There are no translations available.

Learning & Memory: The Basics

(This article is complementary material for Tutorials 2, 5 and 6)

Stretching & Relaxing

First, get the concept of stretching and relaxing, because it's a part of the natural learning cycle.

When you stretch and relax muscles in exercise, they get bigger, fitter and more efficient over time, and consequently your physical performance improves. Exactly the same thing happens to the networks in your brain.

How do you stretch a network? The same way that you stretch a muscle -you give it something to do that is just a little different, but that it can get the hang of with practice. The mental ‘stretching’ takes place when we encounter something new or unknown, and the ‘relaxing’ takes place when that thing becomes known, familiar and automatic. These events are marked chemically by the release of different transmitters in the brain and physiologically by changes in the actual networks themselves, making them more efficient at transferring and processing information, improving the speed and acuity of your mental abilities.

When you stretch the mind it will release SMALL amounts of stress hormones. When you relax the mind it releases other chemicals to neutralize them, so that's fine as long as you DO the relaxation half of the cycle. The stretch half is about learning and the relax half is about remembering. If you can't do that half (and many people have trouble with it) your memory will be poor and it will take many repetitions of the material for you to learn anything permanently.

The stretch response is the 'desire' half of our pleasure system. We are 'drawn towards' and attracted to whatever we want to learn more about, and we become more alert, excited and observant. The relaxation response is the ‘fulfilment’ half of our pleasure system. It occurs when your brain chemistry changes in response to assimilation, success, satisfaction, fulfilment or understanding. During this response, heart rate and blood pressure slow, and cortisol production is turned off. Natural opioids and more oxytocin are released in the brain, making us feel very comfortable and satisfied, yet still ready to interact. During natural learning, this response occurs naturally. When there is too much cortisol present in the bloodstream, it can’t.

So it's important to know how to do the relaxation response, especially if you're a worrier or nervous. The biggest problem in the way of learning is anxiety, and you should study this (Read: “Anxiety and input control: the basics”, in the basics section of the library).

The Learning Cycle

Following the pattern that biology works with is the way you learned to walk and talk, and it’s the fast, easy way to learn.

It's possible to map the learning cycle into either four or six stages. It's easiest to use the four-stage model unless you are going to do serious neurohacking or you're a biological psychology student, so that's the version we'll present here.

A Good Mnemonic: COMP

The learning cycle is a pattern that enables us to move into an unknown, unpredictable area [stretch], interact with it, and understand, assimilate or digest it into our known, predictable body of knowledge [relax]. Each successful learning cycle increases the scope of the known; the relaxed state.

The learning cycle works with our biology to develop our mental skills in the right order. If we ignore the way the brain works, we can still have intent to learn, but it's very hard to manifest it beyond wishful thinking.

The stress/relax cycle breaks down into four stages that we have a simple formula for remembering; "COMP".

COMP stands for "Concentration, Observation, Modeling, Practice & variation." This next section explains what the brain is doing during these stages.

Concentration

This stage is about "the basics". Our intent is to take in information. In order to do so, we have to stay alert and pay attention.

Concentration allows us to pay attention to information so that it stays in our memory long enough to be useful.

Concentrating involves a state of mental alertness, attention over time, and avoiding distraction.
.

Poor concentration means that the information does not get taken in, and memories then have no chance of getting into long term storage. It's very often the case that memory loss, or apparently 'poor memory' is simply a failure to pay enough attention in the first place. That is obvious really, but you must not underestimate its importance. It is easy to sharpen your memory when you realise this first fact: paying attention in a particular way is crucial to memory processing.

Motivation and mental arousal are key factors affecting attention. We must be interested in what we are trying to learn, and not find it distasteful in any way. And we must avoid distractions.

Old theories of motivation hold that satisfaction reduces subsequent motivational drive. But several experiments and later MRI images indicated otherwise. When we desire something and get it, the subsequent feeling of satisfaction reinforces and increases the strength of that desire when it returns. Conversely, chronically unsatisfied desires may diminish the intensity of motivation.

Addiction becomes a useful factor in learning. In addiction, getting leads to more desire to get. One example is alcohol: Most people can live without it before they discover it, but getting pleasure from it does increase the desire for more. We are born addicted to learning, but society 'cures' that quite early on by making sure that it is neither interesting nor pleasant.

