Memory, Learning and Sleep

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Abstract

This development project handles memory, learning and sleep. First I studied the effects of sleep on learning, but gradually I noticed that to understand sleep's effects on learning you have to understand the mechanisms of memory. Memory, learning and sleep are linked onto each other strongly.

In this development project I handle first human memory, what it is and the factors that influence it. Then I handle the intercourses between memory and learning. Finally I try to enlighten sleep's meaning for memories and learning.

The topic is rather demanding because lots of the information are new and the things are very abstract. That is why there are many quotations in my text. Some writers of the articles I studied for this work said that the whole research area develops with such a speed that the information gets old very quickly. I have tried to use the newest possible sources for my work.

Why do we sleep? What function does sleep serve? Why do we dream? What significance can we attach to our dreams? We spend so much of our lives sleeping, yet its precise function is unclear, in spite of our increasing understanding of the processes generating and maintaining sleep. We now know that sleep can be accompanied by periods of intense cerebral activity, yet only recently has experimental data started to provide us with some insights into the type of processing taking place in the brain as we sleep. There is now strong evidence that sleep plays a crucial role in learning and in the consolidation of memories. Once the preserve of psychoanalysts, 'dreaming' is now a topic of increasing interest amongst scientists. Research into sleep is growing and in this development project I try to present the relationship between sleep, learning and memory (as it is understood at the moment

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1. MEMORY, LEARNING AND SLEEP

1.1 Background

When I was accepted for the first time to the Teacher Education College at Jyväskylä University of Applied Sciences in the Line of Internationally Oriented Teacher Education, we got a summer assignment. We were to read newspapers, magazines and other material that dealt with the topics of our country and other countries of the world. The idea was to summarize what had happened in the world and the effects of them on our lives. We were especially told to find articles that handled learning in some way. One of the articles I read was in The Tiede Magazine, which is the Finnish version of The Science Magazine. In that article *Tuula Kinnarinen* told about the new findings that *Robert Stickgold*, a professor of Harvard University in phychiatry, had found out in the field of memory, sleep and learning. The article was fascinating and I gradually started to study more the area of sleep and learning. So it was logical to choose the topic of my development project. Since then I have been very surprised finding articles of sleep’s effect on one’s behaviour or every day life in newspapers in Finland and abroad. There have been at least two dozens of these articles. And the message of all of them is that we should have good sleep seven hours a night. We don’t seem to understand the importance of sleep for our lives! It is partly due to our incapacity to understand how the brain works. We are trying to produce computers which are alike our brain, but is that the right dimension? There may be a better way… I do not know it, but I try to tell the facts of the 300 articles I read that handled memory, sleep’s effect on learning and to understanding. We are close to understand the universe, but we are not able to do it, yet. Could a decent sleep make us clever enough to solve the problems that mankind has caused without the human intellect?

1.2 Memory, Sleep and Learning

First I studied the effects of sleep on learning, but gradually I noticed that to understand sleep's effects on learning you have to understand the mechanisms of memory. Memory, learning and sleep are linked onto each other strongly.

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The topic is rather demanding because lots of the information are new and the things are very abstract. That is why there are many quotations in my text. Some writers of the articles I studied for this work said that the whole research area develops with such a speed that the information gets old very quickly. I have tried to use the newest possible sources for my work.

1.3 Results

Memory, learning and sleep form a very complex system. A lot is known of them, but still every day new things of are learned and found out. Especially the role of sleep is not known well. And when we totally understand why we sleep we would be a lot wiser.

Why do we sleep? What function does sleep serve? Why do we dream? What significance can we attach to our dreams? We spend so much of our lives sleeping, yet its precise function is unclear, in spite of our increasing understanding of the processes generating and maintaining sleep. We now know that sleep can be accompanied by periods of intense cerebral activity, yet only recently has experimental data started to provide us with some insights into the type of processing taking place in the brain as we sleep. There is now strong evidence that sleep plays a crucial role in learning and in the consolidation of memories. Once the preserve of psychoanalysts, 'dreaming' is now a topic of increasing interest amongst scientists. Research into sleep is growing and in this development project I try to present the relationship between sleep, learning and memory (as it is understood at the moment). If we just could understand it, we would feel like millionaires.

2 HUMAN MEMORY

At its simplest level memory is a mental activity for recalling information that has been learned or experienced. It involves receiving, retaining and retrieving data – much like our computers.[11]

Human memory is also the generative, interactive ongoing mental process of retaining and recalling knowledge or experiences. A human’s ability to use and manipulate his memory greatly influences the learning process. [9]

2.1 Attention and Selection

The first process of memory is attention. Attention is the ability to concentrate mentally and observe carefully. There is much more information in your environment than you can process at any one time. As a rule, the more you notice the more you will learn, though not necessarily a higher percentage of the things you noticed. Retaining a higher percentage depends on what you notice and in what order. Both quantity and quality matter. Thus, you must make choices (conscious and unconscious) regarding the stimuli to which you will attend.

In general, observing/noticing things creates memories and using memories reinforces them. The most useful thought patterns for memory building are those that create new memories while reinforcing old ones.

As soon as something has been noticed the new knowledge is ready to be used. This can be done in several ways. Knowledge is often used in forming new memories, for example. Or you might be researching something for a specific purpose in which case new discoveries will be applied to your problem.

The sad reality of learning is that most of what you set out to learn is wrong and perhaps deliberately misleading so one of the main uses of knowledge is in evaluating the likely truth of what you have been told.

What to notice, and in what order, is vital to learning. It determines what you know and how useful and long lasting your memories are. What you should notice depends on the structure of knowledge you want to build. The best choice is determined by:

- the structure of the information you are working with;
- what you want to use the knowledge for; and
- the characteristics of the human brain.

In practice you will not go back to first principles every time you start to learn something. Instead, as your skill develops you will learn to spot features of the material and your circumstances that immediately tell you what approach to take, based on pre-digested reasoning. So although the reasoning behind some learning strategies is complex, actually spotting when to use the strategies and doing so is easy.

Much of our learning time is actually taken up with searching for something worth remembering. It's time consuming and tiring skimming through chapters of stuff that doesn't make sense, isn't useful, or is just plain wrong.[14]

Imagine two students who are driving to some island during summer vacation. Both have different plans for how they want to spend their vacation: one listening to local bands, the other surfing and swimming. They stop to eat at a sidewalk cafe, where they are approached by a stranger who asks if they know of a surf shop nearby. Assuming they passed one on the way to the cafe, the chances are that the surfer, but not the friend, would have remembered seeing it. Had the stranger asked about music clubs, you might find the opposite scenario. Each one likely attended to what was of interest.[2]

There are three basic questions to ask about memory.

How are memories formed (encoding), retained (storage) and recalled (retrieval)?

