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The Mechanics of Learning

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Abstract

The adage "Knowledge is power" is often accepted uncritically, yet this concept warrants deeper examination. In reality, knowledge, much like a steam engine, is not inherently powerful but is a tool that requires proper application and context to generate influence. Drawing on Annette Fisk's observation that psychology, originally the "science of the soul," has devolved into a mere "science of the mind," this paper explores the evolution of learning and its role in personal and societal development. While society perpetuates the belief that continuous learning is essential because life itself is an unending teacher, this research questions whether learning is truly within an individual's control. Can individuals selectively acquire knowledge, or are they at the mercy of what they encounter? Additionally, the paper examines the commonly held notion that practice is the key to mastering a skill, probing whether practice alone suffices or if other factors contribute to skill acquisition and perfection.

Keywords: *Knowledge Power, Learning Control, Psychology Evolution, Skill Acquisition, Practice Effectiveness.*

Introduction

Dopamine, undeniably, plays a crucial role in learning.

However there are other chemicals, Acetylcholine for example that are more relevant to us, due to their contribution to memory. While dopamine might remind us how good it feels to do a certain action, Acetylcholine makes sure we don't forget.

Dopamine is relatively more famous than Acetylcholine is when it comes to talking about chemicals of the brain, and yet more often than not they get mistaken for doing the same thing. Acetylcholine is a neurotransmitter that carries messages from your brain to your body through nerve cells. Dopamine on the other hand plays a role as a "reward center" and in many body functions, including memory, movement, motivation, mood, attention and more. A common misunderstanding is that dopamine is released when we feel good about something and it therefore leads us to remember that good feeling and makes us want to repeat the action. This understanding is not completely wrong but it's not right either.

"Researchers have long thought that rewards like food or money encourage learning in the brain by causing the release of the "feel-good" hormone dopamine, known to reinforce storage of new information. Now, a new study in rodents describes how learning still occurs in the absence of an immediate incentive." (Tritsch)

This study shows that while the increase dopamine and decrease Acetylcholine (something that happens simultaneously and with rewards) is the optimum learning environment because it promotes neuroplasticity.

Neuroplasticity occurs when there is a change in Acetylcholine and Dopamine levels. It's similar to diffusion, where the concentration of particles doesn't need to be higher in one place, just different. There's a very fine distinction, like the difference between walking into an arena with your head held high versus being dragged in. Harry Potter references aside, neuroplasticity plays a crucial role in learning. According to Lori Desaultes " When our brains change, our minds change, because our mind is the brain in action. As we use our brains, they grow and change through the use-dependent principle of neuroplasticity. Our brains prune away connections or synapses that we no longer use or need, while sprouting connections when we learn something new." (Desautels and Straus)

Neuroplasticity is the biological basis of learning.

"Neuroplasticity is the brain's ability to change and adapt due to experience. It is an umbrella term referring to the brain's ability to change, reorganize, or grow neural networks. This can involve functional changes due to brain damage or structural changes due to learning."(Cherry)

The ability to change and adapt due to experience. To modify, to make better and more suitable for future use, to learn and to grow.

"Plasticity refers to the brain's malleability or ability to change; it does not imply that the brain is plastic. Neuro refers to neurons, the nerve cells that are the building blocks of the brain and nervous system. Thus, neuroplasticity allows nerve cells to change or adjust." (Cherry)

So, to summarize neuroplasticity is equal to learning. Before delving into what factors make the brain plastic or the niceties of how it occurs and the steps taken to increase or decrease it, let's first have a look at the 'source of mental life', 'the cradle of our thoughts': the brain.

The brain

Up until recent years psychologists and neuroscientists believed that the brain stops developing and starts degrading after a certain age. It was also generally believed that we only used around 10% of our brain. Both are myths and the latter probably gained support to imply the fact we had untapped potential, and later started getting accepted as gospel, causing children to try moving books with their minds and realize they are not, in fact, Matilda.

It is true ,however, that our brain has limitations. We can't do two things at the same time, like texting and driving or listening to music and reading or taking an online class and sleeping, at least not successfully.

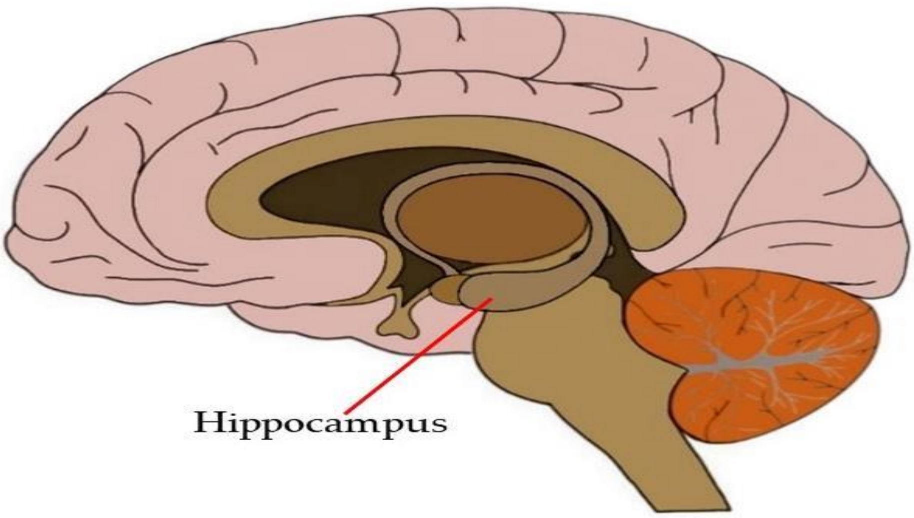
"If we have an abundance of brain fuel and neurons, how can we explain our limited cognitive abilities? Why can't we do more at once?

