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Memory as a Foundation for Learning

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MEMORY AS A FOUNDATION FOR LEARNING

> "When you memorize a fact, it's arbitrary… it makes no difference whether sine of π/2 is one, zero, or a million. But when you *learn* a fact, it's bound by a web of logic..." (Orlin, 2013, p. 2).

"Any web of logic will be holding… nothing if memory is lost. Non-memorized information is brief and useless." (The Author).

Memory is a function that is quickly dismissed in the present educational system that favors associative learning; however, just by revising the definitions of both functions - memory and learning - it is obvious that both are inextricably connected.

Memory is the cognitive ability to store, encode and retrieve information. As an adjunct to intelligence, it retains information over time to influence solutions to new challenges. By allowing the retrieval of past experiences, it makes possible intelligent decisions, language, social units, and overall survival (Sherwood, 2015).

Learning, on the other hand, is the process by which new information is acquired by the nervous system and is observable through changes in behavior (Purves 2004). Learning establishes the understanding of information for its application in activities of daily living, from basic skills to the practice of a profession. And here comes the importance of memory. What would happen if all understood information, is immediately forgotten? Students will be in an interminable circle of understanding lessons, but unable to use them.

One is all too familiar with the argument that memorization is not necessary because understanding is more important to perpetuate solid knowledge. However, knowledge should be remembered to be useful for inferences, analogies, and associations. If the memory function is impaired, other cognitive functions suffer disastrous effects. One can see the ravages of age over memory in those brilliant professionals in command of profound knowledge that in their retirement became unable to remember the simplest details of daily life. Detractors also argue that rote memorization, gives immediate results, but is quickly forgotten. However, that is not the case. Rote memorization is so strong that it can last for many years, as can be proven by the firm memories of songs and rhymes learned in childhood. As research will demonstrate in this chapter, memory function - encouraged at an early age - promotes stronger memory in adult life as well as faster development of logical reasoning, fluid speech, abstraction, and eidetic memory, among others.

The emphasis on understanding - against of the vacuous repetition of lessons - is justified as a foundation of any educational system. However, emphasizing only understanding, is leading students to believe that any memorization is unnecessary; nevertheless, their exams - and life in general - will show them that the mantra "memory is not important" is utterly unjustified.

The "understood" lessons need remembering to build on newer concepts. Because of this, students recur to numerous substitutes and acronyms to recall information. Wouldn't it be remarkable to just remember relevant information instead of using memorization gimmicks? That is not possible in the present system because memory function is discouraged precisely at the age when it is easier to develop.

There are very intelligent students that have excellent memory and if one delves into their past will find they had early memory training, formal or otherwise. It is important, therefore, to promote the value of a natural good memory during the developmental years – the earlier, the better. This was stressed by the educational system of a century ago, and with good results as proved by the amazing achievements of that generation's students.

All curricular information or "conceptual learning" - including inferences and associations - needs cognitive storage, and that is memorization. Learned associative knowledge is hopeless if not recalled by memory - as requested by formative education and the professional exams. Students need to memorize the foundations of knowledge and the system allows it because of the repetition built into it. I am not alluding to the mindless repletion of rote learning, but the coordinated repetition during conceptual associations, inferences, and pre-testing. Even associations need memory as it is the link between two similar ideas. Therefore, it is important to stress that students will fail academically if they are unable to store "conceptual learning" in memory.

"Conceptual memorization" is a term that the author brings to this debate as more frankly subsumes the learning process. The importance of memory development needs to be encouraged in the academic environment so students would have quicker recall of abstract ideas - kept secure in their highly trained memory centers.

FUNCTIONAL DEFINITION OF MEMORY

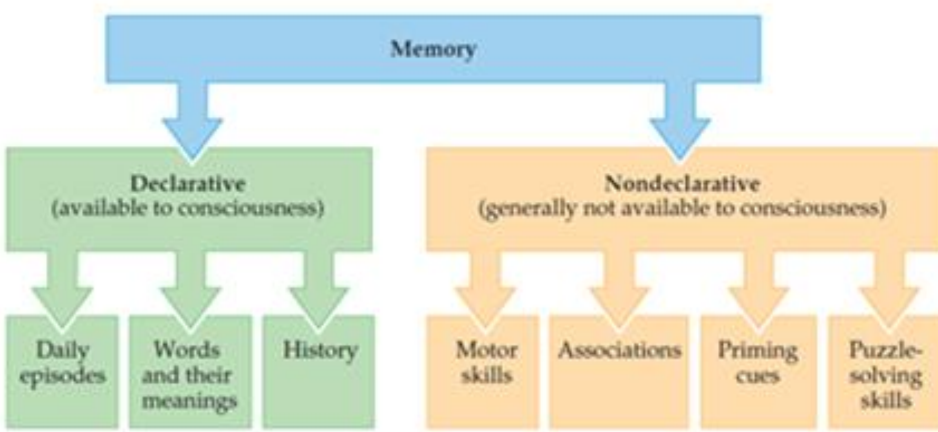
Memory is a brain function dedicated to the encoding, storage, and retrieval of information and, from a functional viewpoint, is classified as declarative and non-declarative (Forde & Poldrak, 2010):

Declarative memory

Contains all the information available to language, that is, includes the memory of facts and its verbal expression. It is the memory of regular activities such as remembering numbers, images of past events, and familiar movies or songs. This function is localized at the medial temporal lobe and associate structures.