2.2 Encoding

Encoding is an active process that requires selective attention to the material to be encoded. One question is at what point in the process is the distracting material screened out. However, "cocktail party phenomenon" suggests a late filtering: all messages are registered but only the ones with meaning are actually put into memory. Another possibility is that where the filter occurs depends upon the task: the more attentional capacity that is available at any one time, the more one can use meaning and then the later input filter (selection).[2]

Once something is attended to, it must be encoded to be remembered. Basically, encoding refers to translating incoming information into a mental representation that can be stored in memory. Memories may then be affected by the amount or type of attention devoted to the task of encoding the material. There may be different levels of processing which occur and that some are deeper than others. You can encode the same information in a number of different ways. For example, you can encode information according to its sound and the sound of the words (acoustic or phonemic code), what it looks like (visual or structural code), or what it means (semantic code). Semantic coding is considered deep processing, acoustic encoding is an intermediate level and visual a shallow level. Suppose, for example, that you are trying to remember these three types of encoding from your notes. You might say each of the terms aloud and encode the sounds of the words (acoustic), you might see the three types of encoding on your page and visualize the way the words look (visual), or you might think about the meanings of each of the terms (semantic). [2] There are also other aspects of encoding: elaboration, which means associating with other information, self-referent, which means making the material personally relevant and requires deciding how the information is personally relevant and visual imagery can be used to add richness to the material to be remembered.[1]

How does encoding apply to memory? The way you encode information may affect what you remember and how you recall it later. If you encoded the three things visually or acoustically, but not semantically, you may be able to list them during a test, but you may have difficulty recalling what each term means. If you encoded them only semantically, you might be able to explain what they mean but have difficulty remembering the order in which they were listed on the page.[2]

You may be able to remember information best if you use techniques (while retrieving the information) that are related to the way you encoded it. For example, if you encoded something visually, you will be able to recall it most easily by drawing on visual cues. Knowing the memory techniques discussed will help you encode the information in different ways.[2]

2.3 Storage

Over the years, analogies have been made to the new technology of the day to try to explain memory. Storage is the process of holding information in your memory. Memory is retention of information over a period of time. *Ebbinghaus (Hermann Ebbinghaus* (January 24, 1850-February 26, 1909) was a German psychologist who pioneered experimental study of memory, and discovered the forgetting curve and the learning curve), studied memories by teaching himself lists of nonsense words and then studying his retention of these lists over periods of hours to days. This was one of the earliest studies of memory in psychology. [1]

While Ebbinghaus studied retention over long intervals, later experiments studied memory loss over periods of seconds to minutes. Short term memory was postulated to explain temporary retention of information as distinct from long term retention of information . Short term memory acts to also store current sensory information and to rehearse new information from sensory buffers. It has limited capacity (*Miller's* 7 plus or minus 2). The probability of encoding in long term memory has been directly related to time in short term memory.[6]

It is now believed that the loss of information stored in short term memory has the same characteristics as loss of information stored in long term memory. It happens quicker because it involves information that is not learned as well. What we call the learning process is transferring information from short term to long term memory and is a physiological process. The shape of the memory loss curves are the same. Hence we don't need to postulate a special type of memory. Instead, we need a theory of:

. Why we can rehearse only a limited amount of information at a time.
. How different memories get different strengths (and so are forgotten at

different rates).

Current theories use a computer based model or information processing model. The most accepted model states that there are three stages of memory storage: sensory store, short-term store, and long-term store.

Sensory store retains the sensory image for only a small part of a second, just long enough to develop a perception. [6]

2.3.1 Short-term Memory

A distinction is often made between short-term and long-term memory. Short-term memory is just that, brief and transient. Think about looking up a new phone number in the phone book and making a call. You may remember it long enough to make the call, but do not recall it later. This is your short-term memory, which can hold a small amount of information for a short period of time. The period of time lasts for about 20 to 30 seconds without rehearsal of the information. The capacity of short-term memory is about seven items but it can be increased by "chunking", by combining similar materials into units. A chunk is a single idea, made by lumping together other ideas. It is not a statement that is true or false, not a question, not an instruction-it says nothing. It is just a chunk. The bigger and more appropriate the chunks already are in your memory the quicker you can learn new things. That’s because you build new memories out of existing memories so the better your stock of building blocks the quicker you can assemble new and useful memories. [1,11,14]

Originally short term memory was perceived as a simple rehearsal buffer but it turns out to be more complicated. It is not limited to phonemic encoding, loss of information occurs by other means than simply decay and displacement, etc. Perhaps short term memory is better modelled by the CPU of a computer, it has the ability to store a limited amount of information in its cache ram while it processes it - a sort of working memory. Once you stop attending to the phone number, perhaps after you make the call and move on to another task, you are likely to forget it. In order to remember the number for a longer period of time (and after attending to other things), you would need to store it in your long-term memory.[1,5]

2.3.2 Long-term Memory

The transfer of information from short- to long-term memory can be achieved in many ways. Simply repeating the information can help if it's repeated enough times. For example, frequently called phone numbers are remembered because you have used (repeated) the number many times. Although simply repeating, or practicing, something can help move it into long-term memory, another strategy for transferring information is to think about it deeply. That is, elaborate on the information, drawing connections between what you are trying to remember and the other things with which you are already familiar. You might learn that telephone number quicker, for example, if you notice that it includes the dates of your friend's birthday, the numbers on your license plate, or some other familiar number pattern.

Long term memory has been suggested to be permanent. Nothing is forgotten only the means of retrieving it is lost. Supporting evidence includes the existence of flashbulb memories as vivid recollections of important events such as the death of JFK or the Challenger Space shuttle crash or WTC attack.[1,5]

2.3.3 Short-term vs Long-term Memory

Working memory is a relatively recent term, a refinement of an older concept - that of short-term memory. Short-term memory was called thus to distinguish it from "long-term memory" - your memory store.

One important difference between the idea of short-term memory and working memory, is that short-term memory was conceived of as a thing. Different from

long-term memory (variously analogized as a library, a filing system, a computer) chiefly in the duration of the records it held. But working memory, as its name suggests, is now conceived more as a process than a thing. A state of mind. A pattern of activation.

To put information into our memory store, it must be worked on - i.e., be held in working memory. To get information out of the memory store - to “remember” something - it must again be in an active state - be in working memory. How can we know what we remember if we're not conscious of it?

However, you can only keep something "active" for a very short time without your conscious attention. It is this which so limits working memory capacity.

Probably the most widely known fact about working memory is that it can only hold around seven chunks of information (between 5 and 9). However, this tells us little about the limits of working memory because the size of a chunk is indeterminate.

1 2 3 4 5 6 7 are seven different chunks - if you remember each digit separately (as you would, for example, if you were not familiar with the digits - as a young child isn't). But for those of us who are only too well-versed in our numbers, 1 through to 7 could be a single chunk.

Recent research suggests however, that it is not so much the number of chunks that is important. What may be important may be how long it takes you to say the words (information is usually held in working memory in the form of an acoustic - sound-based - code). It appears that you can only hold in working memory what you can say in 1.5 — 2 seconds. Slow speakers are therefore penalized.

What we term "working memory" contains several functions, including the "central executive" which coordinates and manages the various tasks needed. The extent to which working memory is domain-specific (different "working memories", if you like, for different sensory and cognitive systems, such as language, spatial memory, number) is still very much debated. However, at a practical level, we may think of working memory as containing several different components, for which you have different "capacities". Thus, your capacity for numbers may well be quite different from your capacity for words, and both from your capacity for visual images. [8]

These memories are not as accurate as once thought so perhaps long term memory is not permanent. So how does short-term memory "stuff' get into long-term memory?

2.4 Retrieval

Retrieval is the process of actually remembering something when you want to. If you think about tip-of-the-tongue experiences, when you know a word or name but just can't seem to recall it, you will understand how retrieval is different from storage. In terms of memory improvement, it can help to understand how the retrieval process relates to encoding and storage. Retrieval relates to storage as well. Obviously the memory has to be stored in order for you to retrieve it, but knowing how it was stored can help. This is where elaboration and processing come in. Consider the relationship between retrieval and encoding. If you encoded something visually, but are trying to retrieve it acoustically, you will have difficulty remembering. Like encoding, information can be retrieved through visualizing it, thinking about the meaning, or imagining the sound, etc. The more ways information has been encoded, the more ways there are for retrieving it. Imagine that you are taking a test in which you are given a definition and asked to recall the word it describes. You may recall the page of your notes that the word was on and visualize the word, or you might say the definition to yourself and remember yourself repeating the word. Thus, memory is aided by encoding and retrieving information in multiple ways.