The most likely explanation is the way these neurons are wired up. We know, for instance, that many neurons in the visual cortex (the part of the brain responsible for processing visual information) are hooked up in such a way as to inhibit each other (Beck & Kastner, 2009). When one neuron fires, it suppresses the firing of other nearby neurons. If two neurons that are hooked up in an inhibitory way both fire, then neither neuron can fire as vigorously as it would otherwise. This competitive behavior among neurons limits how much visual information the brain can respond to at the same time. Similar kinds of competitive wiring among neurons may underlie many of our limitations. Thus, although talking about limited resources provides an intuitive description of our limited capacity behavior, a detailed understanding of the brain suggests that our limitations more likely reflect the complex way in which neurons talk to each other rather than the depletion of any specific resource." (Baker and Sperry)

According to Baker and Sperry, we literally can't do two tasks as efficiently as we would one task at a time. With regards to learning it would seem quite obvious that we shouldn't try learning multiple things at the same time, but it's still worth mentioning. This also means that we can't say, cycle and learn facts about the digestive system or paint a masterpiece while simultaneously reading about the Roman empire. To be effective one must focus only on Julius Caesar.

This makes us ask some more pressing questions. Like where does the information go? Are memories not stored in glowing orbs or files of neat paper which you can access whenever you want?

Sadly no. However, there is a special brain region in the brain devoted to memory storage. It's called the hippocampus.



But how exactly does the hippocampus work?

Memory

In light of current research in cognitive science, the very, very short answer to these questions is that memory operates according to a "dual-process," where more unconscious, more routine thought processes (known as "System 1") interact with more conscious, more problem-based thought processes (known as "System 2"). At each of these two levels, in turn, there are the processes through which we "get information in" (encoding), how we hold on to it (storage), and and how we "get it back out" (retrieval or recall).("How Memory Works"). While System 1 is characterized by automatic, unconscious thought, System 2 is characterized by effortful, analytical, intentional thought. How do System 1 and System 2 thinking relate to teaching and learning? In an educational context, System 1 is associated with memorization and recall of information, while System 2 describes more analytical or critical thinking. Memory and recall, as a part of System 1 cognition, are focused on in the rest of these notes.

As mentioned above, System 1 is characterized by its fast, unconscious recall of previously-memorized information. Classroom activities that would draw heavily on System 1 include memorized multiplication tables, as well as multiple-choice exam questions that only need exact regurgitation from a source such as a textbook. These kinds of tasks do not require students to actively analyze what is being asked of them beyond reiterating memorized material.

System 2 thinking becomes necessary when students are presented with activities and assignments that require them to provide a novel solution to a problem, engage in critical thinking, or apply a concept outside of the domain in which it was originally presented.

It may be tempting to think of learning beyond the primary school level as being all about System 2, all the time. However, it's important to keep in mind that successful System 2 thinking depends on a lot of System 1 thinking to operate. In other words, critical thinking requires a lot of memorized knowledge and intuitive, automatic judgments to be performed quickly and accurately. ("How Memory Works")

Memory has 3 stages. The encoding, the storage, and the retrieval. There isn't a lot of work that can be done in these stages, however retrieval is often the step we make mistakes in.

An interesting method to improve retrieval is the spacing effect. According to the spacing effect, when a student repeatedly learns and recalls information over a prolonged time span, they are more likely to retain that information. This is compared to learning (and attempting to retain) information in a short time span (for example, studying the day before an exam). ("How Memory Works").

All of this is about school-related, academically-oriented memory recall. What about the ohhh-I-forgot-my-car-keys-at-the-kitchen-table kind of memory?

Having that kind of memory always seems like an innate gift, to those who are bad with remembering. Either you are born with it or you're not. This is actually a very wrong notion.

According to memory champions and experts, your memory can be trained.

When the brains of these memory experts were scanned they show that their brain lights up in very different regions when they are memorizing phone numbers or faces or anything else.

In the short term memory the brain can only store up to 7 (give or take 2 depending on the person) chunks of information at a time. The question is, how big can you make this chunk. Take an example:

If you know nothing about French and I show you this word and I asked you to remember it you most probably wouldn't be able to.

LA MAISON

You, as an English speaker, might break it up into L A M A I S O N which would be 8 chunks and really push your short term memory. You could break it up into LA MAI SON (pretending LA and MAI are English words) or if you spoke or understood French LA MAISON(which means the house).

