retrieval was demonstrated by presenting word lists to four groups of deep-sea divers and testing recall (Godden & Baddeley, 1975). One group both encoded and retrieved the words on shore, another group while under water. The third and fourth groups, however, encoded and retrieved in different contexts (studying the lists underwater and recalling them on shore, and vice versa). The groups that encoded and retrieved in the same physical context had the most successful retrieval (Figure 5–13).

Thus context-dependent effects not only support the idea that retrieval is cue dependent, they also reveal another important characteristic of episodic memory: when a stimulus or event is encoded, features of the physical environment are typically bound into the resulting episodic memory representation, providing another route to recall. If those features are present in the environment at the time of retrieval, they serve as further cues to memory and increase the likelihood of retrieval of other details of the experience. Similarly, aspects of our internal states, as affected by drugs or mood, also are encoded in memory and provide important cues at retrieval. Research has demonstrated state-dependent effects—better retrieval when internal states at retrieval match those at encoding—that parallel context dependent effects. For example, Eich and colleagues (1975) demonstrated that participants who learned a list of words

after having smoked marijuana were better able to recall the words if they smoked again just before retrieval. And if the learning was done without marijuana, retrieval was better without marijuana. As with external environmental features, internal states facilitate retrieval when the internal state at retrieval matches that encoded in memory at the time of the encounter with the stimulus or event.

MEMORY DISTORTIONS

Memory's fate is determined by factors present at encoding (when the memory is first recorded), storage (how and where the memory is represented in the brain), and retrieval (when the memory is reported). The level of attention paid to the original event, the time that passes after the original encoding, the match between encoding and retrieval contexts, and the presence of competing and interfering information in memory are but a few of the factors that determine memory accuracy.

- Memories are not stored as exact replicas of reality; rather, they are modified and reconstructed during recall. Because memories are reconstructed, they are susceptible to being manipulated with false information.

Memories are fallible. They are reconstructions of reality filtered through people's minds, not perfect snapshots of events. Because memories are reconstructed, they are susceptible to being manipulated with false information. Memory errors occur when memories are recalled incorrectly; a memory gap is the complete loss of a memory.

ypes of Memory Bias

A person's motivations, intentions, mood, and biases can impact what they remember about an event. There are many identified types of bias that influence people's memories.

Fading-Affect Bias

In this type of bias, the emotion associated with unpleasant memories "fades" (i.e., is recalled less easily or is even forgotten) more quickly than emotion associated with positive memories.

Hindsight Bias

Hindsight bias is the "I knew it all along!" effect. In this type of bias, remembered events will seem predictable, even if at the time of encoding they were a complete surprise.

Illusory Correlation

When you experience illusory correlation, you inaccurately assume a relationship between two events related purely by coincidence. This type of bias comes from the human tendency to see cause-and-effect relationships when there are none; remember, correlation does *not* imply causation.

Mood Congruence Effect

The mood congruence effect is the tendency of individuals to retrieve information more easily when it has the same emotional content as their current emotional state. For instance, being in a depressed mood increases the tendency to remember negative events.

Mood-State Dependent Retrieval

Another documented phenomenon is mood-state dependent retrieval, which is a type of context-dependent memory. The retrieval of information is more effective when the emotional state at the time of retrieval is similar to the emotional state at the time of encoding. Thus, the probability of remembering an event can be enhanced by evoking the emotional state experienced during its initial processing.

Salience Effect

This effect, also known as the Von Restorff effect, is when an item that sticks out more (i.e., is noticeably different from its surroundings) is more likely to be remembered than other items.

Self-Reference Effect

In the self-reference effect, memories that are encoded with relation to the self are better recalled than similar memories encoded otherwise.

Self-Serving Bias

When remembering an event, individuals will often perceive themselves as being responsible for desirable outcomes, but not responsible for undesirable ones. This is known as the self-serving bias.

Source Amnesia

Source amnesia is the inability to remember where, when, or how previously learned information was acquired, while retaining the factual knowledge. Source amnesia is part of ordinary forgetting, but can also be a memory disorder. People suffering from source amnesia can also get confused about the exact content of what is remembered.

Source Confusion

Source confusion, in contrast, is not remembering the source of a memory correctly, such as personally witnessing an event versus actually only having been told about it. An example of this would be remembering the details of having been through an event, while in reality, you had seen the event depicted on television.

THE SINS OF MEMORY

Daniel Schacter defined seven sins of memory. The first three are "sins of omission" that involve forgetting, and the second four are "sins of commission" that involve distorted or unwanted recollections.