Retrieval relates to storage as well. Obviously the memory has to be stored in order for you to retrieve it, but knowing how it was stored can help. This is where elaboration and processing come in. When attempting to retrieve information, it helps to think about related ideas. For example, you are trying to remember a chemistry formula during an exam. Although you are able to visualize the page of your chemistry notes, you cannot recall the exact formula. You do remember, however, that this same formula was used in the biology class you took last semester. As you think about that class, you are able to recall the formula. This is one reason why intentionally organizing information in your memory when you are learning it helps you recall it.

Steps of memory:
First, you select the information to which you will attend. You then code the information for storage (where it can be practiced and processed more deeply). Later, when needed, information is retrieved by using a search strategy that parallels how the information was coded and stored.[2]

2.5 Forgetting

Although information can be stored in long-term memory for extended periods of time, "memory decay" does take place. In other words, we can forget what we learn. In fact, we forget things quickest shortly after we learn them. This has two implications in terms of improving our memory. First, as disheartening as it is, you will often learn a great deal more than you can retain in the long run. But, before you lose heart entirely, keep in mind that the memories can be retained with a little effort. So, the second implication for improving memory involves maintaining memories with the least amount of effort. In order to retain information in memory, you must practice, think about, and sometimes relearn things. Every time you practice and relearn the information, you are reinforcing it in your memory. Taking a few moments to do frequent, but brief, reviews will save you time by helping you retain what you have learned. For example, it's a good idea to make rehearsal part of your reading and note-taking regimen. When you complete a reading assignment or a note-taking session, take a few minutes to rehearse the material as a way of moving the information from short-term to long-term memory. Not that this practice alone is sufficient to prepare for most test, but it will enhance your understanding and recall of the material, facilitating serious study.[2]

2.6 Memory Consolidation Theory

Initially, information is thought to be encoded as patterns of neural activity - cells "talking" to each other. Later, the information is coded in more persistent molecular or structural formats (e.g., the formation of new synapses). It has been assumed that once this occurs, the memory is "fixed" — a permanent, unchanging, representation.

With new techniques, it has indeed become possible to observe these changes. Researchers found that the changes to a cell that occurred in response to an initial stimulation lasted some three to five minutes and disappeared within five to 10 minutes. If the cell was stimulated four times over the course of an hour, however, the synapse would actually split and new synapses would form, producing a (presumably) permanent change.

The hypothesis that new memories consolidate slowly over time was proposed 100 years ago, and continues to guide memory research. In modern consolidation theory, it is assumed that new memories are initially “labile” and sensitive to disruption before undergoing a series of processes (e.g., glutamate release, protein synthesis, neural growth and rearrangement) that render the memory representations progressively more stable. It is these processes that are generally referred to as “consolidation”.

Recently, however, the idea has been gaining support that stable representations can revert to a labile state on reactivation.

In a way, this is not surprising. We already have ample evidence that retrieval is a dynamic process during which new information merges with and modifies the existing representation — memory is now seen as reconstructive, rather than a simple replaying of stored information.

2.6.1 Reconsolidation of Memories

Researchers who have found evidence that supposedly stable representations have become labile again after reactivation, have called the process “reconsolidation”, and suggest that consolidation, rather than being a one-time event, occurs repeatedly every time the representation is activated.

This raises the question: does reconsolidation involve replacing the previously stable representation, or the establishment of a new representation, that coexists with the old?

Whether reconsolidation is the creating of a new representation, or the modifying of an old, is this something other than the reconstruction of memories as they are retrieved? In other words, is this recent research telling us something about consolidation (part of the encoding process), or something about reconstruction (part of the retrieval process)?

2.6.2 Hippocampus Involved in Memory Consolidation

The principal player in memory consolidation research, in terms of brain regions, is the hippocampus. The hippocampus is involved in the recognition of place and the consolidation of contextual memories, and is part of a region called the medial temporal lobe (MTL), that also includes the perirhinal, parahippocampal,and entorhinal cortices. Lesions in the medial temporal lobe typically produce amnesia characterized by the disproportionate loss of recently acquired memories. This has been interpreted as evidence for a memory consolidation process.

Some research suggests that the hippocampus may participate only in consolidation processes lasting a few years. The entorhinal cortex, on the other hand, gives evidence of temporally graded changes extending up to 20 years, suggesting that it is this region that participates in memory consolidation over decades. The entorhinal cortex is damaged in the early stages of Alzheimer's disease.

There is, however, some evidence that the hippocampus can be involved in older memories — perhaps when they are particularly vivid.

A recent idea that has been floated suggests that the entorhinal cortex, through which all information passes on its way to the hippocampus, handles "incremental learning" — learning that requires repeated experiences. "Episodic learning" — memories that are stored after only one occurrence — might be mainly stored in the hippocampus.

This may help explain the persistence of some vivid memories in the hippocampus. Memories of emotionally arousing events tend to be more vivid and to persist longer than do memories of neutral or trivial events, and are, moreover, more likely to require only a single experience.

Whether or not the hippocampus may retain some older memories, the evidence that some memories might be held in the hippocampus for several years, only to move on, as it were, to another region, is another challenge to a simple consolidation theory.[7]

3 MEMORY AND RELATED LEARNING PRINCIPLES

How well you learn and remember given material depends less upon your inborn talent than upon the specific strategies you follow as you study. These strategies are or principles are simple to learn and simple to use.

3.1 The Principles of Short-Term and Long-Term Memory

This principle of long-term memory may well be at work when you recite or write the ideas and facts that you read. As you recite or write you are holding each idea in mind for the four or five seconds that are needed for the temporary memory to be converted into a permanent one. In other words, the few minutes that it takes for you to review and think about what you are trying to learn is the minimum length of time that neuroscientists believe is necessary to allow thought to go into a lasting, more easily retrievable memory.[3]

The two main ways to access memory are recognition and recall. Recognition is an easier stage of memory than the recall stage. Recognition involves a process of comparison of information with memory. Recall involves a search of memory and then a comparison process once something is found. For example, in an examination, it is much easier to recognize an answer to a question if five options are listed, than to recall the answer without the options listed. But getting beyond just recognizing the correct answer when you see it is usually necessary for long-term memory, for the more we can recall about information the better we usually remember it.[3]

3.2 Learning New Material

You can use distributed practise while studying. It means to break up your study into smaller parts and to study a little every day instead of a lot all at once. Studying for an extended period without a break is unproductive.[11]

It is also very important to make sure that you understand new material before trying to remember it. A good technique to ensure understanding is to recite or write the author's ideas in your own words. If you cannot, then you do not understand them. The conclusion: you cannot remember what you do not understand. In other words, you cannot form a clear and correct memory trace from a fuzzy, poorly understood concept.

In the classroom, do not hesitate to ask the instructor to explain further a point that is not clear to you. If the point is unclear to you, there is a good chance that it is unclear to others, so you will not be wasting anyone's time. Furthermore, most instructors appreciate the opportunity to answer questions.[3]

3.3 Getting it Right the First Time

We have learned that all remembering depends on forming an original, clear neural trace in the brain in the first place. These initial impressions are vitally important because the mind clings just as tenaciously to incorrect impressions as it does to correct impressions. Then we have to unlearn and relearn. Incorrect information is so widespread in our modern world. We can really talk about information flood.