Many things can distract you when you are trying to learn, including your body. You may be too hot or too cold right now, hungry, tired, needing the bathroom, a cigarette or a cup of coffee. Your thoughts can distract you too –you may be wondering whether your friend is going to be okay or why some person said something strange about you last week or whether you will pass your exams this summer. All of these things distract you and slow down learning, and if you're distracted while you're reading this you're not even going to get the first point.

The first point is that we have to operate fully in the here and now with our attention focused on what we are doing; not on whatever might happen in the future or has happened in the past. Only then can we have true concentration without distractions, and that's the first thing we need to grasp the basics.

What's biology doing, when we get this right? –Concentration on our subject in an attentive manner fires the brain's "stress" response, sending dopamine and other chemicals like noradrenaline and acetylcholine around our brain to increase our alertness, attention and interest in what we are doing. Our perception improves and we notice more details and we start to take more notice of what is going on.

This is one of the areas where anxiety can be particularly troublesome because anxiety in itself is a distraction that makes it very, very hard for us to learn anything new. We can't explore the unknown effectively, because unconsciously we're too afraid to try anything different, too afraid to make a mistake, too worried what other people might think if they are watching and too worried about things that might or did happen to pay any real attention to what is going on in the present.

To get an idea of how all-pervasive anxiety can be, imagine trying to concentrate on something new in school one morning after a bully has told you they are going to beat you up at lunchtime. –How can you think of anything else but the coming threat? You cannot concentrate on anything except for the thing causing the anxiety, and the more that you imagine it, the worse it gets. It is obvious in this example just how powerful anxiety can be, but that is because this is a physical example. Far less obvious is unconscious anxiety, which is how many little things can stress us out over time or we can feel anxious without really knowing a logical cause. This is why it's important to reduce your anxiety hormone levels by whatever methods you can, even if you don't feel consciously anxious.

Observation

This stage is about understanding "the details" and making associations about what you are learning. It is where we start to [still partly unconsciously] look for connections, between the new thing that we are exploring and experiences that we have had before. We compare for example what we are reading now to stuff that we know already and to our own ideas, we make associations, and slowly we start to see where these new ideas fit into our scheme of "how things work” and why and how the new thing is relevant.

From time to time during this phase our brain moves bits of information around in memory, to help us to associate more effectively. When this happens, the natural thing for us to do is to stare, often apparently blankly at the wall and this is sometimes known as ‘daydreaming’ [daydreaming is not the same as ‘fantasizing’ about winning the lottery, or going out with your favorite celebrity, for example –this is wishful thinking; not daydreaming. Nor does it count if you’re staring blankly at the wall because you’re too stoned.]

Daydreaming [and consequently staring] is a vitally important part of learning which, if allowed to proceed without interruption, will speed up the learning process a lot. We should not interrupt people who are doing it, because we are interfering with their learning speed if we do. Our brainwave patterns change when we are staring; we are unconsciously accessing relevant information to “fill in the details” of what we know about the new information. To sustain your attention consistently enough to process information into long term memory [that is, to encode it], you need to keep a good balance between observation [taking in input] and assimilating it so regular breaks, especially if spent staring, are beneficial.

You cannot easily initiate ‘staring’ on purpose –the brain knows when it needs to be done naturally, and you should work with that. If you find yourself losing concentration, getting confused or bored, stop and take a break, or do something totally different. The subject will return to your conscious awareness when the unconscious networks of the brain have ‘caught up’.

What’s biology doing? As you learn more of the details, your brain creates an increasingly complex net of associations, integrating the new information with what you know already. When you’re staring, your brain is doing on the spot “Defragmenting”, moving important bits of what you have learned into your long term memory and connecting the pathways for access to it. And at that point we begin:

Modeling

In modeling we are not merely an observer; we begin to interact with the subject of our inquiry [the observer becomes a participator, because of the nature of learning]. This is the part of learning that requires skill in creativity and imagination, because in order to learn anything well we jump forwards in time in our imagination. This is what biology is designed to do. You have to imagine what it would be like and feel like if your intent had already come to pass, and then you have to behave as though it has happened or is happening. You behave as though you had “got it” and put that to the test, then watch where you go wrong, and do it again. You have to do what a child would do –you have to play. The moment you get the hang of behaving exactly as you would if your intent had become reality, it starts to.

