5

How to Memorize

How long does it take to memorize a shuffled deck of fifty-two cards? Alex Mullen from Mississippi, a medical student at the time, found a way to do it in less than 19 seconds. It's easy to think that Mullen is simply a genius, but as he himself says, his brain is nothing special. By using powerful memory techniques, anyone can learn to memorize information more easily and quickly.

Why Bother? The Value of Committing Information to Memory

In a world where you can look up any information, you might wonder: Is it necessary to memorize anything anymore? The answer is *yes*. You save time by knowing important information by heart. And during exams, interviews, and public interactions, you *can't* always just look stuff up. But perhaps the most important reason for thoughtful memorization is that it can help with complex problem-solving, and also help you acquire a deeper understanding.

KEY POINT
Memorizing key pieces of information releases mental power so you can understand more complex concepts and solve more advanced problems.

technique—trying to retrieve information from memory. Of course, you would do this several times spaced out over a number of days.

But often, there's an even smarter way. Memory tricks—also called mnemonics—can speed things up. You'll still need to practice and repeat to some extent if you use a trick, but much less than without it. **Memories made with memory tricks are not only easier to make, but "stickier." That is, they stay in long-term memory and can be more easily drawn from there into your conscious working memory when you need them.**

Verbal Memory Tricks

Here are some tried-and-true verbal memory tricks:

Acronyms

If you sprain your ankle, there's a good chance your doctor will recommend "Rest, Ice, Compression, and Elevation" and tell you to think of the word "RICE" to help you remember these four remedies.

You can use this trick with virtually any list of items you need to remember. Simply take the first letter of each word that you need to memorize and play around with the order to see if you can create a word. The names of the three major ancient Greek philosophers, for example—Socrates, Plato, and Aristotle—form the acronym "SPA."

Sentences

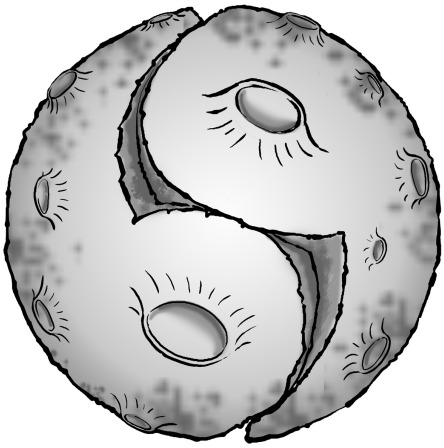
If your words don't form a neat acronym, you can create a quirky sentence in which each word corresponds to a word on your list. The sentence "My Very Elderly Mother Just Served Us Noodles" could represent the planets in order: Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune. Sentences can also help you memorize numbers. "How I wish I could calculate pi" helps you remember seven digits of pi, since the number of letters in each word corresponds to the digits of pi (3.141592).

Visual Memory Tricks


OH, SUGAR, HONEY, ICE TEA.

Have you noticed that it is easier to remember someone's face than their name? Your brain is super visual—almost half of the human cortex is involved in visual processing, while less than 10 percent is auditory.[5] This means your brain has a great visual memory. In one University of Iowa study, a group of people was shown a series of 2,560 images. A few days later, some of these pictures were shown again, but mixed with many images that hadn't been shown before. On average, people identified 90 percent of the original 2,560 images they'd seen.[6]

Vivid Image



The easiest visual memory trick is to create an image that represents the concept you're trying to remember. The more crazy, fun, and vivid your image is, the more it will stick in memory.[7] It's also good to build in some movement—as if the images make up a short movie clip. Say you want to remember that the moon landing happened in 1969. You could visualize a moon looking like a yin-yang (which in turn looks like the number 69). Vivid images can sometimes be strengthened by adding sounds or feelings. You could, for example imagine the moon swirling around with a swooshing sound.

Memory Palace

When medical student Alex Mullen from Mississippi memorized an entire deck of cards in less than 19 seconds—setting a world record in the process—he used an advanced version of one of the oldest and most well-known visual memory techniques: the Memory Palace.

The Memory Palace, also called "the Method of Loci," is a technique in which you create an image for every concept you want to remember, and then anchor these images to familiar physical locations, often inside a building—hence the name Memory Palace.

Let’s say you want to memorize the first five elements of the periodic table. With the Memory Palace Technique, the first step would be to come up with an image for each of the five elements. Here’s one way to do it:

- Hydrogen: fire hydrant
- Helium: (helium) balloon
- Lithium: (lithium) battery
- Beryllium: strawberry
- Boron: boar

As you can see, for some elements, we have chosen images that are typically associated with the element, such as “battery” for lithium. For others, we have chosen images where the sound of the word leaves a helpful clue, such as “strawberry” for beryllium.

The second step is to place those images in a familiar location, such as your office or home, your friend’s apartment, the street you live on, or your favorite park. We’ll create a walk through your home for this example. Start outside the entrance door to your home where we’ve placed the fire hydrant (representing hydrogen)—it’s leaking water and making a big mess. Next, you walk into the kitchen where you find a helium balloon (representing helium) hanging below the ceiling. You walk into the living room where a battery (lithium) is lying on the living room table. From there, you walk into the bathroom that is covered with strawberries (beryllium), squeezing the berries to jam as you walk around. Finally, you walk into your bedroom where a boar (boron) is running wild, creating a mess.

Once you come up with a Memory Palace, you’ll still need to practice it a few times by going through your palace and visualizing the items. It can

be a bit difficult to come up with good images when you first try this technique—but as with everything else, you'll get better with practice.

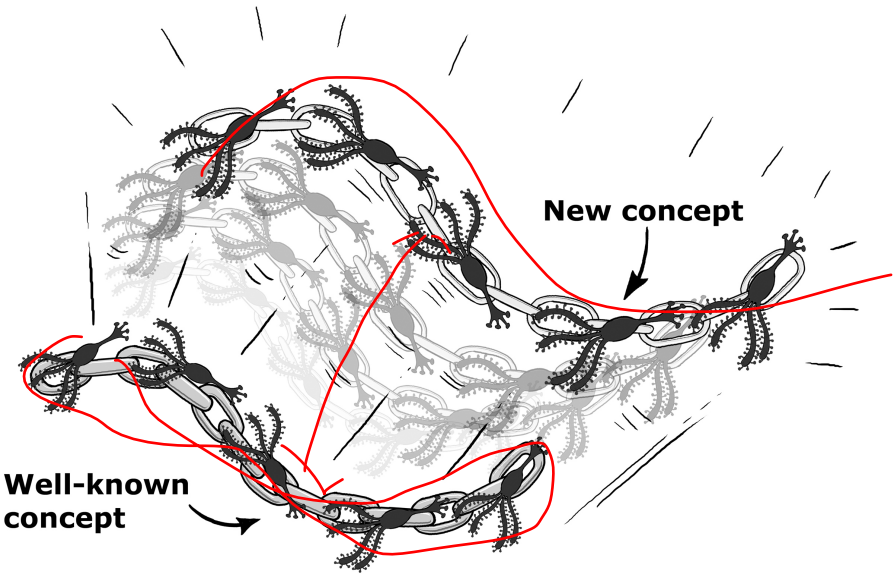
Whatever method you use to memorize, remember to strengthen those new sets of links by actively testing yourself over several days.