Evaluate the learning. Another way to improve retention is through evaluation. After you have studied, work the matter over in your mind. Examine and analyze it; become familiar with it like a friend. Use comparison or contrast: how is this topic like or different from related topics? If the learning concerns things conjectural, do you tend to agree or disagree? Are there aspects of the subject which you can criticize? Analytical thinking encourages you to consider the matter from various aspects and this kind of mental manipulation makes you more knowledgeable. For all these reasons, recall is significantly improved. [3]

3.4 The Principle of Overlearning

After you have recited a lesson long enough to say it perfectly, if you continue reciting it a few times more, you will overlearn it. *Ebbinghaus* has reported that each additional recitation (after you really know the material) engraves the mental trace deeper and deeper, thus establishing a base for long-term retention. For many people over learning is difficult to practice because, by the time they achieve bare mastery, there is little time left and they are eager to drop the subject and go on to something else. But reciting the material even just one more time significantly increases retention, and remembering this and utilizing the technique when you can may give better results.[3]

In other words you should not stop studying when you have acquired 100% mastery of the material, continuing studying would produce overlearning. Continuing to study after mastery gives you a margin that you will need on the exam. The rule here is: after you have learned it, keep practicing.

3.5 The Principle of Recitation

There is no principle that is more important or more effective than recitation for transferring material from the short-term memory to the long-term memory. For one thing, you are obviously in the process of repeating the information. Recitation can take several forms -- thinking about it, writing it out, or saying it out loud. "Thinking about it" is potentially the least effective because it gives us the least amount of reinforcement since writing or speaking involve more electrical muscle movement messages to the brain which are known to increase mental response and recording. Vocal, "out loud" recitation is usually the most effective single technique for review because it employs more of the senses than any other review technique (utilizing both auditory and vocal senses.) If, for example, when reviewing your notes immediately after class the reviewing is done by vocal recitation, you will not only be consolidating the new information but also strengthening the neural traces made to your brain.[3]

3.5.1 What is Recitation?

Recitation is simply saying aloud the ideas that you want to remember. For example, after you have gathered your information in note form and have categorized and clustered your items, you recite them. Here's how: you cover your notes, then recite aloud the covered material. After reciting, expose the notes and check for accuracy. You should not attempt to recite the material word for word; rather your reciting should be in the words and manner that you would ordinarily use if you were explaining the material to a friend. When you can say it, then you know it. (This is why it is best not to recite directly from the text.)

3.5.2 How Recitation Works

Recitation transfers material to the secondary or long-term memory. While you are reading the words in a sentence or paragraph, the primary memory (short-term memory) holds them in mind long enough for you to gain the sense of the sentence or paragraph. However, the primary memory has a very limited capacity, and as you continue to read, you displace the words and ideas of the initial paragraphs with the words of subsequent paragraphs. This is one reason for not remembering everything in the first part of the chapter by the time we reach the end of the chapter when we read continually without taking a break or taking time to review what we have already read. It is only when we recite or contemplate the idea conveyed by a sentence or paragraph that the idea has a chance (not guaranteed) of moving on into the secondary memory (a long-term storage facility).

All verbal information goes first into the primary memory (short-term memory). When it is rehearsed (recited), part of it goes into our secondary (long-term) memory. The rest of it, usual1y the part we are least interested in, returns to the primary memory and is then forgotten.

Whether new information is "stored" or "dumped" depends, then, on our reciting it out loud and on our interest in the information.[3]

3.6 Remembering

As a student, one of your main concerns is to retain old learnings while you continue to acquire new ones. Do we remember more when we begin to study a subject or after we already know something about it? According to several recent studies, learning which involves memorization of a unit of material begins slowly, then goes faster, and finally levels off. In other words, the amount learned per unit of time is small at first, then increases, and then becomes small again. This finding contrasts with older studies which showed that learning was rapid at first, then became slower until it leveled off.[3]

Even though a person continues to study, he may expect to encounter periods when there seems to be little or no gain. Such plateaus in learning may be due to severa1 causes such as fatigue, loss of interest, or diminishing returns from using the same inefficient methods. Another explanation of plateaus is that they represent pauses between stages of understanding; when the student acquires a new insight, he can move on. Sometimes the lower stage of an understanding or a skill may actually interfere with progress to a higher level. For example, learning to read by individual letters of the alphabet interferes with learning to read by words. Learning to read word-by-word delays reading by phrases or sentences.

The important thing is to recognize that plateaus or periods of slow learning are inevitable, and they should not discourage the student unduly. Learning may still be taking place, but at a slower pace. Recognizing that he is at a plateau, the student should first try to analyze and improve his study methods, if possible. Sometimes, however, an incorrect mental set may be interfering with the necessary perception of new relationships. Sometimes slow learning may simply be due to fatigue. In either of these circumstances the most efficient procedure may be to drop the activity temporarily and return to it later, after a good night's rest.

The rate at which a student learns depends upon his learning ability, but slow learners remember just as well as fast learners, provided that they have learned the material equally well. The reason a bright student may do better on examinations is that he has learned the subject matter more effectively within the time available. But if a slower student spends enough time on his studies, he can retain every bit as much as the faster student. Fortunately, there is evidence that both rate of learning and rate of retention can be improved with practice.[3]

3.7 The Principle of Neuro- Transmitter Depletion

Often students study or attempt to read for too long a period of time without stopping for a rest break. *B.F. Skinner* and other experts have concluded that the average student cannot usually study really difficult material efficiently for more than about four hours a day. Then efficiency and memory begin to suffer. Research shows that the average student cannot study effectively on the same subject for more than about four consecutive hours, even with short breaks every hour. What occurs is what is referred to as The Principle of Neuro-Transmitter Depletion. Neuro-scientists have developed techniques to monitor activity (usually defined as electrical impulses) and chemical changes in the brain during study or thought processing. If one studies the same subject too long, fatigue, boredom, sometimes slight disorientation may occur. It is a common result of too much consecutive study when even the most simple concept begins not to make sense any longer. The monitoring of brain activity and chemical changes indicate that studying too long results in a depletion of chemicals in the brain cells necessary for efficient processing of information. Therefore, for effective consolidation of material into memory storage, take frequent breaks (at least 10 minutes every hour) and do not attempt to deal with really difficult material for more than about four hours a day, and do not study any easier subject area (even with breaks) for more than four consecutive hours.[3]

4 IMPROVING MEMORY

Everyone can take steps to improve their memory, and with time and practice most people can gain the ability to memorize seemingly impossible amounts of information. Too many people get stuck and convince themselves that their memory is bad, that they are just not good with names, that numbers just slip out of their minds for some reason. The brain is not a muscle, but regularly “exercising” keep it growing and spurs the development of new nerve connections that can improve memory. By developing new mental skills and challenging your brain you can keep it active and improve its physiological functioning.

Obvious ways to improve memory are aerobic exercises and sufficient amount of sleep. Walking for 3-4 hours a week increases the supply of oxygen to the brain. Exercise increases the number of connections between neurons, which is responsible for improved memory. The amount of sleep we get affects the brain’s ability to recall recently learned information. We will deal with the effect of sleep on learning deeply in the following chapters.

In previous chapters, we have been dealing with memory processes and basic concepts of memory. If you review research on memory and learning, you will find that there exists a vast amount of information on the subject. But how can this knowledge be put into practice? In other words, how can it help you improve your memory. Thus, we focus on memory techniques and strategies.

4.1 Organizing Information

Organizing and ordering information can significantly improve memory. Imagine, for example, how difficult it would be to remember a random list of 62 letters. On the other hand, it would not be difficult to memorize the first sentence in this paragraph (consisting of 62 letters). Similarly, learning a large amount of unconnected and unorganized information from various classes can be very challenging. By organizing and adding meaning to the material prior to learning it, you can facilitate both storage and retrieval. In other words, you can learn it better and recall it easier. The following concepts can help you pull various information together in order to increase understanding and organization. This can mean organizing material on paper, such as when you make an outline or idea web, as simply organizing material in your memory, such as learning it in a particular order or making intentional associations between ideas.[4]

Chunking is here a useful way of handling material. The implications of chunking are simply awesome, and a lot of learning is just building up chunks for later use.