A good example is how we learn to walk. We don’t wait until we feel confident about walking to give it a try, we just behave as though we can do it and set off –and fall over. But all we do in order to correct that error is get right up again and go for it –letting our brain do all the complicated computation to correct our mistakes as we just get on with it. Our brain figures out what it takes to fire the right neurons to make our body move in a coordinated, balanced way simply by using feedback –which is why that feedback needs to be given.

The most important thing about learning to walk though is, again, not being distracted. If, every time we fell over, we focused our attention on the object that had tripped us, we’d never learn to walk. Being distracted by errors is a classic bad habit that most people have learned [again because of schooling] and it can be particularly distracting if you were brought up to believe that error is bad.

Coleman Hawkins (a famous musician) said, “If you don’t make mistakes, you’re not really trying”. Thomas Edison, after more than 2000 attempts, invented a working light bulb. He said, “I learned 2000 ways how not to make a light bulb, and that taught me how to make a light bulb”. Mistakes are, because of the necessity for feedback, the only way we can learn to do things optimally. If you allow your brain to do so, it will learn from your mistakes just as effectively as it did when you were learning to walk.

Modeling is called modeling because during this phase we copy a model. It may be a mental model of how it feels to be adept at the new task, or it may be a physical example of someone who is already adept at a skill we require to learn; either on a screen or in real life. In youth it is often our parents and friends that we learn skills from this way. Some people choose a spiritual model when following a spiritual path, but a model is not a coach so much as an example of how to do it right, whatever it is. If you are learning a creative skill, make sure your role model genuinely has the ability to manifest their intent through their medium, and stick to them like glue.

It’s not essential to have a physical living model for all learning, but it can be a big asset if you do.

The talent for high fidelity copying is among the greatest of human assets. Because of it, humans are uniquely adapted to both receive and pass on information and skills. This natural way of learning is at the root of all human culture.

What’s biology doing? –Firing up special kinds of brain cell called “mirror neurons”, that help us to ‘reflect’ upon the new ideas and start to use our imagination. If the skill being learned is a sport, for example, we would start to imagine ourselves performing it. If we are reading an emotional story, we would begin to empathize with the characters and “get into it” as we imagine how they might have felt. If we are learning scientific information, we may imagine how the new information applies to areas of our lives and the lives of others.

We are able to learn from imitation; not just skills but states of mind. Imitation –copying both the method and the outcome of a task- is not the same as emulation. Emulation focuses on the results of a task and then tries to achieve it by figuring it out. At first, emulation would seem a more optimal way to go about things, so why does biology favor imitation?

Because humans live in groups of massive cultural complexity, young ones need to be able to learn quickly how to do many, many things, modifying techniques later on if need be during practice & variation. Imitation is quicker than explanation because it provides an already-working solution to the problem, with time for explanation along the way while practicing. We are evolved to seek examples from the already-adept, and copy them. Genuine teaching is the art of being adept at demonstrating a skill whilst explaining it until the observers have “got it”. What we are ‘learning’ during explanations is how to think in the same way as the teacher; not the facts themselves. Only by thinking like the teacher can we easily remember those facts, because our mind is redesigned to accommodate them by our biology copying theirs. We must learn to perceive as they perceive; copy their perception, then we will know the subject as well as they.

Demonstration and directed examples would have been necessary for our distant ancestors to learn from each other long before speech emerged, using mime and hands-on demonstration to show how tools were made or techniques used. And this is still one of the basics of our learning today.

P&V – Practice & Variation

Every time you engage in an act of creative play, your brain releases chemicals on the assumption that what you are doing is real. The unconscious brain doesn't know that you are learning to drive –it only knows that you are driving –you are behaving like a person who can drive, in that you are getting into a car and pressing pedals and turning the wheel and things. The brain itself has no concern where its input is coming from; it just does its job and gets on with making the required chemical changes in response to your actual behavior and awareness; not the theory behind driving skills. In effect, you are playing at driving, in a safe space where someone experienced has dual controls. And that's how you teach your brain to drive.