Metaphors

When you take a phenomenon you already know and use it to explain or understand a new concept, you're using a metaphor.* We've used a number of metaphors in this book, such as "sets of links" to explain how neurons form strong connections as you learn; or a "drone" to explain the diffuse mode.

A metaphor is a terrific way to simplify and grasp the essence of a topic. For example, programmers speak of stacks, queues, or trees. In biology, mitochondria are thought to be like batteries. And great literature is riddled with metaphors.

No metaphor is perfect, and you'll always find some parts of your metaphor that don't apply to your concept. For example, a drone will need to be charged regularly to continue flying, but the diffuse mode doesn't have the same need to be charged (well, unless you count sleep!). The point isn't to find the perfect metaphor, but to find one that works for the key aspects of the concept you're trying to understand. In the drone case, we wanted to highlight that the diffuse mode can allow your thoughts to easily move from one place to another, just like a drone.



Metaphors take sets of links you've developed for one concept, like a sponge, and use them to allow you to begin more rapidly building a set of links for the new concept, like wetlands. This approach relates to a concept in neuroscience known as "neural reuse theory," where sets of links developed for one concept can be reused to enable you to understand another.[8]

To think of a metaphor, simply ask yourself, "What does this remind me of or resemble?" Try describing the concept to a friend. It may take several failed attempts to come up with a good metaphor, but that's okay. The time you spend debugging possible metaphors is time spent thinking about difficult concepts that can allow you to understand them even better. Part of the value of a good metaphor is that it helps you to not only understand what a concept *is*—it also helps you to understand what a concept is *not*.

* * *

Memorization works great for information, but what if you have to learn to solve a numerical problem? What you need then isn't *memorization*—it's *internalization*. That's what we'll turn to next.

KEY TAKEAWAYS

FROM THE CHAPTER

- **Memory and understanding are connected.** Having key information memorized so you can readily call it to mind releases mental power and helps you work more easily at higher conceptual levels. It also allows you to form mental patterns involving the subject you're learning.
- **To memorize information, test yourself through active recall (retrieval practice), spacing out your practice over at least several days.** To speed things up, see if you can use memory tricks such as:
  - Acronyms
  - Sentences
  - Vivid images
  - Memory Palace
- **Metaphors are useful for allowing you to more quickly grasp new concepts.**

6

How to Gain Intuition and Think Fast

Can anything good come out of playing video games all day long? For Tyler "Ninja" Blevins, the answer is yes. Blevins is one of the world's most famous gamers. For him, gaming is a full-time job that reportedly earns him around $20 million a year from sponsors and followers. Blevins typically spends ten to twelve hours per day playing games, which he streams to his more than 20 million followers. So far in this book, we've mostly been focusing on how to learn information from books, videos, and lectures. But what about when you want to become an awesome gamer like Blevins? Or become an outstanding race car driver, translator, mathematician, writer, or musician? Although conscious understanding built on strong sets of neural links can help, it's still not enough to bring you to top levels of expertise.

In this chapter, we'll look at how you can enhance and broaden your learning by tapping into your brain's powerful, mysterious (you're mostly not even conscious of it!) *procedural learning system*.

Declarative Versus Procedural Learning

Here's a little surprise. Earlier, we described how, when you learn something, you're depositing sets of neural links in long-term memory. But

we skipped over the fact that there are two *completely different* ways you can deposit those sets of links.[1] One way uses the relatively quick-to-learn *declarative* learning system. This system is closely integrated with working memory, so you're mostly conscious of what you're learning (in other words, you can "declare" it). Most of the memory techniques we've learned so far in this book involve declarative memory.

But there is a second, equally important learning system: the procedural system. When you deposit sets of links through the procedural system, those links go into a different place in long-term memory than where you deposit links declaratively. It's like having two legs to stand on instead of just one. If you learn something using your declarative system, and then build on it by also using your procedural system (or vice versa), you have a much richer and deeper set of links for whatever you've learned.

Let's say you're learning how to serve a ball in tennis. In the beginning, you proceed consciously and declaratively by keeping your eye on the ball. When you first hit the ball, using your working memory to retrieve from declarative links the simple steps for hitting the ball, your serves are pretty bad.

But after lots of practice, serving the ball becomes an automatic procedure. This is because practice allowed you to place and strengthen "how to serve a tennis ball" links in the *procedural* areas of your long-term memory. When you draw on strong procedural links, your serve becomes smooth and natural.

For any given serve, once you decide consciously and declaratively (with the starting nudge of working memory), to serve a tennis ball, you begin to move your arm. The procedural system kicks in, and off the ball goes. Together, the declarative and procedural systems work hand in hand to give you a great serve.

For many decades, researchers thought that procedural learning only involved motor skills—like serving that tennis ball, kicking a football, playing the piano, or learning to type. Then researchers realized that the procedural system was also involved in habits, like putting your pants on before you put on your shirt in the morning, or nodding hello as you greet someone.

But now, researchers are discovering that the procedural and declarative systems work together in most kinds of learning, including writing,

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陈述性记忆

心理学领域中，根据不同标准对记忆有不同的分类。有研究者将记忆分成陈述性记忆（declarative memory）和程序性记忆（procedural memory）。

專家專欄

學習文法的策略

本文希望透過分享『學習文法的策略』，提供語言學習者借鏡。

許多的語言學習者常常苦於『明明知道文法規則』，卻不能『靈活運用這些文法規則在日常溝通』，本文希望能透過語言學習分析，找出可能的學習文法策略，以達事半功倍之效。

從認知科學的角度來看，我們可以把知識分為「陳述性知識」（declarative knowledge）和「程序性知識」（procedural knowledge），前者是核心知識，也就是「knowing what」，後者是執行知識的能力，也就是「knowing how」。「陳述性知識」（declarative knowledge）讓語言學習者可以描述目標語言的文法規則、在習題演練或填空練習時正確作答。另一方面，「程序性知識」（procedural knowledge）可以讓語言學習者有能力在真實的語言環境下，靈活運用目標語言的文法規則。

好比如：母語人士雖然無法清楚說出文法的規則，卻可以正確無誤的使用該語言。相對地則，但在口說或寫作時難免會出現一些常犯的錯誤。

3) Procedural learning

Is a more complex form of non-declarative learning. It includes learning and execution of motor and non-declarative cognitive skills. It occurs through trial -and- error practice.

****what is The neural system underlying procedural (implicit) learning?**

1) Frontal lobe (Sensorimotor cortex).
2) Basal ganglia (Tail of Cuadate nucleus).
3) Parital lobe. 4) Cerebellum (adaptation).

****what is The neural system underlying (explicit) learning?**

1) Frontal brain areas (supplementary motor area, prefrontal cortex).
2) Head of cuadate nucleus.
3) Hippocampus. 4) other medial temporal lobe structures.