Condition-action -pairs are very useful for building skills. The "condition" part is there to recognise situations, while the "action" part is there to say what to do in that situation. The situation includes your goal(s) and the circumstances you face. Research suggests that many skills one might think of as being "algorithms" are actually built of condition → action pairs, and that this makes us better able to adapt to new situations, and better able to cope with interruptions and working memory failures.

The "condition" part is rarely given enough attention when skills are taught but is at least half the skill.

The same might be said of many other sports and other skills where there are variations in conditions that have to be taken into consideration.

Both the condition and action parts will often be built up by chunking.[13,14]

4.2 The Funnel Approach

This means learning general concepts before moving on to specific details. When you study in this manner, you focus on getting a general framework, or overview, before filling in the details. When you understand the general concepts first, the details make more sense. Rather than disconnected bits of information to memorize, such as history dates, the material fits together within the overall framework. Seeing how the smaller details relate to one another, you process the information more deeply (which helps you store, and later retrieve, it from memory). This idea is probably familiar. There are many learning strategies based on the funnel approach. For example, the approach is used in previewing a chapter for the major ideas as a way to enhance your comprehension of details contained in the chapter. You may also notice that many textbook chapters are organized in a "general to specific" format. Finally, you probably use this type of approach when studying from an outline, matrix, or concept map. Because of their organization, these tools are particularly well-suited for learning general to specific.[4]

4.3 Organizing through Meaning and Association

When learning, a person continually makes associations. We make associations between what we are learning and the environment we are in, between the information and our mental states, and between the information and our stream of thoughts. When things are associated in memory, thinking of one helps bring the other to mind. Have you ever actually retraced your path when you have forgotten where you put an object such as your keys? Often, as you approach the place where you put them, you are suddenly able to remember the act of laying them down on the table or putting them in your gym bag. This is association. The memory of putting the keys down was associated with your memory of things in the environment. You can make associations work for you by making them intentional. When you are having difficulty recalling new material, you can help bring it to mind by thinking about what you have associated it with. In other words--retrace your mental path.[4]

4.3.1 Deep Processing

One way to process information more deeply, and also to create meaningful associations, is to think about how the information can be personally meaningful. You might think about how the new material relates to your life, your experience, or your goals. If you can link new information to memories already stored ("mental hooks"), you'll have more cues to recall the new material.[4]

Give yourself time to form a memory. Memories are very fragile in the short-term, and distractions can make you quickly forget something as simple as a phone number. The key to avoid losing memories before you can even form them is to be able to focus on the thing to be remembered for a while without thinking about other things, so when you’re trying to remember something, avoid distractions and complicated tasks for a few minutes.

4.3.2 Grouping

You can organize material by grouping similar concepts, or related ideas, together. Arranging the material into related groups helps your memory by organizing the information. For example, in a sports exercise you can create a list of groups in sports. There may be 6 or 7 sports in each category. Still, with a little thought, this strategy can be used in a variety of ways. For example, can you think of other ways that these sports could be grouped? There are individual sports, team sports, sports you may enjoy, and sports you may dislike. There are sports requiring a great deal of equipment, and sports requiring little or none. When you are trying to remember lists for a test, the concepts and words may or may not have a natural organization. Therefore, you may need to be creative when making associations. Finally, the process of organizing a list into groups can often help you to understand the relationship between the concepts better.

4.3.3 Vivid Associations

When learning something new and unfamiliar, try pairing it with something you know very well, such as images, puns, music, whatever. The association does not have to make logical sense. Often times it is associations that are particularly vivid humorous, or silly that stay in your mind. Some people remember names this way. For example, they may remember the name "Robert Green" by picturing Robert playing golf (on the green), wearing green clothes, or covered in green paint. Or suppose for your anatomy course you have to recall names of the veins in the human body, and the first one on the list is "pancreatic" followed by "right gastroepipeloic" and "left gastroepipeloic" and so on. You can picture a frying pan being creative--maybe painting a picture with bright paints and bold strokes. If the frying pan is working in a studio, picture gas pipes with little padlocks on them (gastroepipeloic) in the left and right studio comers....[4]

4.3.4 Active Learning

You will notice that the term "active learning" has come up frequently. Active learning facilitates your memory by helping you attend to and process information. All of the memory techniques we have discussed require active learning. Even if you attend every lecture and read every assignment, there is no guarantee that you will learn and remember the information. Although you may passively absorb some material, to ensure that you remember important information requires being active and involved, that is attending to and thinking about what you are learning.[4]

4.3.5 Visual Memory

Some people remember information best when it is encoded visually; if that is the case for you, then code information in this manner. But even if you do not consider yourself specifically "a visual learner," you may find that including visual memory can still help. After all, it is one more way of encoding and storing information--and one more way of retrieving it for a test.

There are many ways of visually encoding and retrieving information. The strategy of associating concepts with visual images has already been mentioned. But other aids to visual memory include diagrams, tables, outlines, etc. Often these are provided in texts, so take advantage of pictures, cartoons, charts, graphs, or any other visual material. You can also draw many of these things yourself. For example, try to visualize how the ideas relate to each other and draw a graph, chart, picture, or some other representation of the material. You may even want to make it a habit to convert difficult material into actual pictures or diagrams in your notes, or to convert words into mental images on the blackboard of your mind.[4,11]

Create vivid, memorable images. You remember information more easily if you can visualize it. If you want to associate a child with a book, try not to visualize the child reading the book – that's too simple and forgettable. Instead, come up with something more jarring, something that sticks, like the book chasing the child, or the child eating the book. It's your mind – make the images as shocking and emotional as possible to keep the associations strong.

Finally, using your visual memory can be as simple as writing out vocabulary words, theories, or algebraic formulas. This allows you to not only practice (repeat) the information but also to see the way it looks on the page (developing a visual memory that you may be able to retrieve later). Another advantage is that it helps you take an active role in learning the material. When you draw your ideas on paper or write down things you are trying to remember, you have the opportunity to think about the information more deeply.

4.3.6 Talk it Out

When trying to memorize something, it can help to actually recite the information aloud. You might repeat ideas verbatim (when you need to do rote memorization), or you can repeat ideas in your own words (and thus ensure that you have a true understanding of the information). Repeating information aloud can help you encode the information (auditory encoding) and identify how well you have learned it. Some students have told us that they know the test information and are surprised when they "freeze" and cannot give adequate responses. For some students, this "freezing" may be a result of test anxiety. For others, however, it may be a result of overestimating how well they know the material. If you recite the information aloud from memory (answering questions, defining words, or using flash cards), it is often quite dear how well you know it. If you stumble in your responses, have to look up answers, or can only give a vague response, then you know that you need to study more.[4,11]

Although reciting aloud can be a helpful memory technique, some people avoid it out of fear of appearing foolish ("what if someone sees me talking to myself?"). If this applies to you, work with a friend or study group. Another advantage of working with someone else is that they can inform you when you are missing important concepts or misunderstanding an idea. Keep in mind, however, that studying with others does not work for everyone. For example, some students may become anxious or intimidated in study groups and would be more comfortable studying alone.