But in memory contests breaking them up isn't a feasible option either. Their brains aren't particularly smarter or faster or wired differently than any of ours, the region they're using is.

Our visual memory is a pretty fantastic thing. Our ability to memorize long pieces of boring textbooks might be flawed, but our ability to remember pictures, especially bizarre ones is astounding. Creating mnemonics or small vivid pictures that connect one main idea to the next is a good way to learn. ("Feats of memory anyone can do | Joshua Foer")

But that still doesn't answer the forgot-my-car-keys-again dilemma. Truth is, there doesn't seem to be a concrete solution to that. Maybe put them in a visible spot, put reminders on your door, if you know you forget something, take active steps to make sure you remind yourself.

Chess

It is said that there are more possible variations in this game than there are atoms in the universe (Kiernan). The universe is pretty vast on its own. Every small, seemingly insignificant (atleast to a beginner) may seem of infinite importance to a grandmaster, a small tip in the scale, but it might just decide the result of the game. But how does this work? What goes around in the minds of these extremely brainy people? Are they born different? Some say you can't polish a charcoal to make it into a diamond. You have to begin with a diamond in the rough and then do a lot of polishing. Genes and environment? An unanswered question really, how much weight each one has. So instead we'll be looking at how a person who is born to be a grandmaster, trains, uses their memory, calculates moves, looks at possible variations, and decides the best possible move.

They ask questions, they use techniques, they rely on previous positions, but what is it that they do differently from the rest of the chess players? Is practice alone the key? Grandmasters and weaker players happen to be considerably similar in the gross structure of thought processes. But he (a researcher) was unable to discover any quantitative differences that might underlie chess skill. And nothing has been discovered in the past 30 years to change this basic finding. Nevertheless, Masters invariably explore strong moves, whereas weaker players spend considerable time analyzing the consequences of bad moves(Chase and Simon 216)

What's the difference then? Why is there such a big gap in the skills if the thought process, which is arguably the most important part of choosing a move, is the same?

The best move, or at least a very good one, just seems to come to the top of the Master's list of plausible moves for analysis. de Groot did, however, find an intriguing difference between Masters and weaker players in their ability to perform a task involving perceptual and short-term memory processes. Masters were able to reconstruct a chess position almost perfectly after viewing it for only 5 seconds or so. There was a sharp drop-off in this ability for players below the Master level. This result could not be attributed to a generally superior visual short-term memory capability of the Masters because, when the pieces were placed randomly on the board, recall was equally poor for Masters and weaker players. Masters are subject to the same limitations on short-term memory as everyone else. To understand this feat of memory, therefore, we must ask what it is that the Master is perceiving during the brief exposure of a coherent position. It appears that the Master is perceiving familiar or meaningful constellations of pieces that are already structured for him in memory, so that all he has to do is store the label or internal name of each such structure in short-term memory. At recall, then, the Master simply uses the label to retrieve the structure from long-term memory. With a normal memory span of about 5 to 7 chunks (Miller, 1956), the Master must be perceiving about 4 or 5 pieces per chunk in order to recall about 25 pieces. We believe that this interesting demonstration of de Groot's, far from being an incidental side effect of chess skill, actually reveals one of the most important processes that underlie chess skill; the ability to perceive familiar patterns of pieces. To understand the skilled process more fully, we must isolate and characterize these perceptual structures that the Master holds in memory. (Chase and Simon 217)

People seem to generally agree, that playing chess or taking intuitive tests for example, tend to use both system one and system two of their memory. Drawing conclusions from what they already know and making on the spot decisions based on their past experiences(which counts as system one as well) and thinking ahead.

The question is, does this count as seeing the future? Chess players analyze all future possibilities, but can they ,with practice, analyze futures unrelated to the board? Obviously not. The key difference between weak players and grandmasters is the amount of experience they have. "Recognizing familiar chunks reduces the need for ''look-ahead'' search by giving access, for example, to information stored in memory about moves that may be advantageous when that chunk is present. (For example, (''If there is an open file, consider moving a rook onto it.'') Rapid recognition of patterns or chunks is also essential for evaluating the positions at the termini of searches. This recognition and memory retrieval capability explains how skilled players are able to play rapid-transit or simultaneous games at a relatively high level of competence—games that do not allow time for much look-ahead search" (Chase and Simon 2).

Repeated practice is a fundamental principle in the journey toward mastery .When people engage in consistent and deliberate practice, they reinforce their understanding and abilities, gradually moving from a novice level to more advanced stages. Repeated practice is vital to growth in any sphere, and chess is no different.

Conclusion

A review of the available literature reveals that one of the key ways to develop skills is manipulating brain chemistry, particularly through dopamine and neuroplasticity. The dual systems of thinking—System One and System Two—are significant when dealing with memory retention. Studies also show that an average person can hold about 7 chunks of information in their short-term memory (give or take two) so how you divide the chunks becomes important.

When it comes to intuitive games like chess, practice alone is the key. Practice to have more information, experience and data to retrieve from Perhaps perfection is a far shot, but expertise is definitely within the reach of anyone willing to try.

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