Types of Learning 1/2

- Procedural Learning
  - Occurs without attention or conscious thought
    - Walking, swimming, riding a bike
  - Develops slowly through very high repetition
  - Expressed through improved performance on a task
  - Controlled by the cerebellum
    - Therefore ↑ performance is still possible in the absence of cortex (brain injury, dementia)

language, math, music, and, of course, video games. Unlike declarative learning, you're largely not aware of when you are learning through or using your procedural system.*

In essence, the procedural system is a black box—you can't see what's going on inside. The procedural system can receive input from your working memory (such as when you decide to try to serve a tennis ball), or input from what you sense (such as seeing a pothole ahead when riding a bicycle). But you are unaware of how the black box of the procedural system does its learning. All you know is whether you hit the baseball and it went to where you wanted it to go, or whether your bicycle glided smoothly around the pothole—or it crashed.

Despite its "black box" behavior, the procedural system can be extremely sophisticated—it can help you learn both simple and complex patterns without consciously thinking about them. Toddlers and children, with their exceptionally powerful procedural systems (their declarative systems don't come online until they grow older), pick up virtually their entire native language using their procedural system. Do you know how to solve a Rubik's Cube quickly? You're using your procedural system. Do you like to watch real-life surgeons in action on television? Their procedural systems play an important role in their expertise.

Well-developed links in your procedural system allow you to be lightning quick, even in stressful situations. These links involve not only actions such as serving a tennis ball, but also the ability to quickly see relationships such as 7 and 5 sum to 12 without having to think about them, or that a certain type of calculus problem requires taking a derivative. When you face a native speaker of the language you're studying, procedural links are also what enable you to speak comfortably and fluently, instead of finding yourself searching for words. Together, the speed and smooth confidence of the procedural system, coupled with the flexibility of the declarative system, can make you a learning force to be reckoned with.

Learn Using Both Systems

The declarative system is kind of humdrum. It learns best through step-by-step explanations. But the procedural system is unusual. It learns by

intuitively feeling out patterns. In fact, you often cannot explain what you've learned procedurally, or at least not very easily: try explaining how to tie shoelaces without resorting to "watch me."

Let's cut to a key point. It's not possible to flip a switch and consciously move back and forth between declarative and procedural learning. As we mentioned, the procedural system learns by developing a feel for patterns. That happens through practice—and lots of it, in a variety of situations. So let's look at several different subject areas to get a feel for how to best use practice to improve both your procedural *and* your declarative learning.

Use Your Procedural System to Improve Your Problem-Solving Intuition, Speed, and Confidence in Math and Science

It's relatively straightforward to learn math declaratively. Just follow the step-by-step procedure you've been taught to solve the problem, and you're done. But this straightforward approach does little to help build links in long-term memory through your *procedural* system. A much better approach is to internalize key, exemplar problems. This helps develop your intuitive, fast procedural system.

To internalize a problem, you should pick a problem where the complete worked solution (not just the numerical answer) is available— *but don't look at the solution or procedure explanations*. Listen to your internal voice instead—can you feel or intuit a whisper of your first step? (Remember, your procedural system often can't put what you're doing into words, as the declarative system can. But it can hint!)

KEY POINT

The way to develop your problem-solving intuition is to try to draw the solution from *inside yourself* when working problems. Only peek at the next step of the solution if you absolutely have to, and then make sure you practice the problem again later on to make sure you can do it all without peeking.

If you do get an intuition about what that first step is, great! Do it. If you don't get word from your intuition after trying hard, take a peek, and then

Is my sentence right: I've been in the trenches of education field for some 10 years.

Your sentence, "I've been in the trenches of the education field for some 10 years," is grammatically correct. It effectively communicates that you have been actively involved and experienced in the education field for approximately 10 years. The phrase "in the trenches" is a figurative expression often used to convey being deeply engaged, hands-on, and facing challenges in a particular field or profession.

do you think the trenches and field are redundant?

Yes, you are correct. The use of both "trenches" and "field" in the same sentence could be considered redundant since they convey a similar idea. "Trenches" metaphorically refers to being actively involved, facing challenges, and working hard in a specific field or profession. In this context, using just one of the terms would be sufficient to convey the intended meaning.

Here's a revised version of your sentence to remove the redundancy:

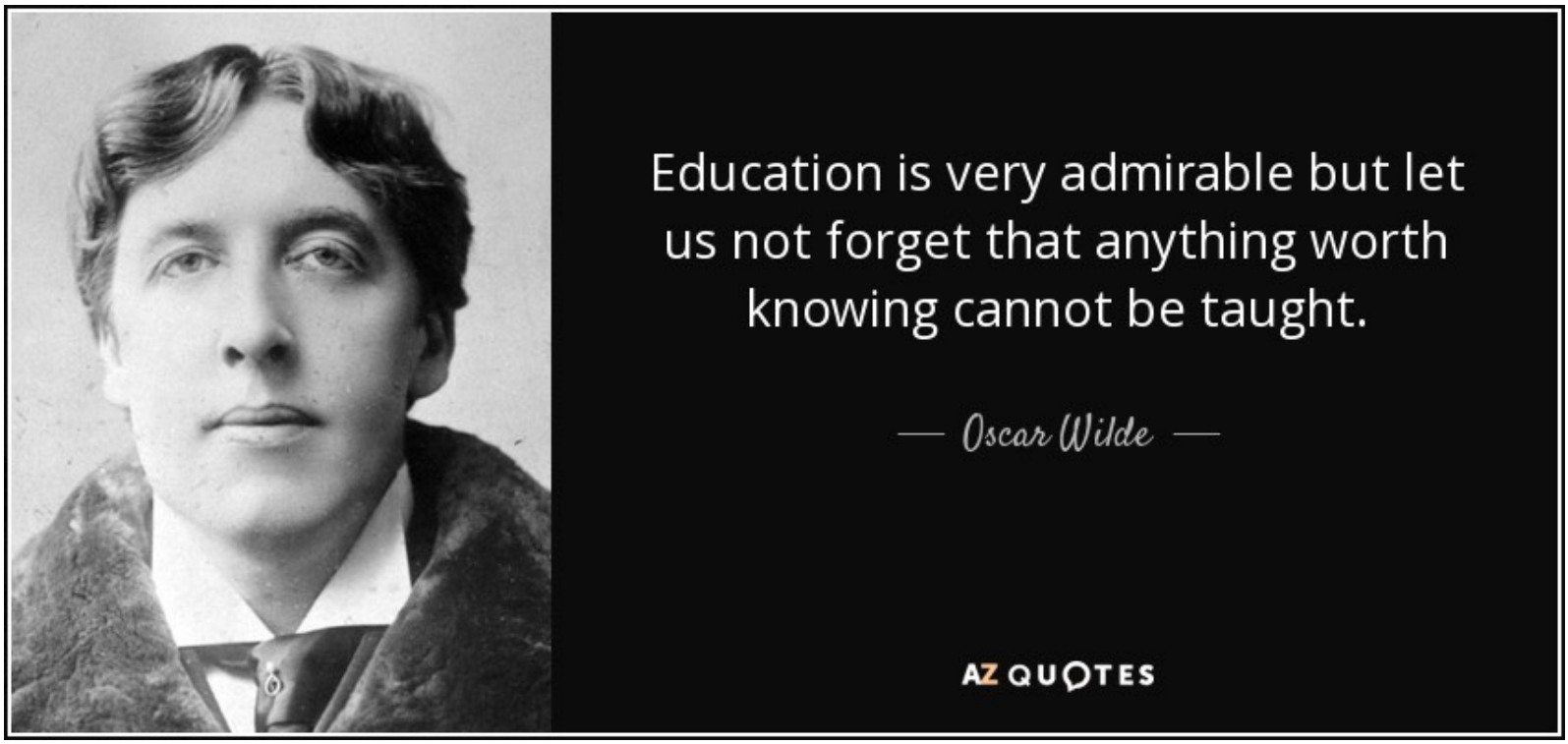
"I've been in the education field for some 10 years."