4.3.7 Visualize yourself Teaching the Material

An effective way to enhance recall and understanding of dense material is to teach it to an imaginary audience. By doing so, you are forced to organize the material in a way that makes sense to you and to anticipate potential questions that may be asked by your students. Moreover, by articulating your lecture aloud, you will uncover gaps in your comprehension (and recall) of the material. (Far better to discover those "weak" areas before a test than during it.) After you have mastered a particular section from your textbook, try delivering an organized lecture on any topic from that section. Then check for accuracy. Don't forget to anticipate questions that students might ask about the material as a way of anticipating potential test questions.[4,11]

ASAP Review means that if you go over what you have learned for just five minutes immediately after you have learned it, your retention will be far higher than if you skip this valuable step.[11]

5 SLEEP AND LEARNING

5.1 Sleep

Sleep isn't just a form of rest! Sleep plays a critical physiological function, and is indispensable for your intellectual development! Those who do not respect their sleep are not likely to live to their full mental potential! [15, 29]

Although scientists are still trying to learn exactly why people need sleep, it appears that sleep is necessary for our nervous systems to work properly. Too little sleep leaves us drowsy and unable to concentrate the next day. It also leads to impaired memory and physical performance and reduced ability to carry out math calculations. If sleep deprivation continues, hallucinations and mood swings may develop. Some experts believe sleep gives neurons used while we are awake a chance to shut down and repair themselves. Without sleep, neurons may become so depleted in energy or so polluted with byproducts of normal cellular activities that they begin to malfunction. Sleep also may give the brain a chance to exercise important neuronal connections that might otherwise deteriorate from lack of activity.

5.2 Sleep Deprivation in Society

Few people realize how important sleep is! The alarm clock is an often-used fixture in an overwhelming majority of homes of the modern world. By using the electric lighting, alarm clocks, sleeping pills, and shift-work, we have wreaked havoc on the process of sleep. Over the last hundred years of the twentieth century, we have intruded upon a delicate and finely regulated process perfected by several hundred million years of evolution. Yet only recently have we truly become aware that this intrusion may belong to the most important preventable factors that are slowing the societal growth in industrial nations! In a couple of years from now, we may look at alarm clocks and "sleep regulation", in the same way as we look today at other "great" human inventions in the league of cigarettes, asbestos materials or radioactive cosmetics. [15,23]

Cutting down on sleep does not make people die (at least not immediately). It does make them feel miserable but the ease with which we recover by getting just one good night of sleep seems to make sleep look cheap. Even the reports from the Guinness Record attempt at sleeplessness (*Randy Gardner's* awakathon in 1964 lasted 11 days) trivialized the effects of sleeplessness. Many books on psychiatry and psychology still state that there aren't any significant side effects to prolonged sleeplessness! This is false! [15,23]

Children are usually happy to go to bed when tired but most teenagers see it as part of their emancipation from parental interference to stay up late. And our society seems to approve: today, we sleep 20% less than our ancestors did because we push ourselves to work longer hours and to have evenings full of social activities (*Hargreaves*, 2000).

A simple indicator of sleep deprivation is the urge to fall asleep during the day. This happens to pupils during lessons, to students over their textbooks, to travelling business people, or to elderly people in front of the TV. So, sleep deprivation is a widespread phenomenon and apart from its potentially fatal consequences, this impinges strongly on our ability to remember and hence to learn. [21,15]

5.3 The Effect of Sleep on Learning

In evolutionary terms, sleep is a very old phenomenon and it clearly must play a role that is critical to survival. Only quite recently, it has been proven beyond doubt that the function of sleep is related to learning! All scientists do not agree with this, but the results of new research show that sleep is inevitable for learning.

It has been known since the 1920s that sleep improves recall in learning. However, only recently, research by Dr *Robert Stickgold*, assistant professor of psychiatry at Massachusetts Mental Health Center, has made international headlines. Dr *Stickgold* demonstrated a fact that has long been known yet little appreciated: sleep is necessary for learning! Without sleep we reduce the retention of facts we have learned the previous day (and not only). Studying nights before an exam may be sufficient for passing the exam, yet it will leave few useful traces in long-term memory. The exam on its own replaces knowledge as the main purpose of studying![15]

5.4 Experiments to Test the Effect of Sleep on Learning

Some memory tasks are more affected by sleep deprivation than others. A recent study, for example, found that recognition memory for faces was unaffected by people being deprived of sleep for 35 hours. However, while the sleep-deprived people remembered that the faces were familiar, they did have much more difficulty remembering in which of two sets of photos the faces had appeared. In other words, their memory for the context of the faces was significantly worse.

While large doses of caffeine reduced the feelings of sleepiness and improved the ability of the sleep-deprived subjects to remember which set the face had appeared in, the level of recall was still significantly below the level of the non-sleep-deprived subjects.

Interestingly, sleep deprivation increased the subjects’ belief that they were right, especially when they were wrong. In this case, whether or not they had had caffeine made no difference.

In another series of experiments, the brains of sleep-deprived and rested participants were scanned while the participants performed complex cognitive tasks. In the first experiment, the task was an arithmetic task involving working memory. Sleep-deprived participants performed worse on this task, and the fMRI scan confirmed less activity in the prefrontal cortex for these participants. In the second experiment, the task involved verbal learning. Again, those sleep-deprived performed worse, but in this case, only a little, and the prefrontal areas of the brain remained active, while parietal lobe activity actually increased. However, activity in the left temporal lobe (a language-processing area) decreased. In the third study, participants were given a "divided-attention" task, in which they completed both an arithmetic and a verbal-learning task. Again, sleep-deprived participants showed poorer performance, depressed brain activation in the left temporal region and heightened activation in prefrontal and parietal regions. There was also increased activation in areas of the brain that are involved in sustained attention and error monitoring.

These results indicate that sleep deprivation affects different cognitive tasks in different ways, and also that parts of the brain are able to at least partially compensate for the effects of sleep deprivation.[28]

The paper, "Consolidation During Sleep of Perceptual Learning of Spoken Language," was prepared by researcher *Kimberly Fenn; Howard Nusbaum*, Professor in Psychology; and *Daniel Margoliash,* Professor in Organismal Biology & Anatomy. It was published in the journal *Nature.*

In fact, the idea for the study arose from discussions *Nusbaum* and *Fenn* had with *Margoliash*, who studies vocal (song) learning in birds. "We were surprised several years ago to discover that birds apparently 'dream of singing', and this might be important for song learning," *Margoliash* said.

For their study, the team tested college students' understanding of a series of common words produced in a mechanical, robotic way by a voice synthesizer that made the words difficult to understand. They first measured the students' ability to recognize the words. They then trained them to recognize the words and then tested them again to measure the effectiveness of the training.

None of the students heard the same word more than once, so they had to learn how to figure out the pattern of sounds the synthesizer was making. "It is something like learning how to understand someone speaking with a foreign accent," *Nusbaum* said.

The team tested three groups of students. The control group was tested one hour after they were trained, and they recognized 54 percent of the words, as opposed to the 33 percent they recognized before training.

The scientists trained the second group of students at 9 a.m. and tested them at 9 p.m., 12 hours later. During that 12-hour interval, the students had lost much of their learning and only made a 10 percentage point gain over their pre-test scores.

A third group was trained at 9 p.m., allowed a night's sleep and then tested the next morning at 9 a.m. Those students improved their performance by 19 percentage points over their pre-test scores.

The second group was then re-tested after being allowed a night’s sleep, and their scores improved to the same level as the students in the third group.

“We were shocked by what we found,” *Nusbaum* said. “We were particularly intrigued by the loss of learning the students experienced during the day and then recovered.”

Researchers have yet to determine if the reduction in performance was because students had forgotten what they learned, had listened to other speech or had thought about unrelated issues during the day.

“If performance is reduced by interference, sleep might strengthen relevant associations and weaken irrelevant associations, improving access to relevant memories,” the authors wrote. If information was forgotten, sleep might help people restore a memory.

“Sleep has at least two separate effects on learning,” the authors wrote. “Sleep consolidates memories, protecting them against subsequent interference or decay. Sleep also appears to ‘recover’ or restore memories.”[27,22,29]

Learning is, in its most basic sense, a matter of forming memories. Dr. *Stickgold's* experiments show that a person trying to learn something does not improve his or her knowledge until after they have had more than six hours of sleep (preferably eight). It seems the brain needs time to file new information and skills away in the proper slots so that it can be retrieved later. Without enough sleep to do all this filing, the new information does not get properly encoded into the brain's memory circuits.