Non-declarative memory (Procedural memory)

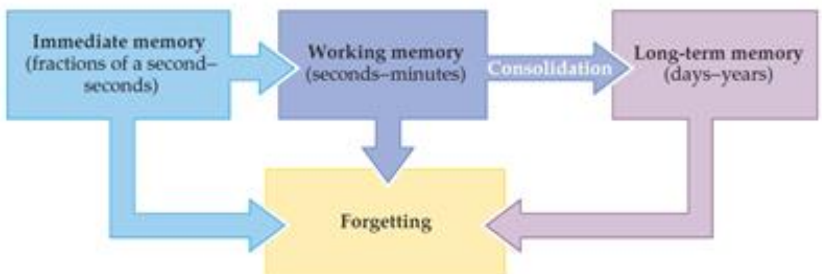
Conversely, non-declarative memory is the unconscious memory of dexterities and associations, such as driving a bicycle, performing sports, making associations, or playing an instrument. An example of this function is when one is asked to name any city in the world. Let's suppose that the person responds "Istanbul"; the individual doesn't know why. It just came out from the collection of names and images stored in the past. The same phenomenon occurs when one hears an odd explanation and automatically says : "that does not make any sense". It is because the information is not congruent with stored associations from prior experiences and the brain is responding according to its non-declarative memory – As a side note, some philosophers believe that this is a proof that free-will does not exists and the brain is the only one in control as the individual merely reacts to its commands (Harris, 2012).



Temporal Categories of Memory

From a temporal standpoint, memory is classified in: Immediate memory, working memory and long-term memory (Janeson & Squire, 2011).

Immediate memory consists in the ability to retain information for a very short period; about seconds or fractions of a second. Each one of the senses – hearing, smell, visual, tactile, and gustative - is connected to this register; they have a large capacity for processing.



Working memory preserves information for seconds or minutes and allows a more detailed analysis. This occurs during problem solving, when the mind compares information from different sources, for instance, during a mathematical evaluation. A more mundane example of this function is when one searches is in a hurry for the car-keys. Working memory, in this instance, avoids the places that have been looked at. Medically, it is tested by requesting the person to repeat a sequence of random numbers; the accepted recall is seven to nine digits, which is used to keep the telephone numbers at seven digits (Kasper, et al. 2015).

Long-term memory allows the retention of information for long periods of time, for weeks, years, or a lifetime. It involves biochemical and structural changes at the neural cell connections, that is, at the synapsis (Dunn, 1977).

Forgetting. - It allows the elimination of non-usable information, and its replacement by newer concepts.

STAGES IN THE MEMORY PROCESS

There are three stages in the memory process: encoding, storing, and retrieval (Shiffrin, 1963). Encoding is the registration of the initial encounter; storing is the safekeeping of the information for a long time; and retrieval is the ability to recall that information when needed.

For instance, meeting a new friend involves the **encoding** of his name and its association with the characteristics of the person, his appearance, or the tone of voice. This information is **stored** in the brain for some time. Then, when one sees the person again, there is immediate recognition by **retrieval**. In this way, memory becomes a valuable aid to the nervous system in its continuous scanning to make possible a life with the least amount of conflicts.

Nevertheless, as with any process, there are **errors** that could be of omission, of identification, or false recall. Furthermore, it is difficult to decide at which stage the blunder occurs because the stages are interdependent and not clearly defined. On the other hand, this codependency presents advantages, as in the case of initial retrieval which can be difficult at first, but becomes easier with repeated challenges - Because of this, educators recommend frequent testing to improve retrieval of academic material. That is, even though they abhor the word “memory”, they continuously promote it. The damage is that by ridiculing this function, students are discouraged from developing a good memory on their own.

Encoding

Encoding occurs upon interaction with new information. The environment is continually stimulating the brain, but not all the inducements are memorized. One can be on a camping trip contemplating the bright colors of nature, perceiving the sounds of birds and insects, and even noticing the clean smell of the countryside. However, one will remember only of those perceptions that have a special personal meaning. A person will seldom remember contemplating a few sailing boats on a placid lake. However, that will not be the case if suddenly one of the sloops tips over and a rescue effort is triggered - the mind would be intrigued, trying to understand why these events happened. There are at least two factors that will make the experience unforgettable. First, it was something so unusual, unexpected, that it started an emergency response. The second factor is that many senses and emotions are involved: the vision is acutely focused, the hearing is stimulated by the roaring of the rescue motorboats, and fear is present, as well as surprise and empathy. These elements of uniqueness and intense stimulation will make this experience unforgettable for years to come (Hunt, 2003). Applying these observations to education, academic programs are designed to promote sensorial stimulation such as taped conferences, visual aids, group discussions, and intense reading and writing.

The impact of emotions is most decisively seen in the encoding of memories. The neurology of emotions involves primal functions that instantly imprint in memory shocking emotional information (Liu, 2012). Furthermore, these experiences are remembered with special precision and more intensely than others. Almost everyone associates what one was doing at the time of the twin tower's destruction because of the anguish felt. The same for the Challenger space shuttle explosion. For older generations it is indelible the instant they heard of President Kennedy's assassination. This dramatic characteristic was for a while called "flashbulb memory", referring to its emotional impact of sensational news and the flash photographs (Brown & Kulik, 1977). These two coding elements - distinctiveness and association – are used in the learning process, as they provide links to academic material and improve retention.

It is important to note that memory of details is far from perfect, and different people can have **distorted recollections** of the same event. The reason is because the encoding of the memories is a personal experience. Under the same circumstances, one person may remember the color of the shoes of a visitor, another the color of his hair, while both miss that he was left-handed (Talarico & Rubin, 460).