This revised sentence maintains the essence of your original statement while eliminating the redundancy.

how about "I've been in the trenches of education for some 10 years"? better off?

Yes, the revised sentence "I've been in the trenches of education for some 10 years" is concise and effective. It communicates that you have been actively involved and experienced in the field of education, facing challenges and working hard for approximately 10 years. The use of the phrase "in the trenches" adds a figurative element, emphasizing the hands-on and dedicated nature of your experience. Overall, it's a strong and impactful sentence.

什么是模仿能力？
模仿做什么，step by step
模仿思路，develop a feel for patterns



do the first step. Then try to do the next step on your own. And the next—all the way to the end of the problem. Only peek if you need to—and, of course, after you're done, to check that you've done the problem correctly.

If the material is difficult, you may find yourself taking a peek at virtually every step the first time you try to solve a problem—that's okay. Be sure to work the entire problem by writing it down—don't skip steps. Then try to work the problem again—hopefully without peeking until you are finished.

Here's an example, just to give you a sense of what we mean.

Problem-solving steps	**Examples of what you might be thinking as you look at each step. (As you advance further in math, you may not be able to verbalize the steps.)**
3(3 + x) = 21 + x	How can I simplify this? Oh yes—multiply the 3.
(3 × 3) + (3 × x) = 21 + x	Okay, just need to multiply the items inside the parentheses now.
9 + 3x = 21 + x	Hmm—how do I get the x's by themselves more? If I move the 9 right and single x left, that'll do the trick.
3x–x = 21−9	At this point, I just need to do the simple subtraction.
2x = 12	To get x entirely by itself, all I need to do is divide both sides by 2.
x = 12 / 2	This is simple math.
x = 6	I'm done!

Most students do not do this extra internalization practice, and it's a big mistake that differentiates pro learners from ordinary learners.[2] Once you've internalized the problem you've selected, and several other problems that share resemblances and differences—with the first, your brain begins to develop an intuition for how to solve these kinds of problems.[3] That's your procedural system in action!

In other words, as your brain internalizes seemingly simple but important procedures like "get rid of the parentheses" and "group the *x* variables on one side and numbers on the other," you begin to develop a deeper sense of the patterns involved in this and related types of problem-solving. This deeper, broader pattern sense can allow you to tackle

problems even if the problems might seem superficially quite different from anything you've solved before.

This means, to develop your problem-solving intuition, you should internalize different types of problems, each over several days, until the solutions flow out easily with no peeking. (You don't need to wait to internalize one problem completely before you begin internalizing others.) Eventually, you should be able to just look at a given problem and step quickly through the various parts of the solution procedure in your mind, almost as if it were a song.

Don't be surprised if, the first day you try to internalize a problem, you feel it's just too hard. When you try again the next day, you'll be surprised at how much easier it is. And by the third day, it will start feeling natural—even, yes, intuitive!

You can quickly check your answers in math using a website like WolframAlpha or Mathway. Just enter what you want to calculate or know about, and AI technology will get you to the solution.

Remember, though, that you *can't* always look it up—you need a solid internal structure so you have an intuitive understanding of what's behind the computations.

Start Interleaving

The next strategy to use with your internalization technique is *interleaving*—that approach where you alternate different types of problems—for example, alternating module 3 problems with module 7 problems.[4] If you build interleaving practice into your internalization studies, you're laying a solid neural foundation. This will help you create sets of links about how to use specific techniques. It will also show you how those links relate to other sets of links involved in other techniques. You're allowing your procedural system to do one of the things it does best—detect different patterns. Later, on tests, you will find you have a natural, faster intuition about which technique or concept to bring into play.

What Should You Internalize?

15:44

实在找不到问的人了只好打扰老师了。。求问这句怎么翻译啊。。

如何翻译?

1) 翻译的前提是理解，哪里没有理解呢？先找到问题

2) 理解需要了解语境，熟悉词汇和语法。

3) 语境不充分怎么办?

4) 词汇和语法有盲点怎么办?

5) 有没有现成的翻译可参考?

6) 有什么人/工具可以利用?

7) 我理解了吗？如何用我的话 paraphraze?

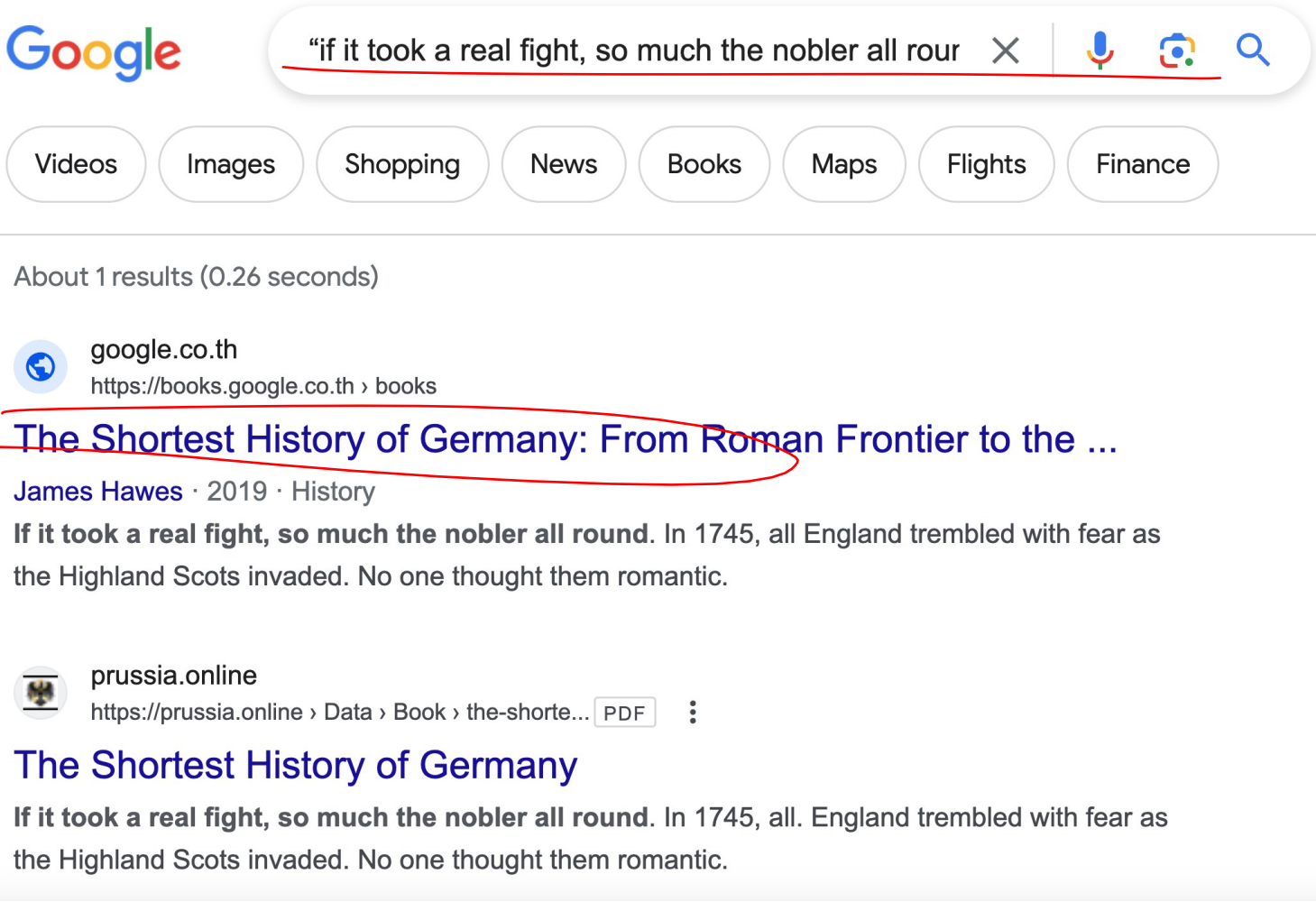
8) 需要什么样的翻译版本？目标读者是谁?