To sort out the role of sleep in learning, *Stickgold* trained Harvard undergraduates to look for particular visual targets on a computer screen, and to push a button as soon as they were sure they had seen one. At first, responses were relatively sluggish -- it typically took 400 milliseconds for a target to reach a student's conscious awareness.

With an hour's training, however, many students were hitting the button correctly in 75 milliseconds.

How well had they learned? When retested from 3 to 12 hours later on the same day, there was no further improvement past a student's best time in the training session. If *Stickgold* let a student get a little sleep, but less than six hours, then retested the next day, the student still showed no improvement in performing the target identification.

For students who slept more than six hours, the story was very different. Sleep greatly improved performance. Students who achieved 75 milliseconds in the training session would reliably perform the target identification in 62 milliseconds after a good night's sleep! After several nights ample sleep, they often got even more proficient.

Why six or eight hours, and not four or five? The sort of sleeping you do at the beginning of a night's sleep, and the sort you do at the end are different, and both, it appears, are required for efficient learning.

The first two hours of sleeping are spent in deep sleep, what psychiarists call slow wave sleep. During this time, certain brain chemicals become used up, which allows information that has been gathered during the day to flow out of the memory center of the brain, the hippocampus, and into the cortex, the outer covering of the brain where long-term memories are stored. Like moving information in a computer from active memory to the hard drive, this process preserves experience for future reference. Without it, long term learning cannot occur.

Over the next hours the cortex sorts through the information it has received, distributing it to various locations and networks. Particular connections between nerve cells become strengthened as memories are preserved, a process that is thought to require the manufacture of new proteins, a slow process. If you halt this process before it is complete, the day's memories do not get fully "transcribed" and you don't remember all that you would have, had you allowed the process to continue to completion. A few hours are just not enough to get the job done. Four hours, *Stickgold* estimates, is a minimum requirement.

The last two hours of a night's uninterrupted sleep are spent in rapid-eye-movement (rem) sleep, when dreams occur. The brain shuts down the connection to the hippocampus and runs through the data it has stored over the previous hours. This process is also important to learning, as it reinforces and strengthens the many connections between nerve cells that make up the new memory. Like a child repeating a refrain to memorize it, the brain goes over what it has learned, till practice makes perfect.[24]

5.5 The Physiological Function of Sleep

Researchers have long known the particular importance of the hippocampus, a small brain organ, for memory formation. Yet it has always been difficult to find out what is special about the hippocampus that distinguishes it from other areas of the cerebral cortex that also show synaptic plasticity, i.e. the ability to store memories.

Doctor *György Buzsáki* provided by using his knowledge of neural networks, ingenuous experiments on neuronal firing and sophisticated mathematical analysis of spatiotemporal firing patterns an good model explaining how the two components of sleep, REM and non-REM sleep, work together to consolidate memories. The hippocampus acts as the central switchboard for the brain that can easily store short-term memory patterns. However, these patterns have to be encoded in the neocortex to provide space for coding new short-term memories. This complex process of rebuilding the neural network of the brain takes place during sleep. Unlike rest or conservation of energy, this highest feat of evolutionary neural mathematics, requires the brain to be shut off entirely from environmental input! This automatic rewiring is the main reason for which we sleep and why there is no conscious processing involved! During sleep, the brain works as hard as during exams. It rewires its circuits to make sure that all newly gained knowledge is optimally stored for future use.[15]

5.6 Memory consolidation

Scientists at the Max Planck Institute for Medical Research in Heidelberg have been investigating how memories might be consolidated. Their new study offers the hitherto strongest proof that new information is transferred between the hippocampus, the short term memory area, and the cerebral cortex during sleep. According to their findings and contrary to previous assumptions, the cerebral cortex actively controls this transfer. The researchers developed a new technique for their investigations which promises previously impossible insight into the largely under-researched field of information processing in the brain (*Nature Neuroscience*, November 2006). The question of how the brain stores or discards memories still remains largely unexplained. Many brain researchers regard the consolidation theory as the best approach so far. This states that fresh impressions are first stored as short-term memories in the hippocampus. [26, 21,22,23]

Is sleep necessary to consolidate memories? This is the big question, still being argued by the researchers. The weight of the evidence, however, seems to be coming down on the answer, yes, sleep is necessary to consolidate memories — although maybe for only some types of memory. Most of the research favoring sleep's importance in consolidation has used procedural / skill memory — sequences of actions.

From this research, it does seem that it is the act of sleep itself, not simply the passage of time, that is critical to convert new memories into long-term memory codes.

Some of the debate in this area concerns the stage of sleep that may be necessary. The contenders are the deep "slow wave" sleep that occurs in the first half of the night, and "REM" (rapid eye movement) sleep (that occurs while you are dreaming). Experiments that have found sleep necessary for consolidation tend to support slow-wave sleep as the important part of the cycle, however REM sleep may be important for other types of memory processing.

5.7 Sleep Studies Cast Light on the Memory Cycle

Two new studies provide support both for the theory that sleep is important for the consolidation of procedural memories, and the new theory of what I have termed the "memory life-cycle".

In the first study, 100 young adults (18 to 27) learned several different finger-tapping sequences. It was found that participants remembered the sequence even if they learned a second sequence 6 hours later, and performance on both sequences improved slightly after a night's sleep. However, if, on day 2, people who had learned one sequence were briefly retested on it and then trained on a new sequence, their performance on the first sequence plummeted on day 3. If the first sequence wasn't retested before learning the new sequence, they performed both sequences accurately on day 3.

In another study, 84 college students were also in this research trained to identify a series of similar-sounding words produced by a synthetic-speech machine. Participants who underwent training in the morning performed well in subsequent tests that morning, but tests later in the day showed that their word-recognition skill had declined. However, after a full night's sleep, they performed at their original levels. Participants trained in the evening performed just as well 24 hours later as people trained in the morning did. Since they went to bed shortly after training, those in the evening group didn't exhibit the temporary performance declines observed in the morning group.

On the basis of these studies, researchers identified three stages of memory processing: the first stage of memory — its stabilization — seems to take around six hours. During this period, the memory appears particularly vulnerable to being “lost”. The second stage of memory processing — consolidation — occurs during sleep. The third and final stage is the recall phase, when the memory is once again ready to be accessed and re-edited.

The researchers made a useful analogy with creating a word-processing document on the computer. The first stage is when you hit “Save” and the computer files the document in your hard drive. On the computer, this takes seconds. The second stage is comparable to someone coming and tidying up your word document — reorganizing it and tightening it up.

The most surprising aspect of this research is the time it appears to take for memories to initially stabilize - seconds for the computer saving the document, but up to six hours for us![28]

In the past few years, scientists have discovered that there is more to sleep than a simple refreshing of our nerves. The process of learning is actively taken up by our brain during sleep (*Huber et al.*, 2004), which is essential for the formation of long-term memory. The first memory that is built when we learn a new task is susceptible to interference. After a certain time, an automatic process called memory consolidation sets in, which stabilises that memory. Memory consolidation continues during sleep, but then leads to the additional effect of memory enhancement. Thus, our brain performs better after an afternoon nap and much better after a full night of sleep (*Stickgold*, 2005). Also, when we are searching for the solution for a tricky problem, our brain continues to work on it while we are sleeping. As a result, we may experience a sudden understanding of a rule, an insight, that is sometimes even triggered by a dream.

What happens to our brain while we sleep?

The hypothalamus, as the central regulatory organ of the autonomic nervous system, controls the circadian rhythms (body clock) of our body temperature, hormone release, appetite and sleep. It contains a neuronal switch that regulates ‘wake nerves’ and ‘sleep nerves’. A sudden transition to the sleeping mode (‘falling’ asleep) means that sleep nerves fire to inhibit wake nerves. The switch is stabilised by a third group of neurons, otherwise we would frequently wake up at night.