What's biology doing? –Engaging in creative play on a regular basis creates a concentration of chemicals that trigger changes in your genome –a change in the expression of your genetic code. Different genes are turned on that produce new proteins for new brain growth; new connections between cells. Remember that the brain doesn't grow larger outwards as you become more adept –it grows in density –in the number of connections between brain cells. As it builds these connections, you "get it". You begin to truly understand whatever you are learning and it starts to become 'known' to you, and eventually automatic.

Practice literally changes your mind –you become more adept and these changes in intelligence will remain, as long as you use the skills that they bring. By varying the circumstances of practice we come to understand what we are learning ever more fully.

Whenever we reach this point in the learning cycle, your brain releases serotonin. This initiates the relaxation response. Other chemicals are triggered including the brains own natural opioids, and it feels very very nice.

The neural pathways through which we learn about the world tap into the same pleasure network in the brain as are activated by drugs like heroin. It's nature's way of saying, "well done you!" Opioids are released at the "I get it!" part of comprehension and until we have achieved that, we'll remain enthusiastic about learning the same thing. It is this part of the system that gives us the intent to seek new information.

Going through the learning cycle in the right order is important. The further information travels through the processing networks, the more receptors there are for these chemicals; that is to say, they occur in increasing numbers as you move through the networks. Because of this, information that triggers the most associations and conveys the most meaning to a person causes the greatest relaxation response and the strongest memory.

Does the effect wear off? Yes. As skills become automatic they use different parts of the networks with not so many receptors. Repetition [P&V] encourages this shift, freeing up the pathways for new learning.

Summary

Concentration needs:

[brain networks 1&2]

- Your physical senses and the brain's physical condition
- Your perception
- Your alertness, attention and orientation

Observation needs all of the above, plus:

[network 3]

- Your memory and association skills
- Your imagination
- Your emotional stability

Modeling needs all of the above, plus:

[Networks 4&5]

- Your creativity and ability to use tools
- Your intellect/IQ

Practice & Variation need all of the above, plus:

[Network 6]

- Your prediction, planning and strategy skills

(If you want to learn more about brain networks, read Anatomy, Physiology and Brain Networks: The Basics in the basics section of the library, or the tutorials)

Memory

Memory is an essential part of intelligence and learning. IQ, creativity and strategy all depend heavily upon it, as do our social skills and sensory motor abilities.

People tend to make two mistakes when considering how memory works. First, they think of memory as our ‘conscious knowledge’, but both learning and memory contribute to our personality in unconscious as well as conscious ways. Unconscious aspects of memory affect all the functions of our mind and behavior just as much as conscious memories do, [and conscious memories in fact depend on them.] Conscious memories could be looked on as “the details”, while unconscious memories are “the basics” of memory itself.

The second mistake people make in considering memory is assuming that it only uses one brain network, when in fact it uses all of them. Memories put themselves together through association (which is why one part of a memory, such as a smell, can remind you of a whole scene). Particular networks do particular tasks, but not in an isolated fashion; just as neurochemicals all work together to achieve the dynamics of an overall ‘state’, so memory networks integrate together and connect all areas, working in synergy to create a whole memory with all the details.

So there is no ‘individual’ network for storing memory. Your memory uses network 3 for many of its complex tasks including learning, but its storage and access system spreads throughout all networks. There’s a sensible reason for this, and it’s the same reason you keep the tools for changing a wheel in the car’s trunk; not at home in your bedroom. Things and events are stored right on site of the networks that control the functions they are most likely to need to deal with those things and events. This saves the brain time and improves performance.

There are 6 different kinds of memory:

- Sensorimotor or 'muscle' memory
- Spatial memory
- Eidetic or 'pictorial' memory
- Procedural memory
- Declarative memory
- Working memory

All of these except for working memory have both short term (RAM) or long term (LTP) storage.

LTP stands for 'Long Term Potentiation', the technical name for how permanent memories are made. Working memory is like a 'clipboard' only, and has limited room.

The early brain networks deal with most of what used to be known as ‘implicit’ memory, so called because much of it is unconscious. These memories are designed to perform specific functions, like discriminating about sensory stimuli, detecting friend or foe, finding food and so on. They develop as a result of experience but they are based on our hard-wired ‘likes and dislikes’ as a biological organism, and they don’t take up conscious awareness simply because they don’t need to. Sensory motor skills like walking can be learned entirely without conscious thought, and so can finding our way around in familiar territory.

