Physiology of Memory for Students

By Rayan Ubaid

The brain's memory is one of the most vital features of any individual, yet we still can't fully wrap our heads around how it works and why it varies between people. Some people have "faster" memory than others, and others can remember every detail of an image or sound effortlessly. However, it is a common misconception that someone's memory can only be "good" or "bad". Just as the brain is a muscle, memory is a skill that can be trained using certain exercises and behaviors. Adversely, there are also bad practices or habits that many people could be doing, oblivious to the damage being done. Many students fall into this category, which may be one reason students performing poorly at school blame their "bad memory". Many factors could potentially induce memory impairment, but the more prevalent issues circulate our recent developments in technology.

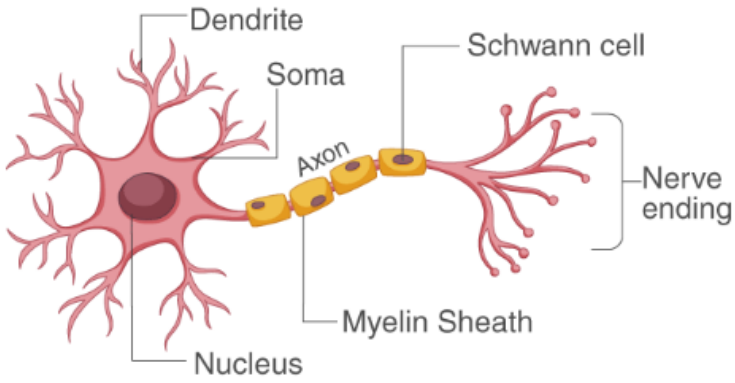
Strengthening the Brain

A human being's attention span is linked closely to their memory. Both of these cognitive functions allow a person to observe and comprehend things around them. A strong memory or attention span can strengthen the other, but the same is true the other way around. Fortunately, most practices that benefit or harm one also similarly affect the other function. Some of the basic habits that many people do

that help memory are simply a stable and strong sleep schedule, regular aerobic exercise, and reading frequently. Eating fruits, vegetables, and whole grain foods can help prevent memory-damaging strokes, whereas eating foods that contain a specific fatty acid called omega-3 can help reinforce neural connections, which are a vital part of memory, as well as other vessels in the body. Caffeine has also been proven to help with short and long-term memory at the expense of its side effects. Vegetables, berries, and fish all help to protect memory and prevent disorders such as dementia and Alzheimer's disease by helping increase the mass of a vital part of the brain called the hippocampus, which is an essential part of a human's cognitive function and is usually threatened early on in one's life by Alzheimer's and such diseases if it is not reinforced properly.

The Neuron

All of the brain's functions are executed or assisted by brain cells, or neurons. Neurons are responsible for collecting and moving around information electrochemically, which is the flow of electrical charges between objects during any other process. The image on the right depicts a neuron, which collects information through a person's senses and transmits it to other neurons. Neurotransmitters are released to other neurons by the dendrites on the right to overlapping axon terminals, or nerve endings as labeled on the diagram, which are the branches on the right side of the neuron. The connections between dendrites and axon terminals are called synapses. Memories are stored in the hippocampus, which recalls memories stored in the brain's long-term memory by activating synapses between a connection of neurons. Most memories are saved depending on the stimuli, which are things that trigger some sort of change, be it a sensory change or a change in your



body. Omega-3 is a fatty acid that is very important in facilitating neurons and can be found in nuts, vegetables, and seafood.

Types of Memory

The consensus among most scientists and doctors is that memory can be classified into three major groups: sensory storage, short-term memory, and long-term memory. Sensory storage is simply a stimulus of a sense that is stored for a very little amount of time, sometimes only a fraction of a second. Usually, the brain won't store these as memories and dump them unless they are associated with significant short-term memory, or an entirely new memory depending on the stimulus. This explains why you won't remember every minor detail of your day. The