Additionally, other brain functions may add elements and distort encoding. This is referred as the Deese-Roediger-McDermont effect that was reproduced by Bunting el al. (2005). In this experiment, the subjects hear the following words: door, glass, pane, shade, ledge, sill, house, open, curtain, frame, view, breeze, sash, screen, and shutter. Later, they are asked to recognize in a second list the words heard in the first one. The result demonstrated a normal recall, but it was startling that a new word, "window", that was not in the first list, was added to the second one. Even more remarkable was that many had the certainty that "window" was presented initially. The explanation is that "window" is so related to the other words that **by autonomous brain processing** it was incorporated into the second list - this experience was included as one of the reasons of altered recollections (McDermont & Roediger, 2018). From a different perspective, the experiment suggests that memory can construct new knowledge, which defies the classic concept of rote learning as useless. In this way, rote memorization can be the foundation for creativity – based on spontaneous association and reasoning - because of the integrative function of the brain on memorized information.

Moreover, **inference** affects the encoding of memories. Through inference one reaches a conclusion based on evidence and reasoning. Continuously, facts are perceived and analyzed resulting in instantaneous inferences. These merging of functions – known as “pragmatic inference” - was described by Brewer and referenced by McDermott & Chan (2006): Subjects were asked to memorize the sentences: “The karate champion hit the cinder box”. It was an easy task; however, the subjects remembered the sentence as “The karate champion broke the cinder box”. The mind made a practical inference, but not based on reality. It was reasonable that a karate champion could break any box, and this assessment was incorporated into the memory; besides, since “braking” is more vivid than “hitting”, the coding of braking was easier to make. As noted previously, emotions have a powerful influence on memories and in this case, dramatism aided the wrong encoding.

Memory and inference can also be distorted by external perceptions. This is illustrated in an example presented by Senge (1994) in which an observer sees a bulge in a person’s jacket and believes he has a concealed weapon; in this case, an inference was made on a perception. Half an hour later, the stranger leaves, but this time his jacket is partially open, and the observer recalls that he saw a hidden gun under that jacket; at this time, an inference was made on a false memory and false perception. This cognitive evolution has been described as “the ladder of inference” and is a well-known cause of perception errors.

Encoding and association.

Association is another dominant factor that influences encoding. Recalling is easier if the information is associated with something that is familiar. Associating many words to sets of numbers is the secret to many professional “mnemonists”. Likewise, association of new concepts to meaningful experiences increases recall. According to Purvis (2004), this is the case of professional chess players who relate their moves to prior contests and can remember the games better because of the adversarial experience - unlike novices that lack that helpful association. From an academic standpoint, associations benefit from assiduous reading as new information is easily linked to prior readings; eventually, this merging of data becomes even more interesting when it is enriched by spontaneous inferences.

Storage

Once information is encoded and analyzed, it is stored through a complex process reviewed in a study by Valenzuela (2003); according to him, storing new information generates biochemical and anatomic changes in brain cells, which occurs at the synapsis – which are areas of contact in between cells. This process is called **consolidation** and is the result of **engrams**, which are the memory changes in cell composition. Psychologists are more generic on these conceptual differences and refer to the whole process as **memory trace**.

Storage is also influenced by associations; in this way, incomplete details are integrated by inferences or experiences. For instance, a person known to be an outstanding member of the community is seen in an altercation in a shopping center; some bystanders will not remember exactly what happened, but their recollection – stored information - will be biased by the good character of that person. On this basis, Schacter (1999) suggests that memory is not a recreation – not a perfect reproduction - but a reconstruction of what happened in the past.

Time also influences recall, as reported by McGeoch (1932). During the lapse between encoding and recalling – called the **retention interval** - memories can be consolidated, eliminated, or altered. If the changes are made on new memories, the experience is called **retroactive interference** and it occurs, for instance, when is difficult to remember information because of distractions occurring after a lecture. Conversely, **proactive interference** occurs when old memories interfere with new consolidation as is the case of a native language influencing the learning of a new one.

Another storage interference is the opinion of others after encoding. This is known as the **misinformation effect** (Loftus, 2005). It occurs, for example, when one's recollection of a fight changes after interacting with other witnesses. Understandably, this experience can have legal consequences and is of special consideration in the judicial system.

Retrieval

Retrieval is the most important and useful part of memory. It is of no benefit having a perfect coding and storage if the information is not accessible. Every day, a person collects thousands of pieces of information from the environment; however, his or her access is limited to only a small part of that plethora. As per Tulving and Pearlstone (1966), retrieval is complemented by accumulated subconscious information as evidenced by the sudden recall of a forgotten experience - or when a student finds the correct answer while scanning the alternatives in a test.

Retrieval efficiency is related to the **encoding specificity principle** as presented by Godden and Baddeley (1975); this principle is related to the impact at the time of the experience. For instance, one recalls vividly a song because it was the soundtrack of a memorable action movie. That melody is a retrieval cue encoded specifically for the memorable experience. An application of this principle is the advice to study in the areas where tests will be taken as retrieval will be more effective in familiar settings.

Retrieval is measured by two tests. Pr**oduction testing** involves the recall processed by rote memorization, whereas r**etrieval testing** involves the recall processed by association, such as in a multiple-choice test.

Either type of testing can bring up memory errors, such as the "**failure to recognize recallable words**"; in this case of production testing, the person fails to identify a word that is well known and easy to remember. For instance, the word "Shaw" can be meaningless; however, if a complete name is presented, "George Bernard Shaw", the identification is immediate. The encoding was to the complete name of the author and a cue not related to that encoding will not produce recognition (Tulving & Thompson, 1973).

Another error affecting retrieval is the retrieval process itself. According to the **retrieval practice model** of Roediger and Karpicke (2006), recalling makes memory stronger and retrieval more fluid; however, according to the **forgetting induced retrieval model** of Anderson, Bjork, and Bjork (1994), retrieval itself can weaken the memory of related information that is not retrieved. It was not decided if the weakening of non-retrieved information was due to retrieval neglect, or simply due to its irrelevance.