This implicit memory is sometimes called “muscle memory”, and it’s because of it that we all have individual ways of moving, walking, talking and thinking. Body language, the way you smile, and the sound of your voice, are all dependent on habits –the habits of implicit sensory-motor and spatial memory. These and many other aspects of behavior are expressed so automatically, they may seem unchangeable, or believed to be innate. But we should not jump to such conclusions, which forget the roles of plasticity and epigenetics in setting up habits in the first place and maintaining them [If you want to know more, read: “Plasticity & epigenetics: the basics”, in the basics section of the library, or the tutorials.]

Sensorimotor memory

The part of the brain responsible for much of sensory/motor and some spatial memory in N1&2 is the cerebellum. The cerebellum is in the bottom back part of the brain and looks a bit like a lump of cauliflower. It contributes to sensory/motor memory in our control of movement in sensory motor tasks such as walking, throwing and catching, cleaning our teeth, riding a bike, dancing, swimming, driving a car, and all the many basic movements that we must make every day. It is also involved in posture and balance, both of which are modified by experience and contribute to spatial memory.

Two other parts of N 1 & 2 are vital for the formation of memory. They are the brain stem and the hypothalamus. They are important because they control and modulate our hormonal state, enabling us to be alert and aware enough to pay attention and to concentrate and to follow the learning cycle COMP. The brain stem, which flanks the cerebellum all the way up into the centre of the brain, produces most of the neurotransmitters we need for COMP, including dopamine, serotonin, epinephrine [adrenalin] and norepinephrine [noradrenalin]. –[Why have the latter two got two alternative names? –Don’t ask us; we didn’t make them up.]

The hypothalamus, a tiny little cluster of pea-like things that dangles down from the bottom of the brain, is responsible for the ‘brain/body link’ that gives the feedback to and from your memory about what your body is doing and what you want it to do. It signals your body to distribute the hormones that you need to match your body state to your mind state; to keep your heart beating at the correct rate, adjust your breathing, temperature and alertness levels. It joins N1&2 to N3. When you recall a memory, it stimulates your mind and body to reproduce an echo of the hormonal state that went with the original event, and it’s the reason why you still feel excited when you remember exciting events of the past, and get that sudden warm feeling once again when you remember someone you love.

Although N1&2 are involved in making new memories, they are mainly made in N3, and here we move into the central seat of memory and learning. N3 includes the most important departments for memory –the hippocampus and the amygdala [hereafter often referred to by their NH nicknames of ‘hippo’ and ‘amy’].

The Amygdala’s Role in Memory

Studies spanning several decades have shown us the amy’s role in the emotional ‘weighting’ of memory. It gets feedback about what’s going on both directly from the body and via the hypothalamus [that sits very close to it in the brain] and it also responds to neurotransmitters in the rest of the brain.

It needs all this, because one of your amys (we have two) functions mainly to see if anything dodgy or dangerous is going on, and its role in memory involves deciding what is relevant to your wellbeing and what isn't. It decides how much events matter by looking at what sort of hormonal and neurochemical responses they cause.

Current research is showing that the one on the left [usually, but not always] deals with detecting of, and weighting memories for, beneficial events, and the one on the right [usually] looks for and weights deleterious events. [There is some variety in this in the same way that some people are right- or left-handed.]

The amy puts an 'importance weighting' on events like this and this weighting strengthens the memories being made during the event. Strongly weighted memories are more easily retrieved, and their details are clearer and more vivid.

The amy also stores some memories itself, but only those that are relevant to its main job of watching out for you. Its main role in memory is modulating the memories that are being made in the hippo.

The Hippocampus's Role in Memory

The hippo roughly speaking does three things:

- It enables spatial memory,
- It makes and maintains the eidetic template 'map' that all memories are compared against for processing.
- It processes memory -including the making of new memories in learning, turning short term memories into long term ones and moving them to their permanent destination, and facilitating recall.

1.
2.

Overall, what it does best is association.