- **Transience**--the decreasing accessibility of memory over time. While a degree of this is normal with aging, decay of or damage to the hippocampus and temporal lobe can cause extreme forms of it. Schacter cited as a somewhat facetious example former President Bill Clinton's "convenient lapses of memory" during the Monica Lewinsky investigation. Clinton claimed in the hearings that he sometimes couldn't remember what had happened the previous week.
- **Absent-mindedness**--lapses of attention and forgetting to do things. This sin operates both when a memory is formed (the encoding stage) and when a memory is accessed (the retrieval stage). Examples, said Schacter, are forgetting where you put your keys or glasses. He noted a particularly famous instance in which cellist Yo-Yo Ma forgot to retrieve his $2.5 million cello from the trunk of a New York City cab.
- **Blocking**--temporary inaccessibility of stored information, such as tip-of-the-tongue syndrome. Schacter recounted the embarrassment of John Prescott, British deputy prime minister, when a reporter asked him how the government was paying for the expensive Millennium Dome. Prescott struggled to find the word "lottery," trying "raffles" instead.
- **Suggestibility**--incorporation of misinformation into memory due to leading questions, deception and other causes. Psychologists Elizabeth Loftus, PhD, and Stephen Ceci, PhD, are among those well-known in this research (see sidebar).
- **Bias**--retrospective distortions produced by current knowledge and beliefs. Psychologist Michael Ross, PhD, and others have shown that present knowledge, beliefs and feelings skew our memory for past events, said Schacter. For example, research indicates that people currently displeased with a romantic relationship tend to have a disproportionately negative take on past states of the relationship.
- **Persistence**--unwanted recollections that people can't forget, such as the unrelenting, intrusive memories of post-traumatic stress disorder. An example, said Schacter, is the case of Donnie Moore of the California Angels, who threw the pitch that lost his team the 1986 American League Championship against the Boston Red Sox. Moore fixated on the bad play, said Schacter, "became a tragic prisoner of memory," and eventually committed suicide.
- **Misattribution**--attribution of memories to incorrect sources or believing that you have seen or heard something you haven't. Prominent researchers in this area include Henry L. Roediger III, PhD, and Kathleen McDermott, PhD. An illustration of it, said Schacter, is the rental shop mechanic who thought that an accomplice, known as "John

Doe No. 2," had worked with Timothy McVeigh in the Oklahoma City bombing; he thought he'd seen the two of them together in his shop. In fact, the mechanic had encountered John Doe No. 2 alone on a different day.

EYEWITNESS MEMORY

Eyewitness memory is a person's episodic memory for a crime or other dramatic event that he or she has witnessed. Eyewitness testimony is often relied upon in the judicial system. It can also refer to an individual's memory for a face, where they are required to remember the face of their perpetrator.

What Is Eyewitness Testimony?

Eyewitness testimony is what happens when a person witnesses a crime (or accident, or other legally important event) and later gets up on the stand and recalls for the court all the details of the witnessed event. It involves a more complicated process than might initially be presumed. It includes what happens during the actual crime to facilitate or hamper witnessing, as well as everything that happens from the time the event is over to the later courtroom appearance. The eyewitness may be interviewed by the police and numerous lawyers, describe the perpetrator to several different people, and make an identification of the perpetrator, among other things.

Eyewitness testimony is a legal term. It refers to an account given by people of an event they have witnessed.

For example they may be required to give a description at a trial of a robbery or a road accident someone has seen. This includes identification of perpetrators, details of the crime scene etc.

AUTOBIOGRAPHICAL MEMORY

Autobiographical memory is a memory system consisting of episodes recollected from an individual's life, based on a combination of episodic (personal experiences and specific objects, people and events experienced at particular time and place) and semantic (general knowledge and facts about the world) memory. It is a complex blend of memories of single, recurring, and extended events integrated into a coherent story of self that is created and evaluated through sociocultural practices. Autobiographical memory encompasses our recollections of specific, personal events.

FACTORS AFFECTING RETRIEVAL

There are many factors that can influence an individual’s autobiographical memory, and these can include a natural decline with age, brain and memory disorders such as Alzheimer’s disease and also an individual’s mood and emotion.

Context

The characteristics of the environment in which a memory is encoded are also encoded along with the memory. This leads to the context-dependency of retrieval which means that the memories are more easily retrieved in the same environmental conditions in which they were encoded.

Gender

Studies have shown that females are better than males at recalling episodic memories, but no differences have been seen in the two during retrieval of semantic memories. The gender differences in memory retrieval are the result of using different strategies for processing information. A study has shown that females remember non-verbal cues while males tend to remember verbal cues.

Attention

Attention has an effect on memory in its encoding process. If someone does not focus on something in the encoding phase, it is very difficult for that person to retrieve it later.

Interference

Interference refers to the interaction between previous memories and newly formed memories. Proactive interference is the forgetting of new memories due to their interference with old memories in the brain. Retroactive interference is a failure to recall previously encoded information due to its interaction with new knowledge.

Physical Activity

Physical activity or physical health appears to be an important factor in the retrieval of memories. Children with poor physical health usually have poor mental and cognitive health. Low physical activity and fitness level is directly linked to low academic achievement due to mental and cognitive problems.

Studies have shown that physical activity plays an important role in influencing the hippocampus. The hippocampus is the part of the brain involved in the encoding of information. It may also affect other areas of the brain. In this way, physical activity and exercise help in the proper functioning of the neural networks.

Food Consumption

Some studies have shown that eating breakfast before going to school helps in more retrieval of information. The students who have a habit of eating breakfast generally scored more in their exams.

EMOTIONS AND AUTOBIOGRAPHICAL MEMORY

Emotion and memory are also known to interact: emotional experiences often leave remarkably durable autobiographical memories. Autobiographical memories are often imbued with emotional significance, leaving long-lasting memory traces. The interactions between emotion and autobiographical memory: First, the emotional content of an experience can influence the way in which the event is remembered. Second, emotions and emotional goals experienced at the time of autobiographical retrieval can influence the information recalled. The most vivid autobiographical memories tend to be of emotional events, which are likely to be recalled more often and with more clarity and detail than neutral events.