Likewise, the consolidation of errors is an additional failing. Throughout the years, a person may reminisce about times past; but during each retrieval, he or she integrates the voids transforming the event. For instance, a father can remember from childhood that a cat took a piece of meat from a plate and darted away; then, several years later, while telling the story to his kids, he adds exaggerated details and from then on, those details will be part of the story (McDermott, 2006). An application of this concept is in the investigation of child abuse cases (Otgaar et al., 2017) where researchers advise case workers to refrain from frequent questioning to preserve the child's true recollections; in this way one prevents children from transforming their past reality.

RETRIEVAL LEARNING

Retrieval learning is touted as one of the most reliable educative processes (Karpicke and Blunt, 2011). As noted, retrieval is the process of bringing back stored memories, whereas learning is the encoding of new knowledge.

The supporting evidence for retrieval learning is that memory is increased when tested (Dunlowsky, 2013) and because of this, the method is known as test-enhanced learning, the testing effect, or retrieval practice. Proponents of retrieval learning believe that it creates consistent and integrated versions of difficult concepts (Butler, 2010). However, it is generally believed that retrieval itself does not produce learning and is used only for assessment.

Karpicke and Bauernschmidt (2011) demonstrated the importance of retrieval in the learning process when they showed that self-testing was more effective than repetitive reading alone. This assessment was supported by other researchers (Callender & McDaniel, 2009: Karpicke, Butler & Roediger, 2009) that postulated that passive repetitive reading, was not very effective and nevertheless, it is the most used strategy by college students. Fortunately, according to Armstrong (2009), this tendency is not followed in all institutions.

The influence of retrieval was tested in the setting of Concept Mapping in which students organize ideas around the central concepts of a reading. The results shown that the group that constructed the maps using retrieval practice - that is, from memory - had a better performance than the group that constructed the maps after regular readings (Karpike & Blunt, 2011). According to the authors, the reason retrieval practice is not used more widely is because it may seem like "rote learning" which is short-lived, poorly organized and does not make inferences.

In fact, there are more than passing similarities between retrieval learning and rote learning. Retrieval learning reads the subject a few times and tests its memorization, the same as rote learning, but both retrieval and rote learning are beneficial because they stimulate all brain functions. The claim that rote learning does not promote understanding is contrary to current knowledge that cognitive abilities are simultaneous and interconnected. Further, the experiment of McDermont & Roediger (2018). showed that the brain has self-directing processes over any type of information, and rote learned is not an exception. It is true that a child cannot make sense of rote learning, but any normal adolescent has the capacity to immediately understand and make inferences during rote learning. Frequent repetition consolidates the exact wordings, but the understanding of the subject is instantaneous. Clearly, some memorized concepts may need explaining but the issue is already within the purview of the educator who has now a substrate to work on. This does not mean that the student should memorize before classes, but that the system may work on unclear issues brought up by a student's good recollection.

Educators have a reluctance to accept memorization, but nevertheless apply all the above repetitive resources - retrieval, rote learning, and self-testing - in a concealed fashion - that is, the same concepts are repeated in different chapters, multiple activities, and finally during the exams. Although derided, memory testing is an efficient learning mechanism as studied by Agarwal et al. (2008), who also showed that close-book testing, that evaluates conceptual memorization, promotes more learning than open-book testing.

MEMORISTIC LEARNING

> Rote learning is a necessary evil in aviation training. Memorizing procedures may not be an activity that students have engaged in during their prior careers, but rote learning is key in acquiring the conceptual elements of helicopter flight training.

The above reading is from an article in Vertical magazine (“Concept”, 2013), and speaks volumes about the importance of a good memory and is an example of the memory challenges one faces outside the academic environment. To the chagrin of some educators, memory function is undeniably one of the foundations of learning (Banikowski & Mehring, 1999).

By definition, rote learning is obtained by continuous repetition with no analysis of the subject learned. As already mentioned, from a neurophysiological viewpoint, isolate mental function – that is repetition with no analysis - is impossible because all functions act in autonomous synchrony, so analysis and understanding are immediate (Bunting el al. (2005). However, small children are an exception since they do not have enough information to make instantaneous associations.

In school, automatic rote knowledge is needed for innumerable pieces of information such as the alphabet, multiplication tables, formulas, names, dates, or sequences - that beside its comprehension need immediate retrieval. Memory is also needed for basic skills that are performed automatically as in the case of setting a table, dishwashing, driving a car, playing and instrument, or travelling to familiar places.

A bad name for memorization

Regrettably, rote learning has been traditionally associated with cases of patients having the mental abilities of a toddler and a prodigious memory - as in the savant syndrome. These patients are barely able to speak or walk but have a special talent for remembering long sets of words, dates, or numbers. The savants' disposition for excellent recall is now explained in the fact that memory is one of their few intact functions and they dedicate all their time to its practice - which leads to its unusual development. Nevertheless, scientists of the past century, not having enough information, associated memory development with diminished mental capacity, given memory the lowest grading in the hierarchy of mental functions; this negative connotation had persisted up to recent time (Howe, 1989).