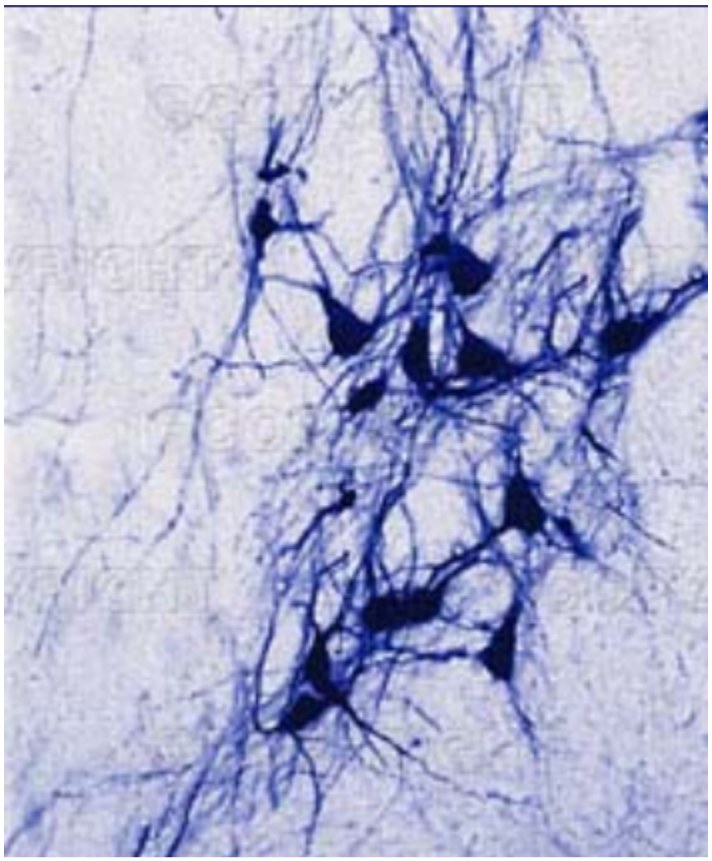
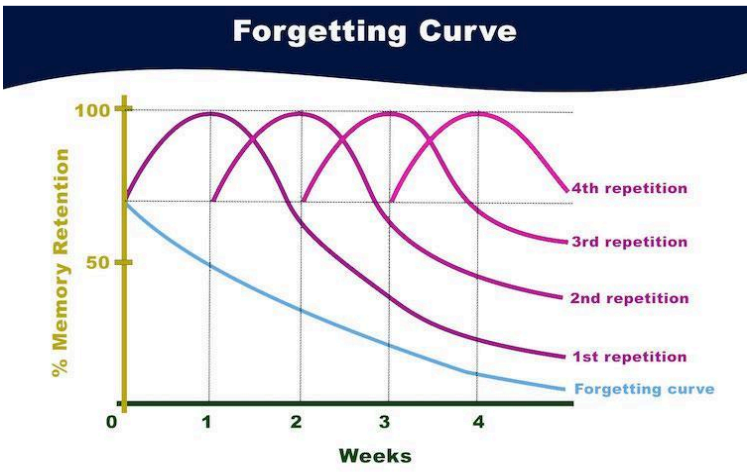


image on the right is a bundle of neurons bundled together to form a synapse. Short-term memory is a system the brain uses for storing memory that is being actively used. Short-term memory generally can only store 5 to 9 different items of information before starting to forget them, however, it appears to be a strange pattern where information in the middle is forgotten before the information in the beginning. To put something into short-term memory, a person must pay attention and focus to engrave it into their memories. Working memory is a class of memory that manipulates short-term memory into doing specific tasks using stored information. The most efficient and accepted way to do this is by repeating the information, and it is why repetition is the most practiced and embraced memorizing technique. This is because a neuron will strengthen the more a signal is sent through it; this is called potentiation. The more used short-term information is, the more likely it is to be relocated into the brain's long-term memory. Long-term memories are stored throughout the brain, not in one specific part, and there are some reports that memories can be stored in muscle tissue since people who have received organ transplants have reported feeling memories or flashbacks of events they never witnessed. To perfect memorizing a topic and make it stick, new synapses have to be formed and fortified to make recall easier. This process is called memory encoding. Memorizing more and more things compels the brain to

create more neurons, creates denser dendrites, and helps improve one's attention in general.