B U @ Cancel

barbarians, yes, but noble ones *uncorrupted by the temptations of public entertainments.*

Later patriots misread Tacitus's book as evidence that the Germans were never romanized. Actually, it means exactly the opposite. The Romans, like many later imperialists, liked nothing better than to read about wild and noble tribesmen on their frontiers—once they'd been beaten. If it took a real fight, so much the nobler all round. In 1745, all England trembled with fear as the Highland Scots invaded. No one thought them romantic. But once they'd been smashed at Culloden, the British Army almost immediately began using them as shock troops, and the English public fell in love with tales of their

unspoiled, natural bravado. So it was with the Romans and Germans in 100 AD. The last serious rebellion in *Germania* had been in 69–70 AD, and that was only because Rome's crack German troops had felt insulted at the disbanding of the imperial



The Noble Savage Germans

The most famous Roman account of the early Germans is the historian Tacitus's *Germania* (c. 103 AD). Like Caesar, Tacitus cast the Germans as the opposite of the Romans. But for him this was no bad thing, since he claimed the Romans had degenerated into a people made soft by vice and luxury, who merely groveled to their emperors. The Germans were barbarians, yes, but noble ones *uncorrupted by the temptations of public entertainments*.

Later patriots misread Tacitus's book as evidence that the Germans were never romanized. Actually, it means exactly the opposite. The Romans, like many later imperialists, liked nothing better than to read about wild and noble tribesmen on their frontiers—once they'd been beaten. If it took a real fight, so much the nobler all round. In 1745, all England trembled with fear as the Highland Scots invaded. No one thought them romantic. But once they'd been smashed at Culloden, the British Army almost immediately began using them as shock troops, and the English public fell in love with tales of their unspoiled, natural bravado. So it was with the Romans and Germans in 100 AD. The last serious rebellion in *Germania* had been in 69–70 AD, and that was only because Rome's crack German troops had felt insulted at the disbanding of the imperial bodyguard, the *cohors Germanorum*. Roman readers in Tacitus's day could safely enjoy tales of their very own wild *Germani*.

我可以这样理解吗：罗马人对自己的手下败将有崇拜之情？

可以这样理解，尽管罗马人在战争中战胜了某个部落或族群，但他们有时会对这些被击败的部落或族群抱有崇拜之情。这种崇拜可能源于被击败者在战斗中表现出的英勇和坚韧，或者他们所代表的文化和价值观与罗马人所欣赏的有所不同。罗马人可能会将被击败者的形象浪漫化，将他们描绘成高贵、纯洁或勇敢的人物，并因此对他们心生敬慕。这种崇拜还可能是对罗马人自身的一种反思，让他们重新审视自己的价值观和行为。

然而，需要注意的是，这种崇拜往往是建立在罗马人取得胜利的基础上的。罗马人之所以能够对被击败者产生崇拜，是因为他们已经战胜了他们并确立了自己的统治地位。这种崇拜往往是在一种权力关系的背景下发生的，而被击败者可能会被罗马人利用为一种象征、宣传工具或者作为其他目的的手段。

因此，虽然罗马人可能对手下的败将产生一定程度的崇拜，但这种崇拜是建立在胜利的基础上，并且通常是出于复杂的动机和目的。

16:47

在我看来，如何翻译并不重要，你知道了如何翻译也没什么帮助。重点可能不是某一句话，而是整个篇章的内容和结构。这样的问题你可以去问问chatgpt，比如某个人我觉得会更高效。

based on this passage, translate " If it took a real fight, so much the nobler all round." into Chinese and explain: The Noble Savage Germans
The most famous Roman account of the early Germans is the historian Tacitus's Germania (c. 103 AD). Like Caesar, Tacitus cast the Germans as the opposite of the Romans. But for him this was no bad thing, since he claimed the Romans had degenerated into a people made soft by vice and luxury, who merely groveled to their emperors. The Germans were barbarians, yes, but noble ones uncorrupted by the temptations of public entertainments. Later patriots misread Tacitus's book as evidence that the Germans were never romanized. Actually, it means exactly the opposite. The Romans, like many later imperialists, liked nothing better than to read about wild and noble tribesmen on their frontiers-once they'd been beaten. If it took a real fight, so much the nobler all round. In 1745, all England trembled with fear as the Highland Scots invaded. No one thought them romantic. But once they'd been smashed at Culloden, the British Army almost immediately began using them as shock troops, and the English public fell in love with tales of their unspoiled, natural bravado. So it was with the Romans and Germans in 100
AD. The last serious rebellion in Germania had been in 69-70 AD, and that was only because Rome's crack German troops had felt insulted at the disbanding of the imperial bodyguard, the cohors Germanorum. Roman readers in Tacitus's day could safely enjoy tales of their very own wild Germani.

如果需要进行一场真正的战斗，那么对所有人来说都更加高贵。

Translation: 如果需要进行一场真正的战斗，那么对所有人来说都更加高贵。

Explanation: 这句话的意思是，如果在征服过程中需要经历一场真正的战斗，那么无论对谁来说都会增添更多的崇高感。在这段文字中，这句话强调了对于罗马人来说，与野蛮而高贵的部落民族进行真正的战斗是一种尊贵的经历，这样的战斗可以增加他们的威望和荣誉感。

How do you know what material is best to internalize? A great place to start is with the example problems that are worked out step by step in a textbook. They may seem easy, but they are often trickier than they first appear, and they usually demonstrate important concepts. Problems your instructor has worked out, as well as practice questions from old tests, are also great to internalize—that is, if you know that the solutions are correct. (As we mentioned earlier, taking practice tests is a great way to prepare for tests.[5]) The broader your pool of internalized problems, the easier you will find it to see analogies and transfer your skills to other, more distantly related areas.[6]

Use Your Procedural System to Improve Your Foreign-Language Studies

As a child, you naturally used your procedural system to learn to speak your native language. But as you grew older, you began to rely more on your flexible, fast-learning declarative learning system. When it comes to learning a second language, however, that reliance on declarative learning is both good and bad.[7]

The declarative system can allow you to easily learn new vocabulary words and to quickly learn the patterns for verb conjugations or noun declensions. The problem is, when you find yourself in front of a native speaker, you often struggle. This can happen because you have put the links of learning in your slower-to-retrieve-from declarative memory. You haven't yet deposited sets of links in your *procedural system*. And it's the procedural links that give you easy, natural fluency in a language. The more you're able to develop your procedural links when learning a specific language, the more fluent your language skills become.