This dynamic system generates the different stages of sleep that have been known for some time: rapid eye-movement sleep (REM) in which dreaming occurs, and non-REM sleep with the light sleep stages I and II and the deep sleep stages III and IV. The pattern of a night of sleep is characterised by 90-minute cycles composed of deep sleep and light sleep phases. An initial long period of stage III and IV sleep is followed by a short period of REM and stage I and II sleep. As the night progresses, the deep sleep phases become shorter and the dreaming phases longer.

The physiological function of sleep seems to be two-fold. First, non-REM sleep is a period of low metabolic demand in which the adenosine triphosphate (ATP) energy stores, used up while we are awake, are replenished. The degradation product of ATP, adenosine, acts as a physiological sleeping agent by directly activating the sleep-promoting neurons. Second, sleep plays a key role in neural plasticity. During sleep, significant connections between neurons are reinforced while accidental connections are eliminated. All the different stages of sleep have been implicated in sleep-dependent learning.[25,21,22]

5.8 The Two-component Model of Sleep Regulation

There are two components of sleepiness that drive you to bed:

- circadian component - sleepiness comes back to us in cycles which are usually about one day long
- homeostatic component - sleepiness increases with the length of time we stay awake

Only the superposition of these two components determines the optimum time for sleep. Most importantly, you should remember that even strong sleepiness resulting from the homeostatic component may not be sufficient to get good sleep if the timing goes against the sleep-high in the circadian component:

Circadian component - there are around hundred known body functions that oscillate between maximum and minimum values in a day-long cycle. Because these function take about a day's time to complete, the term circadian rhythm was coined by Dr *Franz Halberg* of Germany in 1959 (in Latin circadian means about a day). The overall tendency to maintain sleep is also subject to such a circadian rhythm. In an average case, the maximum sleepiness comes in the middle of the night, reaches the minimum at awakening, and again increases slightly at siesta time in the afternoon. However, the circadian sleepiness is often shifted in phase as compared with your desired sleep time. Consequently, if your maximum sleepiness comes in the morning, you may find it difficult to fall asleep late in the evening, even if you missed a lot of sleep on the preceding day. In other words, the optimum timing of your sleep should take into consideration your circadian rhythm.

Homeostatic component - homeostasis is the term that refers to maintaining equilibrium or balance in physiological and metabolic functions. If you drink liquids containing lots of calcium, homeostatic mechanisms will make sure that you excrete calcium with urine or deposit it in the bones. This is used to make sure your blood levels of calcium remain the same. Similar mechanisms are used to regulate overall sleepiness and its multiple subcomponents. The longer you stay awake, the more you learn, the more you think, the higher your tendency to fall asleep. On the other hand, caffeine, stress, exercise and other factors may temporarily reduce your sleepiness. The homeostatic mechanism prepares you for sleep after a long day of intellectual work. At the same time it prevents you from falling asleep in emergencies.

Let us now formulate the fundamental theorem of good sleep:

To get high quality night sleep that maximizes your learning effects your sleep onset should meet these two criteria:

- strong homeostatic sleepiness: this usually means going to sleep not earlier than 15-19 hours after awakening from the previous night sleep
- ascending circadian sleepiness: this means going to sleep at a time of day when you usually experience a rapid increase in drowsiness. Not earlier and not later! Knowing the timing of your circadian rhythm is critical for good night sleep

Additionally, you should be aware that using the circadian component will only work when all its physiological subcomponents run in synch (as it is the case in free running sleep). People with irregular sleep hours and highly stressful lives may simply be unable to locate the point of ascending circadian sleepiness as this point may not exist! [15,21,22]

5.9 Free Running Sleep

There is a little-publicized formula that acts as a perfect cure for people who experience continual or seasonal problems with sleep entrainment. This formula is free running sleep!

Free running sleep is a sleep that comes naturally at the time when it is internally triggered by the combination of your homeostatic and circadian components. In other words, free running sleep occurs when you go to sleep only then when you are truly sleepy (independent of the relationship of this moment to the actual time of day).

The greatest shortcoming of free running sleep is that it will often result in cycles longer than 24 hours. This eliminates free running sleep from a wider use in society. However, if you would like to try free running sleep, you could hopefully do it on vacation. You may need a vacation that lasts longer than two weeks before you understand your circadian cycle. Even if you cannot afford free running sleep in non-vacation setting, trying it once will greatly increase your knowledge about natural sleep cycles and your own cycle in particular.

In free running conditions, it should not be difficult to record the actual hours of sleep. In conditions of entrainment failure, you may find it hard to fall asleep, or wake up slowly "in stages". In free running sleep, you should be able to quickly arrive to the point when you fall asleep in less than 10 minutes and wake up immediately (i.e. without a period of fading drowsiness). In other words, you can remember the hour you go to bed, add 10-15 minutes and record it as the hour you fell asleep. As soon as you open your eyes in the morning, you should record the waking hour. Usually you should not have any doubts if you have already awakened for good (as opposed to temporarily), and you should not fall asleep again (as it may be a frequent case in non-free running sleep).[15]

6 Conclusions

When you see the big picture, you realize the smaller parts of the truth. Education and how to educate is not the easiest thing in the world. All this material I have gone through, proves that you can ease learning different ways.

Learning is, in its most basic sense, a matter of forming memories. Dr. *Stickgold's* experiments show that a person trying to learn something does not improve his or her knowledge until after they have had more than six hours of sleep (preferably eight). It seems the brain needs time to file new information and skills away in the proper slots so that it can be retrieved later. Without enough sleep to do all this filing, the new information does not get properly encoded into the brain's memory circuits.

Your memory and your brain have certain rules. All this taken into consideration you have to understand the co-operation between the brain and memory. When you want to learn something, you have to try to find it interesting.

The seven magic hours of good sleep a night gives the brain the time it needs for adjusting the new information. And then there is the phenomenon of overlearning. Actually it may be one of most important things in this study. When you think you have learned something, use your guts to study it once more. Then you know the idea! Much of our learning time is actually taken up with searching for something worth remembering. It's time consuming and tiring skimming through chapters of stuff that doesn't make sense, isn't useful, or is just plain wrong.

A chunk is a single idea, made by lumping together other ideas. It is not a statement that is true or false, not a question, not an instruction-it says nothing. It is just a chunk. The bigger and more appropriate the chunks already are in your memory the quicker you can learn new things. That's because you build new memories out of existing memories so the better your stock of building blocks the quicker you can assemble new and useful memories. Recent research suggests however, that it is not so much the number of chunks that is important. What may be important may be how long it takes you to say the words (information is usually held in working memory in the form of an acoustic - sound-based - code). It appears that you can only hold in working memory what you can say in 1.5 — 2 seconds. Slow speakers are therefore penalized.

It is also very important to make sure that you understand new material before trying to remember it. A good technique to ensure understanding is to recite or write the author's ideas in your own words. If you cannot, then you do not understand them. The conclusion: you cannot remember what you do not understand. In other words, you cannot form a clear and correct memory trace from a fuzzy, poorly understood concept.

Evaluate the learning. Another way to improve retention is through evaluation. After you have studied, work the matter over in your mind. Examine and analyze it; become familiar with it like a friend. Use comparison or contrast: how is this topic like or different from related topics? If the learning concerns things conjectural, do you tend to agree or disagree? Are there aspects of the subject which you can criticize? Analytical thinking encourages you to consider the matter from various aspects and this kind of mental manipulation makes you more knowledgeable. For all these reasons, recall is significantly improved.

ASAP review means that if you go over what you have learned for just five minutes immediately after you have learned it, your retention will be far higher than if you skip this valuable step.

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