Forming Stronger Memories



The concept of forgetting is a very profound and complicated topic. Memory traces, which are permanent hypothetical changes to the nervous system formed during memorization, begin to decay over time. They will not stop decaying unless the memory is actively recalled or rehearsed. This is the basis for the technique of spaced repetition; reviewing information in short intervals with increasing time between each revision. For example, you revise the parts of the nervous system every hour a day, then 2 hours the next, etc. The graph on the right shows the percentage of lost information over weeks with spaced repetition, with the blue line representing the average loss of memory with no revision. Some memories are very strong without any particular revision or rehearsal. This is most probably because the memory was associated with a strong feeling of emotion or importance. Associating

things with another strong memory is another very efficient way to memorize things since the neurons can be activated easier with sensory cues or other synapses. The speed and efficiency of memorizing things are impacted by the mentality you have when trying to memorize. Many studies have proven this by providing two groups of people with the same set of pictures. One group was told that the images were going to be saved on a computer, and the other group was told the images were going to be deleted. They were tested a week later, and the second group did significantly better than the first group, although they weren't asked to memorize it.

Stress, Memory, and Interference

It is harder to recall information under high stress levels because the body releases a hormone called cortisol under stress, which interferes with memory retrieval by obstructing synapses and making it difficult or impossible to recall information. Cortisol can damage the nerves by blocking synapse connections for a long time and begins to wear out and shrink the synaptic connections. It also prevents short-term memory from encoding into long-term memory and will require much more focus and repetition to go on to long-term memory. Trying to memorize new information that is similar to an older memory

can be hard because of memory interference. The first type, proactive interference, is when an old memory makes it hard or impossible to overwrite or make a new memory, and that's why it's hard to break a habit you've had for a long time. Retroactive interference is when a new memory makes it hard or impossible to recall an old memory, like learning your new phone number and disremembering your old one. Sometimes, when you try to memorize something and encode it into long-term memory, the encoding can fail and prevent some of the information from passing through into long-term memory. There are two reasons that best explain this: either not enough time was spent moving the information into long-term memory, or cortisol abundance was blocking synapses and making it harder for memory to encode into long-term memory. It's a strong reason why you should start revising for a test earlier than the last few days.

It is possible for someone to forcefully forget something, like a tragic or traumatic memory. This is called suppression, which involves actively trying to block out these thoughts, which will likely induce something else called repression, which is unconsciously blocking out these impulses. Normally, when we experience negative events, we feel strong emotions and therefore create a strong natural memory trace.

Furthermore, we tend to dwell on these events and rehearse and encode them deeper and deeper into our memories. Undergoing other events with similar feelings will replay other older memories because the brain subconsciously records the mood we were in when we experienced the event, and instigates memories in which we were in the same state or mood. The brain also creates strong links with memories associated with something which greatly stimulates a certain sense. A particular sound, rich flavor, or vivid picture usually stays strong in the mind's memory because of the senses that the brain translates. Once the memory created is associated with a particular emotion, it can be easily recalled when experiencing the same emotion later on.

Factors that Harm Memory

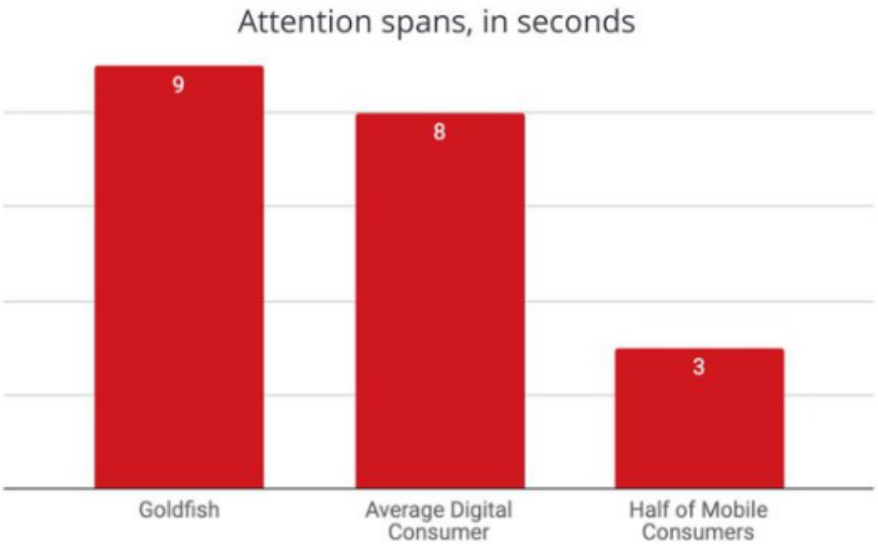
There are a variety of different factors that harm memory. Some of them are uncontrollable, like aging and exposure to smoke, but most factors are choices that can be prevented. Many of these factors have increased greatly with the modern increase of technology and its use, which can directly impair memory if it is used too much. A lot of different foods can bring about many different consequences that can find their way into your nervous system and damage your memory. One