The Value of Retrieval Practice, Spaced Repetition, and Interleaving

No surprise, language learning needs a lot of retrieval practice—additional repetitions of retrieval practice almost always improve your ability to learn and retain the material. But realistically, there are only so many hours in a

day and you're probably facing a deluge of new vocabulary words. So what's the optimal time for you to space out your repetitions? Minutes, days, weeks, or months?

Probably the most important question to ask yourself is how long you want to remember the material. If you have a test in a week, repeat the material each day for a week. If you want to remember it for a year, review it once every three weeks.[8] Once you're comfortable that you've got a word or phrase down, put the next repetition further out—expand the spacing gap. And remember that sleep and brief periods of mental relaxation help.[9]

Of course, interleaving and spaced repetition are also important—they improve not only declarative, but also procedural learning. When it comes to language learning, interleaving means *mix it up*! Don't just study static lists of vocabulary words written on a page. Instead, create either electronic or handwritten flashcards and shuffle them, so they're always in a different order. If you're studying three verb tenses over three weeks, don't just study one verb tense, and then the next and the next (textbooks and teachers love to do it this way). Instead, give yourself a chance to roughly grasp each tense as it is presented. Then, as soon as possible, start mixing up the tenses. This approach is harder and more confusing at first, but you'll learn better.

The best form of interleaving is to speak with a native speaker. You never know what words and sentences are going to be lobbed at you, or in what order. Start practicing with a native speaker as early and as much as possible in your studies, mistakes be damned. Get onto a website like italki and exchange conversations for free or hire a tutor. Remember that classroom instruction tends to emphasize declarative learning, whereas immersion (or as near as you can get to immersion) will help build your procedural system.

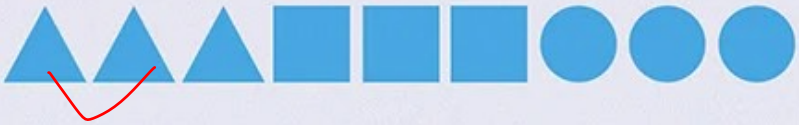
Sometimes people feel that they simply aren't capable of learning a new language. Often, they really could learn the language—it's just that the declarative approaches used in classrooms don't necessarily work well for those who tend to lean on their procedural learning system. For these more procedural types, diving into the deep end of the pool and speaking with native speakers from the very beginning, going back to look things up in books when necessary, can be a good approach.

WHY INTERLEAVING WORKS

by @Inner_Drive
innerdrive.co.uk

What it is:

Blocking



Blocking involves doing topic 1, then topic 2, then topic 3.

Interleaving

Interleaving involves mixing up topics within a subject.

Why it works:

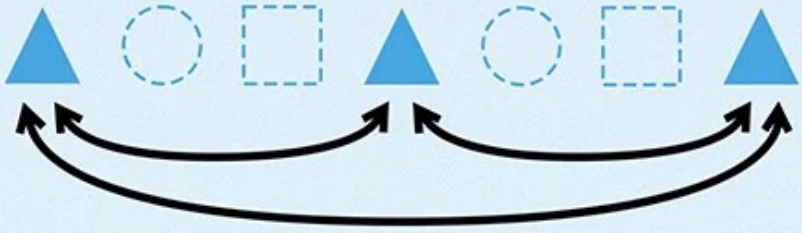
1. Discrimination learning: Spotting **differences between similar things**

When students think about differences, we prompt them to think harder. Contrasting information is more likely to stick in our mind.

2. Involves remembering **similarities between different things**

By highlighting similarities between different things, we provide more "anchor points" for students to hook new information onto.

3. Involves the **benefits of spacing**



Each time the information is revisited, it helps ingrain and cement it into our long-term memory.

GOOD LANGUAGE-LEARNING SOURCES

- Duolingo (an app that teaches you vocabulary, phrases, and sentences)
- Busuu (another language learning app)
- italki (a video chat platform that connects you to native speakers)
- Preply (a video chat platform similar to italki)
- Yabla (a platform with captioned videos that allows you to slow the speaking speed and break the video into small, easily repeated sections)
- FluentU (a platform much like Yabla, with a somewhat different selection of languages)

Use Gestures to Help You Remember Words 

Intriguing research has shown that making a meaningful gesture while learning a new word in a foreign language can help you remember and understand that word better.[10] For example, if you're learning the word for "write" in another language, you might say "write" in the new language as your hands make a writing motion. If you're learning the word for "high," you might move your right hand up above your head. As you "drink," you would move your hand as if drinking from a cup. These gestures seem to help bind the sound of the word to its actual meaning.

Improving Your Writing and Artistic Skills

Famous statesman Benjamin Franklin used a special technique to improve his writing. Is it a declarative or procedural technique? We think it's a bit of both. In any case, it works.

To use the "Franklin approach," find writing you admire. Take a paragraph and jot a word or two down to remind yourself of the key ideas of each sentence. Then use those key words as hints to see if you can re-create the sentence. Check your sentence against the original and see which one is better. Does the original have better vocabulary? Better prose? If it does, you've just learned how you can improve your writing. Notice—you're not just memorizing other people's writing. You're actively beginning to build your *own* sets of links about how to write well. Eventually, using this technique, you will discover ways you can write better than the originals you're learning from.

Of course, this technique can work not only for writing, but also for art, language study, and other creative endeavors.