The above negative qualification of rote memory permeated the hallowed halls of academia, and the result was that many generations of students have seldom memorized anything. Highly educated people in their forties are unable to recite more than a few lines of prose or poetry, depriving themselves of a brief spiritual joy and other intellectual advantages. According to Beran (2004) before the fifties, kids in public schools knew by memory "Ulysses" by Tennyson's or "To a Skylark" by Shelly; they could declaim parts from Shakespeare, Wordsworth, or the Declaration of Independence. But newer educational standards made of memorization a sterile method of promoting servility - unable to compete against the newly endorsed creativity. This wave of enlightened education started with Granville Stanley Hall 1901, who proclaimed in 1901: "We must overcome the fetishism of the alphabet, of the multiplication table, of grammars, of scales, and of bibliolatry, … The true center of correlation on the school subjects is not science, nor literature, nor history, nor geography, but the child's own social activities." (Hall, 1901). His speech embodied a campaign that for all practical purposes banned memorization in schools, to the point that emphasis in memory is now anathema in academic circles. Scorn is reflected in terms such as cramming, parroting, or mugging, because it gives the impression of repeating information without meaning.

The contempt is such that some higher education professors believe memorization is a mantra only in the lower echelons of learning. It is then of no surprise the following expression of a college professor about her new students (Schwartz, 2015): "… unfortunately, they're often not taught until first-year university after they've already had 12 years of education, where they've been memorizing and doing things in a certain way." But that is not the case, because after twelve years of memorizing students should have superb memories, which is far from the truth. The reality is that students are not learning by memorizing or by any other significant means; instead, they spent their time in creative activities that are hard to assess and easy to dodge. Had they memorized some learning, they would have had at least some stored information from which the brain circuits would get inferences through self-directed processing.

Even though memorization is dismissed in education centers, requests involving memory function are concealed in the form of continuous testing. Only the harsh realities of compulsive exams lead students to develop belated memorization skills on their own; however, the conflicting advice against memory make their learning even more difficult. There is the misconception that learning is different from memorization when both are integrated and interdependent. Understanding, learning, and bringing inferences is the easy part; more difficult is remembering learned concepts either at the time of testing or during life challenges. But the system censures memorization at any academic level and this is a situation that should change.

Current use of memory

Memorization is fundamental in the learning of phonics, multiplication tables, formulas, sequences, anatomy, law statutes, and many other subjects, but it does not imply lack of understanding of the subject. Pre-graduate learning in medicine, for instance, needs memorization of anatomical parts and myriads of details in other sciences, but this does not indicate an aimless repetition of names and definitions; the use of memory reinforces conceptual learning and strengthens other cognitive abilities.

Even Mathematics - the utmost representative of abstraction - requires memorization; advocates of its traditional education promote the memorization of basic facts, definitions, and formulas through repetitive exercises. Understanding is necessary, but it should be aided by the speed of memorized nuggets of information and concrete principles (Hilgard, Irvin, & Whipple, 1953)

All professions require the understanding of their foundations and the management of learned knowledge. But all this information is stored in a memory that needs to be trained; otherwise, the whole system will not perform. Learning is intimately connected to the encoding of memory and both functions -learning and memory - are important; therefore, both need to be developed simultaneously (Banikowski & Mehring, 1999).

Advantages of rote memorization:

It is generally accepted that rote memorization is the mindless fixation of words by repetition, with no judgement or understanding of the subject. That implies that rote memory is an isolated function in the brain, which is not the case. Memory works in conjunction with all the pathways of mental abilities such as understanding, abstraction, associations, and inferences. This has been demonstrated in myriads of studies, including MRI and PET scanners. Further, memory has connections with the limbic systems that makes possible communications with emotions and autonomic functions - such as those of the heart, lungs, or digestive organs. The links of memory to all the senses is well known since Pavlov's experiments in the nineteenth century. As mentioned earlier, any person with normal intelligence automatically processes and understands the messages in rote memorization because the brain is prepared to analyze any stimuli, even if the individual is not cognizant of it (Fuster, 2002).

A child can perceive rote learning as senseless because his brain is immature and does not have enough information to make associations or inferences. But even in this age group, there is evidence that retrieval practice improves learning as in the experiment of Karpicke (2016) who stated that the results "… contribute to the growing body of research supporting the mnemonic benefits of retrieval practice and provide preliminary evidence that practicing retrieval may be an effective learning strategy for children with varying levels of reading comprehension and processing speed". This study also supports the beneficial effects of memory on reading comprehension at an early age.

Rote memorization is not stagnant because the brain utilizes basic memorized information in the building of new knowledge. This concept was proven in the priming effect experiment (Key, 1973): The subjects were exposed to a word list and after 24 hours, they were given fragments of those words, mixed with new ones, and asked to make new words with the mix presented. The results showed that the first fragments were remembered with more frequency that those presented on the second day. The explanation was that the initial exposure primed the memory for their recognition in successive presentations and proposed that the more information a person has - even if it is from rote memorization - the quicker its association to new knowledge. We can see a pragmatic application of this principle in the actors' eloquence in their private lives as it comes from a more fluid language processing stemmed from prior memorized texts.

Another educational tool that underscores the use of memorization is the method of "Active Recall", which utilizes the testing effect in flash cards or in multiple choice questions - learning is more efficient when recalling information through memory challenges (Mc Daniel, 2009).

Memorization Techniques.

A review of the most frequent memorization techniques demonstrates how necessary and important this function is; the following methods rely on repetition in one form or another:

1. Rote learning. - Memorizing only by means of repetition
2. Spaced repetition. - Repetition at increasing time intervals.
3. Active retrieval. - Repetition by active recall of learned information.
4. Maintenance rehearsal. - Repetition of known information.
5. Elaborative rehearsal. Repeated association with memorized knowledge.
6. Fragmentation. - Memorization of a large material divided into smaller groups.
7. Peg system. - Association to a memorized list of items, as in acronyms.
8. The loci system. - Association with memorized places
9. Phonetic system. - Association with memorized numbers changed phonetically to objects.
10. Dramatization. Evocation of emotional memory.