The Biggest Overall Enemy of Memory

Is anxiety. As we know, a single rush of stress hormones keeps us alert and makes learning and remembering easier, but if the brain is constantly flushed with them the hippocampus will be damaged, with deleterious affects on learning and recall.

It is important to be aware of the limitations of memory because they often go unnoticed. False memories are not unusual; in fact, they are impossible to define, because what is ‘true’ in one circumstance is no longer true in another, and memory is dynamic –that is to say it is updated in the light of our current knowledge and experience. Memories evolve. Falsities creep into almost every mundane recollection but only some of them become apparent [such as when you are sure you remember putting your phone in your bag, but it isn’t there]. Memory does not record real events like a videotape, it re-creates the past, producing a version of events that makes most sense to us from our current perspective. Even long term memories may in the end bear little resemblance to what actually happened. This is a normal and necessary part of maturing and having a broader understanding of reality.

The Second Biggest Problem for Memory

Is sleep-deprivation. Even a small amount of sleep/dream deprivation is bad news for memory and perception, because it results in unpleasant events being remembered more often than pleasant ones! The amy prioritizes ‘danger’ events if the hippo doesn’t have time to fully process all its contents, in fact it even has a special backup network to do this -so if you go short on sleep you will still recall bad events but your memory of good ones will fade. As you can imagine, this can have a very distorting affect on your perception of life in general!

How Much Can Your Memory Improve?

The brain has around 100 trillion connections joining billions of neurons and every single junction has the potential to be part of a memory. New connections can also be forged, so the memory potential capacity of the human brain is effectively pretty massive. In fact, we don’t know the limit yet.

Humans can also maximize their capacity because human memory differs from a computer's in several important ways. For one, it can be selective. Items of interest are retained better than those that are not. So personal and meaningful and creative memories can be held in their billions while dry facts learned at school and never used will fade away. Secondly, the brain works in linkages. If you cannot remember a fact, you can link it to a meaningful memory and use the latter to retrieve the former –this is how mnemonics work.

Self Assessment – Memory

Make a list of the different types of memory, like this:

- sensory motor
- spatial
- eidetic
- procedural
- declarative
- working

Now, read the statements below and follow the instructions after each group of statements.

- I have a good attention span
- I practise sports, dancing, martial arts [or any sensory motor skill] regularly
- I make sure I get good quality sleep and nutrition
- I don’t drink and I don’t take sleeping pills

[For each statement above that describes you, put one point beside ‘sensory motor’, then continue]:

- I can remember faces really well, I always recognise people I’ve met before
- If you show me a shape, I can usually also recognize it upside down or sideways
- I remember stuff from long ago more clearly than recent stuff
- I spent most of my time playing outdoors as a kid, and I still like to be outdoors now

[‘Outdoors’ means feet on the ground, head beneath the sky. Being in a vehicle does not count as ‘outdoors’.]

[For each statement above that describes you, put one point beside ‘spatial’, then continue]:

- I’m very good at navigating without a map, and I rarely get lost
- I totally “get” magical and mystical stuff
- I have perfect pitch
- I remember recent stuff more clearly than stuff from long ago

[For each statement above that describes you, put one point beside ‘eidetic’, then continue]:

- Once I’ve had a go at performing a task, I rarely forget how to do it
- I’m methodical, tidy and organized and I rarely lose things
- If I don’t use a machine or a tool for a while, I still don’t forget the instructions
- I learn pest if I’m shown, rather than told, how to do things

[For each statement above that describes you, put one point beside ‘procedural’, then continue]:

- I can remember most facts I read, even if I read them only once

- I usually feel confident about the accuracy of my memory
- I'm better at remembering written or verbal instructions than demonstrations
- I'm aware that my memory of facts seems better than most, and I have a higher than average IQ

[For each statement above that describes you, put one point beside 'declarative', then continue]:

- I always remember people's names, from right after we're introduced
- I can usually remember a phone number long enough to call back without writing it down
- I rarely worry about anything
- I'm aware of what sort of things I might forget, so I write them down

[For each statement above that describes you, put one point beside 'working']

Now look at your list, and see which types of memory are strongest (the ones with most points). You also now know which parts of your memory need the most work.

If you want to know more about learning and memory and how to improve them, read the tutorials.