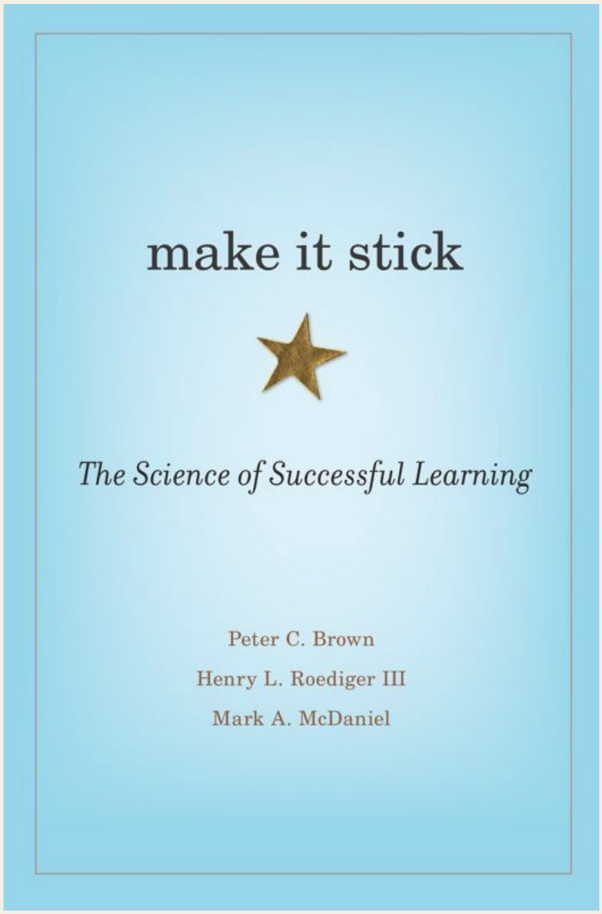
★ ★ ★

Knowing the best way to learn something will help you to learn it better and more quickly. But what if you'd rather play Fortnite (like Blevins) than completing your study assignment? To address this problem, we turn next to the critical role of self-discipline.

KEY TAKEAWAYS

FROM THE CHAPTER

- Your brain has two pathways to store information in long-term memory. The declarative pathway helps you to get started with learning difficult topics or skills. The procedural system helps you to handle those topics or skills more quickly and intuitively.
- **Practice, especially spaced repetition and interleaving, helps you develop procedural sets of links in long-term memory.**
- **Internalize the procedures for solving scientific or mathematical problems** to help develop your intuition. Use interleaving to ensure you understand the differences between different types of problems.



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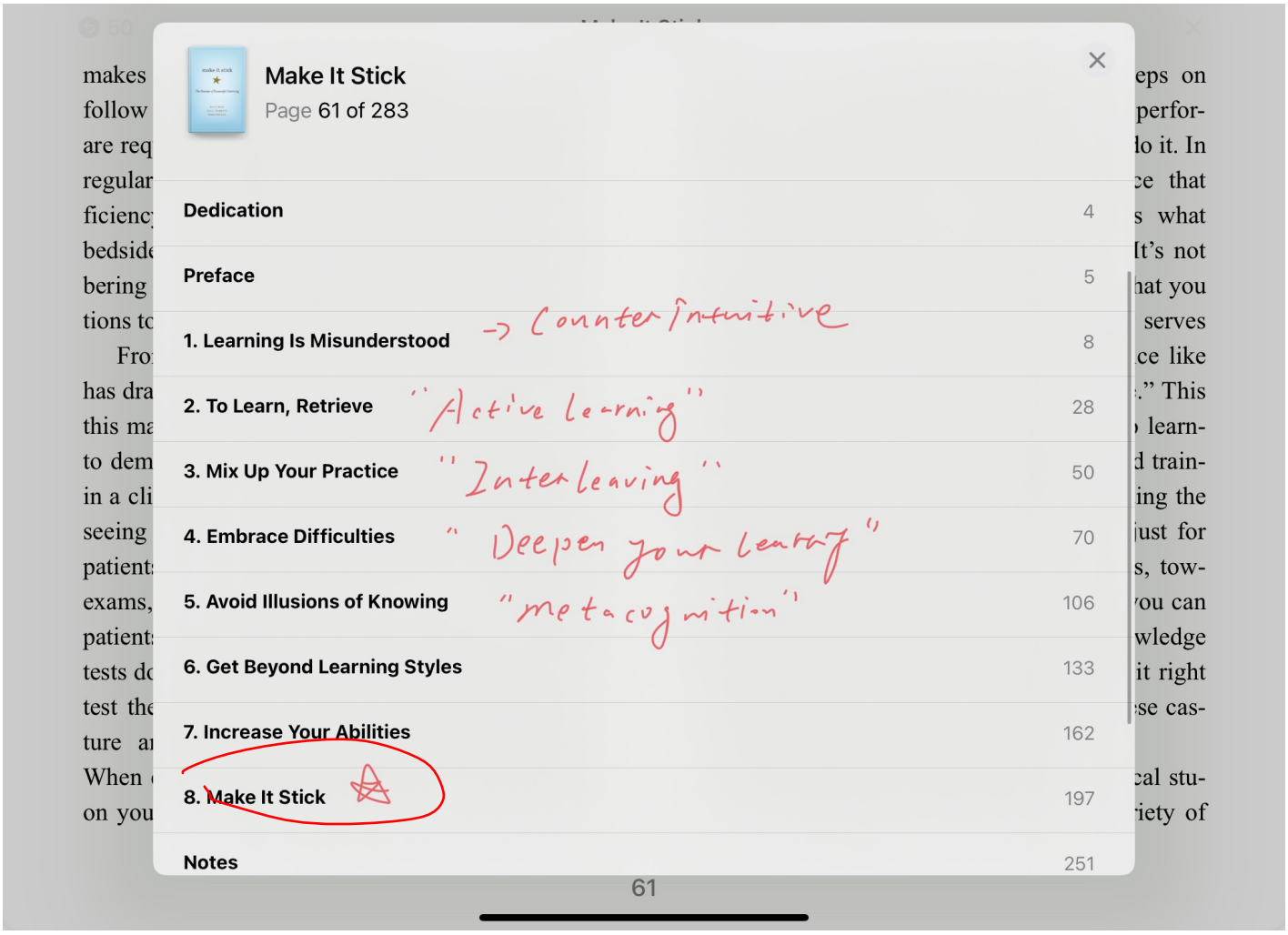

The Takeaway

For the most part, we are going about learning in the wrong ways, and we are giving poor advice to those who are coming up behind us. A great deal of what we think we know about how to learn is taken on faith and based on intuition but does not hold up under empirical research. Persistent illusions of knowing lead us to labor at unproductive strategies; as recounted in Chapter 3, this is true even of people who have participated in empirical studies and seen the evidence for themselves, firsthand. Illusions are potent persuaders. One of the best habits a learner can instill in herself is regular self-quizzing to recalibrate her understanding of what she does and does not know. Second Lieutenant Kiley Hunkler, a 2013 graduate of West Point and winner of a Rhodes Scholarship, whom we write about in Chapter 8, uses the phrase "shooting an azimuth" to describe how she takes practice tests to help refocus her studying. In overland navigation, shooting an azimuth means climbing to a height, sighting an object on the horizon in the direction you're traveling, and adjusting your compass heading to make sure you're still gaining on your objective as you beat through the forest below.

The good news is that we now know of simple and practical strategies that anybody can use, at any point in life, to learn better and remember longer: various forms of retrieval practice, such as low-stakes quizzing and self-testing, spacing out practice, interleaving the practice of different but related topics or skills, trying to solve a problem before being taught the solution, distilling the underlying principles or rules that differentiate types of problems, and so on. In the chapters that follow we describe these in depth. And because learning is an iterative process that requires that you revisit what you have learned earlier and continually update it and connect it with new knowledge, we circle through these topics several times along the way. At the end, in Chapter 8, we pull it all together with specific tips and examples for putting these tools to work.

fate, the better the story stays with you. Likewise, if you're trying to learn an abstraction, like the principle of angular momentum, it's easier when you ground it in something concrete that you already know, like the way a figure skater's rotation speeds up as she draws her arms to her chest.