    Only two techniques rely on functions not directly related to repetition:

11. Mnemonics. Evocation by pure associations.
12. Mnemonic link system. Evocation of linked associations

When someone raises any subject more than once, the chances of memorizing the repeated information are higher and hence its benefit; however, repetition in academia brings the subject of rote learning, which is banned outright with seething scorn. Nevertheless, concepts are repeated in discussions, concept maps, summaries, assignments, research, or multiple testing. At graduation the new professional is in command of his specialty technical language; no one made him memorize it directly, but nevertheless it is etched in his memory. However, the neglect is that the system did not develop his memory at an early age, which would have made his academic life easier. It can be said that academia built his understanding without rote memorization. Agreed, but the fact that knowledge can be recalled is pure memory function and the stronger that function is – by specific training, including rote - the more freedom the student has to build conceptual connections and intelligent conclusions. Memory and understanding are together in a symbiosis in which one enhances the other and memory should be promoted as much as learning and logic. Conversely, memory and understanding are not mutually exclusive; for instance, a person can memorize a text by rote and then repeat it with passion and full understanding of its meaning. This is the case of attorneys citing legal precedents, actors declaiming poetry, or politicians inflaming their followers with partially memorized speeches.

Memory - Maintenance and elaborative rehearsal.

There is no substitute for a strong memory. So far, only a few methods are based on rote memory as in the cases of maintenance rehearsal - that uses literary repetition - and elaborative rehearsal – that uses abstract repetition, that is, encoding the meaning of previously stored information. Maintenance rehearsal is useful for rapid memorization, whereas elaborative rehearsal is useful for a deeper understanding and a stronger recall. Elaborative rehearsal is a vindication of memory, as it shows that memorization enhances conceptual learning rather than hinders it (Jahnke & Nowaczyk, 1998), (Craik & Lockhart, 1972).

Memorization promotes higher mental abilities

Isolated memorization by itself is a misnomer; this is because memorization acts in synchrony with other brain functions as it has been demonstrated by numerous studies presented in this chapter. Memory stimulation enhances other cognitive functions such as association and inference (Fuster, 2002). Many generations of children were educated by rote memorization in centuries past and the results have been the marvels of western civilization of the last century. This brings the question if memorizing has any influence on the cognitive abilities of modern-day students; however, because memory-based education is no longer offered, there is a lack of information on the subject. Nevertheless, it still prevails in some Asian countries, and it makes perfect sense to evaluate the influence of rote memorization on their students to see if it enhances other intellectual skills.

One of those Asian countries still using rote memorization in their education is Pakistan and providentially the government conducted a study on the effects of memory development in its students. The project was delegated to the Pakistani Arm Forces who conducted the testing on medical students in one of their universities (Iqbal, 2015). The researchers compared students trained in memorization against those without training in memorization. The students in the memorization group had memorized the Quran, word by word, when they were children and, because of this, were part of a religious elite with no doubt on their rote training. Contrary to expectations, the higher scores of the "memorization group" were not in Anatomy which requires higher memorization skills, but in Human Physiology, which requires abstract and associative skills - also based on memory but at a higher elaborative level. The study concluded that memory training promotes the critical and abstract thinking necessary to excel with the more dynamic concepts of Human Physiology; it also demonstrated the boundless character of creativity and associations developed by memory. The researchers further elaborated that the grading in Anatomy was limited to the knowledge established in the curriculum and here, the students with good memory had less difficulty and more time for other academic duties – as this author mentioned earlier, memory made their lives easier. These findings were supported by the study of Andrew Butler (2010), that showed that memory exercise in the form of repeated testing produces superior learning as compared to that of simple studying.

MRI and PET scans research on brain interconnections give the explanation for the role of memory in the simultaneous improvement of other mental functions. In this context, there is no room for the idea of “rote learning” as an isolated and primitive function. From the moment information is received, brain scanning shows that it is immediately processed by all the layers of functioning including stimulus representation, goals, interferences, memory input, and executive functions, which are first organized in the dorsolateral prefrontal cortex and then distributed to related centers (Michael & Randall, 2002). It was demonstrated that the stimulus of one function motivates the inclusion of all brain functions; there is no evidence that one develops to the detriment of another as all functions work for the harmonious benefit of each other. Rote learning, therefore, is a fundamental memory exercise that has a positive effect on the highest cognitive abilities.

It is important to emphasize that rote learning includes meaning and understanding because the alleged isolation of rote memory is the center of its criticism. Even if the person does not pay attention during rote learning, meaning and understanding appear spontaneously when the brain interconnects the new input with stored memories to form associations. Any person with normal intelligence can understand the messages imbued in a memorized text, much more if a teacher explains the obscure points; evidence of this claim was presented in this book in the chapter of memory encoding. A more direct confirmation of brain integration is the easiness by which any person can detect deception regardless of cultural background; this is one of the universal characteristics of human nature involving the involuntary integration of memory, intelligence, imagination, and inferences. This research on deception was performed on the Shiwiar tribe - a primitive group in the Amazonia - and stablished that, as predicted, primitive Shiwiar… "were as highly proficient at cheater detection as subjects from developed nations. Indeed, the frequency of cheater-relevant choices among Shiwiar … was indistinguishable from that of Harvard undergraduates" (Sugiyama, Tooby, & Cosmides, 2002). Considering that the brain integrative function involves all the systems working in synchrony and synergy, it is not reasonable to believe that rote memory works in isolation to the detriment of learning capacity (Fuster, 2002), (Eichembaum & Cohen, 2001).

Memorization produces structural brain changes.