of the most common and destructive factors, as stated earlier, is excessively high levels of stress and anxiety. While stress can be a motivating factor, being overstressed for too long can cause the released cortisol hormones to gradually cause the hippocampus to shrink over time, which will permanently damage a person's memory, attention, and cognitive functions, as well as short-term effects like headaches and muscle cramps, and slumps your focus. Foods, such as bananas and dark chocolate, can help reduce the levels of cortisol produced by your body by helping the body create a different chemical, serotonin, that lowers stress levels in your body and helps lift your mood. Some proteins will also help in counteracting the effects of high cortisol levels. Theanine, namely, is an amino acid that is the most viable and most used option due to its other beneficial side effects. Tea is a good way to get theanine into your system, as well as a good way to start your day. Cortisol which stays in your body for a long time can damage your memory, but enduring regulated amounts of stress can help your brain cope with stress better and better over time.

Digital Amnesia and Social Media

There are over 5.5 billion people who Google many different things daily. This may seem like a good testament to how our

technology is revolutionizing, but this is a reason why the average human attention span has dropped from 12 to only 8 seconds, as shown in the results of a 2021 study shown on the left. This is because of something called digital amnesia. Digital amnesia is a tendency we have to forget information that our brains think we can easily retrieve digitally, and thus our brains don't memorize those things. Technology also distracts us from putting 100% focus into something. It can interrupt the process of encoding information from short-term to long-term memory, which can easily be abrupted by the sound of a notification or the urge to check Instagram. According to multiple surveys, roughly more than 90% of teenagers use some platform of social media, which is not a bad thing. What makes social media so dangerous is how many people spend many hours a day on them. This is very detrimental to their attention span and other primary cognitive functions. Social media is also a big source of dopamine, which is the main factor that makes social media addicting. Theoretically, many



other things that cause your body to secrete dopamine can also raise the same issues as long-time social media use, but almost none of them have even close to the detrimental side effects of social media. Staring at a screen for multiple hours a day, regardless of what you are doing, can cause many problems for someone later on in their old age.

Permanent Memory Loss and Brain Damage

Many times, in a severe car accident, the victims can suffer severe trauma to regions of the brain. This can sometimes induce permanent loss of memory because many regions vital to memory can be damaged in the process. Damage to these areas can also be instigated by other, non-physical causes. These include frequent smoking, insufficient sleep, and high levels of chronic stress. However, most often permanent memory loss is induced by second-hand medical issues, such as stroke and epilepsy. Higher amplitudes of these issues can lead to permanent brain damage in a more widespread region, damaging cognitive functions and making way for more dangerous issues and further

potential damage. Overusing technology has also been proven in many studies to shrink many parts of the brain, such as the hippocampus and anterior cortex.

Bad Habits that Harm Memory

Many modern teenagers practice many harmful habits that can instigate long-lasting or even permanent damage to one's memory. Staying up late, eating too much or too little, and wearing headphones too often or too loud all will contribute to eventual and irreversible brain damage. Many studies show that frequently having negative thoughts will also have an impact on causing future brain damage. Even sitting for too long or not socializing is proven to decrease the average time of memory retention.