Hintzman in 2010 demonstrated that the repetitive stimulation of memory from different mental pathways produced fixation of the knowledge through biochemical changes and that without those changes all information will vanish.

Other researchers concluded that memorization is a powerful mental function that produces biochemical and cellular transformations in the brain; these changes improved cognitive ability and occur at the synaptic level - the area where two cells contact each other. Anatomically, these metabolic changes were detected in the left posterior hippocampus at the base of the brain (Roche, Mullally, McNulty, et al., 2009), (Valenzuela, Jones, Wen, et al., 2003).

According to Purves (2004), the memory circuits are in the left inferior prefrontal cortex, posterior parietal cortex and medial temporal lobe; their activation was elicited by recall of memorized information; and the observed changes were not only biochemical, but also structural, involving the growth and reordering of cellular interconnections.

Memorization with different names.

Many learning techniques are based on memory, but academia refuses to acknowledge this foundation and adjudicates them new names such as “retrieval practice”, “testing-learning”, “test-enhanced learning” or “active retrieval”. The premise is that the knowledge is not mechanically memorized as in rote learning but understood and integrated. However, this knowledge has its origins in rote that is encoding and automatically builds relationships and inferences, as described previously. In sum, rote learning, retrieval practice, active retrieval, and others achieve learning by building memory links without giving memory function its well-deserved recognition.

Memorization and learning

Research confirms the value of memorization in the learning process in the study of Roediger (2011), who found that “… retrieval practice is actually a powerful mnemonic enhancer, often producing large gains in long-term retention relative to repeated studying.” - repeated studying is the reviewing of understood text without any conscious attempt to memorize it. As advised by the proponents of retrieval practice, the more testing, the higher the probabilities of keeping the learned material for longer periods of time. The same author summarizes: “The power of retrieval practice in consolidating memories has important implications for both the study of memory and its application to educational practice.”

The lifelong benefits of memorization.

A more direct statement on the beneficial effect of developing a strong memory is in a recent study by Jonathan McNulty of the University of Dublin (2006). He demonstrated that rote learning improves memory and verbal recall in older adults. The subjects were asked to memorize 500-word poems and after six weeks of rest, laboratory testing showed considerable changes in the physiology and biochemistry of the brain. Another researcher from the same institution, Dr Richard Roche (2009), confirmed the findings: “Unlike other studies on memory involving specific training, memorizing is an everyday activity that anyone can undertake… The brain is like a muscle that should be exercised through the retirement years as a defense against dementia, cognitive lapses, and memory failure.”

One wonders then, why wait until old age to exercise memory, and prevent brain function decline? And why is it advised in the elder and shunned in the youngster? Wouldn’t be wiser to start that prevention much earlier in the thirties or forties? And why not even earlier, during childhood, with the additional benefit of a good memory for academic learning? So far, no study has demonstrated that memorization has a detrimental effect on brain function.

Children are capable of absorbing information with astonishing speed and have the plasticity to build more pathways between memory and other cognitive functions. Those connections will benefit them for years to come during their schooling and careers. Their stronger memory will facilitate reliable storage and their improved intelligence will give them quick understanding. Students need to memorize concepts, names, amounts, sequences, relationships, and all types of data. They need to use mnemonics based on associations, imagination, prior experiences, and even electronic games to improve memory. Wouldn’t it be better to have the ability to remember spontaneously and with no effort? According to all research presented in prior pages, that ability can be obtained by training the brain cells to create more synaptic bridges at an early age when that possibility is almost effortless.

THE IMPORTANCE OF CONCEPTUAL MEMORIZATION

This author proposes the term “Conceptual Memorization” because it is a phrase that properly emphasizes the importance of memory in the origin, processing, interconnections, and retrieval of concepts. Once the idea is encoded, is automatically processed, and becomes part of stored knowledge; but without memory encoding, it will vanish within the random algorithms of brain functions. In this vein, understanding does not give learning proprietorship, memorization does.

Because of its importance in the processing of learned knowledge, memory should have a special place in the Olympus of educational virtues. However, educators stress that one should strive for “concept learning” instead because it includes associations, reasoning, imagination, and evocation; nonetheless, these abilities are dependent of memory and by ignoring it, students miss the opportunity to make their learning quicker and more enduring.

According to Feldman (2003), conceptual learning is the abstraction of the characteristics of an object and the building of categories based on relevant features. However, conceptual learning cannot reject memory as elevated knowledge because memory is its platform and works in synchrony with all the higher functions of the brain - to the extreme that simple isolated memorization does not exist (Fuster, 2002), (Eichembaum & Cohen, 2001). Furthermore, since learning - by definition - is the encoding of information, one can argue that learning is only a semantic substitute for memory; the latter, on the other hand, is a whole anatomic institution in the issue of brain capacities.

Conversely, there is not a brain center of “conceptual learning” and this function suffers the fundamental need of storage in long-term memory. To be of any use, information needs retrieval from stored memory, but if the retrieval mechanism is impaired, all conceptual learning would be pointless. Therefore, even though conceptual learning is glorified as the highest achievement of education, its origin and functioning are dependent on memory, which so far has been formally neglected.

Literary memorization implies the prefect recall of anything one reads or hears. One probably has had the rare experience of seeing a very intelligent student with excellent memory that quickly understand the lessons, and, amazingly, recite a literary presentation of the subject. This enviable ability – elevated understanding and memory - is difficult to achieve since there is no emphasis on memory. If trained early, probably any student of average intelligence can develop these amazing qualities; anecdotally, most outstanding intellectuals, artists, and athletes have a history of childhood cultivation of exceptional memory.

From a physiological viewpoint, repetition is the basis of memorization and the bulwark or rote learning. Rote learning and repetition are banned in education but are still covertly endorsed in the form of essays, consultations, research, graphics, concept diagrams, testing, and many other teaching tools. The system fosters memory development indirectly bouncing memorized information from classroom to classroom in an orchestrated effort to consolidate the secrets of a profession. At the end, the licensure evaluation tests the years of conceptual learning which in reality is the accumulation of "conceptual memorization." Educators should openly reassure the value of this term, conceptual memorization, so students can feel free to apply all types of direct memorization exercises to reach a better and more fluid performance.

COMMENTS

It is said that memorization is not an important function in the learning process. Educators argue that more important than memorization is the "concept" of the information presented; however, those "concepts", or pearls of knowledge, need to be safely stored in memory to be useful.

Some disciplines are highly dependent on memory for their basic precepts, in particular the biological sciences. Human anatomy would be unsupported if students were unable to memorize the details of the 206 bones in the skeleton, which is the most elemental of all learnings in medical knowledge. There are many techniques to "understand" those bones, but at the end, the student needs to retrieve information to continue the process of dressing those structures with muscles, tendons, arteries, veins, nerves, organs, and skin. That recall needs to be perfect, otherwise its utility will be dangerously flawed because it is the foundation of surgical procedures.

In the field of literature, the flow of ideas is quite free and random, but its matrix of expression follows memorized rules that the writer automatically applies. The fact that he "understands" these messages is founded on memory function and - because of their continuous repetition - those engraved rules become a second nature to his art. Much is said about the originality of the writer's creative process, but even this "inspiration" is based on the storing of myriads of readings until those threads of memory finally became a weaving of his own construction. The importance of his memory is tragically highlighted by the senility of later years when his tapestry of information, so feverishly obtained, is removed and there is no essence for any original work.

On the other hand, mathematicians, take pride on the prowess of their executive function, their goal-directed ability to solve problems; however, that executive function is also founded on working memory that allows quick mental manipulations. As demonstrated by Craig & Gilmore (2014) memory retrieval is the foundation of problem resolution and creative function; in this way, even if a mathematician can solve a difficult problem following ten approaches, each one of those routes – even the creative one - has a history of persistent rehearsal of memorized principles, sequences, connections, rules, and exceptions.

A painter would be lost without the memorized dexterity for reproducing backgrounds, light effects, or color combinations. His dexterity is the result of countless hours or routine repetition leading to the merging of his art with his memory and subsequent creativity. In this way, even unique artistic expression is dictated by the accumulated knowledge and interconnections of memory.

The same for the musician who has memorized the notes of various instruments. For instance, Arturo Toscanini - a conductor of the NBC Philharmonic Orchestra in the 1950's - knew the complete scores of about 250 orchestral presentations, and 100 operas. Legend says that once before a concert in St. Louis, an alarmed bassoonist approached him because one of the keys of his instrument was broken; after a moment of recollection, Toscanini dispelled his concerns by telling him that that note was not needed in any of his interventions - showing the accuracy of his fabulous memory. However, critics of the time did not attribute his capacity to rote learning, but to the "… fascination that aficionados bring to their special interest." (Purves, 2004). But what can it be if not rote learning? We know that rote learning is repetition and musicians need to repeat innumerable times to master their knowledge. There is a limit to “finding the logic” in the notes. It can be said that music is surrounded with emotion and therefore defies understanding; but emotion and memory are inextricably linked in the musical experience. Still, there is a redeeming lesson in the rote-learning music analysis: rote learning does not need to be boring if one is truly interested in the activity.

Inferences are also predicated on memory. They are the elevated activity of intelligent behavior consisting in conclusions reached through evidence and reasoning (Mc Kay, 2003). However, to apply inferences one needs a collection of related experiences stored in memory. In this vein, even the humblest piece of information can bring the solution to a serious dilemma.

Because of the paramount importance of memory in the educational process, its development should be acknowledged and encouraged at all academic levels; but instead, memorization has been shunned for more than one hundred years. Only in recent times, research outlining its benefits is bashfully emerging and – fortunately - with a positive reception. Current studies emphasize the beneficial effects of exercising memory which in turn - because of the brain integrative function - heightens other higher cognitive functions (McNulty, 2006). Even more encouraging: in the last one hundred years there has not been a single experiment demonstrating any detrimental effect of memorization exercises.

The present educational emphasis of “conceptual learning”, does nothing more than give luster to its memorizing nature at the time of examinations. It is said that it is the understanding - not the memory - that is tested, but in reality, the memory of the understanding is under scrutiny. Any student with normal intelligence is capable of comprehending during class explanations. After that, they need not only the understanding, but the recalling of the concepts. Therefore, as previously mentioned, the emphasis should be placed on the importance of memory; hence, the phrase "conceptual memorization" which is not rote memorization strictly, but memorization, nevertheless.

Currently, students are overwhelmed with dozens of methods to develop understanding and learning, with the caveat of avoiding memorization at all costs. Students struggle on their own to "understand" in preparation for the exams. Fortunately, studying by itself develops memory even if teachers advocate against it, but one must wonder about the number of good students that had refrained from developing an excellent memory, just because of the disdain it provoked among the teachers.

Why not free students from the bridles of present orthodoxy and promote memorization as a very useful tool in the learning process? By the principle of functional reciprocity, memorizing will develop other higher mental abilities. Its application is immediate, it is inexpensive, there is no need of special books or laboratories - and the benefits are innumerable, including the prevention of senility. Further, favoring memorization at an early age will facilitate the building of pathways among the centers of higher brain function which will make the student's life easier and more enjoyable.

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