People who learn to *extract the key ideas from new material and organize them into a mental model* and connect that model to prior knowledge show an advantage in learning complex mastery. A mental model is a mental representation of some external reality.[1] Think of a baseball batter waiting for a pitch. He has less than an instant to decipher whether it's a curveball, a changeup, or something else. How does he do it? There are a few subtle signals that help: the way the pitcher winds up, the way he throws, the spin of the ball's seams. A great batter winnows out all the extraneous perceptual distractions, seeing only these variations in pitches, and through practice he forms distinct mental models based on a different set of cues for each kind of pitch. He connects these models to what he knows about batting stance, strike zone, and swinging so as to stay on top of the ball. These he connects to mental models of player positions: if he's got guys on first and second, maybe he'll sacrifice to move the runners ahead. If he's got men on first and third and there is one out, he's got to keep from hitting into a double play while still hitting to score the runner. His mental models of player positions connect to his models of the opposition (are they playing deep or shallow?) and to the signals flying around from the dugout to the base coaches to him. In a great at-bat, all these pieces come together seamlessly: the batter connects with the ball and drives it through a hole in the outfield, buying the time to get on first and advance his men. Because he has culled out all but the most important elements for identifying and responding to each kind of pitch, constructed mental models out of that learning, and connected those models to his mastery of the other essential elements of this complex game, an expert player has a better chance of scoring runs than a less experienced one who cannot

The Takeaway

Practice at retrieving new knowledge or skill from memory is a potent tool for learning and durable retention. This is true for anything the brain is asked to remember and call up again in the future—facts, complex concepts, problem-solving techniques, motor skills.

Effortful retrieval makes for stronger learning and retention. We're easily seduced into believing that learning is better when it's easier, but the research shows the opposite: when the mind has to work, learning sticks better. The greater the effort to retrieve learning, provided that you succeed, the more that learning is strengthened by retrieval. After an initial test, *delaying subsequent retrieval practice* is more potent for reinforcing retention than immediate practice, because delayed retrieval requires more effort.

Repeated retrieval not only makes memories more durable but produces knowledge that can be retrieved more readily, in more varied settings, and applied to a wider variety of problems.

While cramming can produce better scores on an immediate exam, the advantage quickly fades because there is much greater forgetting after rereading than after retrieval practice. The benefits of retrieval practice are *long-term.*

Simply including one test (retrieval practice) in a class yields a large improvement in final exam scores, and gains continue to increase as the frequency of classroom testing increases.

Testing doesn't need to be initiated by the instructor. Students can practice retrieval anywhere; no quizzes in the classroom are necessary. Think flashcards—the way second graders learn the multiplication tables can work just as well for learners at any age to quiz themselves on anatomy, mathematics, or law. Self-testing may be unappealing because it takes more effort than rereading, but as noted already, the greater the effort at retrieval, the more will be retained.

Students who take practice tests have *a better grasp of their progress* than those who simply reread the material. Similarly, such testing enables

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The Takeaway

Here's a quick rundown of what we know today about massed practice and its alternatives. Scientists will continue to deepen our understanding.

We harbor deep convictions that we learn better through single-minded focus and dogged repetition, and these beliefs are validated time and again by the visible improvement that comes during "practice-practice-practice." But scientists call this heightened performance during the acquisition phase of a skill "momentary strength" and distinguish it from "underlying habit strength." The very techniques that build habit strength, like spacing, interleaving, and variation, slow visible acquisition and fail to deliver the improvement during practice that helps to motivate and reinforce our efforts.[12]

Cramming, a form of massed practice, has been likened to binge-and-purge eating. A lot goes in, but most of it comes right back out in short order. The simple act of spacing out study and practice in installments and allowing time to elapse between

quiz, suddenly you *have* to do it, there's an expectation, you can't cheat, you can't take mental shortcuts around it, you simply have to do that."

The nine quizzes Andy Sobel administers over the twenty-six meetings of his political economics course are a simple example of spaced retrieval practice, and of interleaving—because he rolls forward into each successive quiz questions pertaining to work from the beginning of the semester.

Interleaving two or more subjects during practice also provides a form of spacing. Interleaving can also help you develop your ability to *discriminate* later between different kinds of problems and select the right tool from your growing toolkit of solutions.

In interleaving, you don't move from a complete practice set of one topic to go to another. You *switch before each practice is complete.* A friend of ours describes his own experience with this: "I go to a hockey class and we're learning skating skills, puck handling, shooting, and I notice that I get frustrated because we do a little bit of skating and just when I think I'm getting it, we go to stick handling, and I go home frustrated, saying, 'Why doesn't this guy keep letting us do these things until we get it?' " This is actually the rare coach who understands that it's more effective to distribute practice across these different skills than polish each one in turn. The athlete gets frustrated because the learning's not proceeding quickly, but the next week he will be better at all aspects, the skating, the stick handling, and so on, than if he'd dedicated each session to polishing one skill.

Like interleaving, *varied practice* helps learners build a broad schema, an ability to assess changing conditions and adjust responses to fit. Arguably, interleaving and variation help learners reach beyond memorization to higher levels of conceptual learning and application, building more rounded, deep, and durable learning, what in motor skills shows up as underlying habit strength.

Something the researchers call *"blocked practice" is easily mistaken for varied practice*. It's like the old LP records that could only play their songs

Undesirable Difficulties

Elizabeth and Robert Bjork, who coined the phrase "desirable difficulties," write that difficulties are desirable because "they trigger encoding and retrieval processes that support learning, comprehension, and remembering. If, however, the learner does not have the background knowledge or skills to respond to them successfully, they become undesirable difficulties."[19] Cognitive scientists know from empirical studies that testing, spacing, interleaving, variation, generation, and certain kinds of contextual interference lead to stronger learning and retention. Beyond that, we have an intuitive sense of what kinds of difficulties are *undesirable* but, for lack of the needed research, we cannot yet be definitive.

Clearly, impediments that you cannot overcome are not desirable. Outlining a lesson in a sequence different from the one in the textbook is not a desirable difficulty for learners who lack the reading skills or language fluency required to hold a train of thought long enough to reconcile the discrepancy. If your textbook is written in Lithuanian and you don't know the language, this hardly represents a desirable difficulty. To be desirable, a difficulty must be something learners can overcome through increased effort.

Intuitively it makes sense that difficulties that don't strengthen the skills you will need, or the kinds of challenges you are likely to encounter in the real-world application of your learning, are not desirable. Having somebody whisper in your ear while you read the news may be essential training for a TV anchor. Being heckled by role-playing protestors while honing your campaign speech may help train up a politician. But neither of these difficulties is likely to be helpful for Rotary Club presidents or aspiring YouTube bloggers who want to improve their stage presence. A cub towboat pilot on the Mississippi might be required in training to push a string of high-riding empty barges into a lock against a strong side wind. A baseball player might practice hitting with a weight on his bat to strengthen his swing. You might teach a football

The Takeaway

Learning is at least a three-step process: initial *encoding* of information is held in short-term working memory before being consolidated into a cohesive representation of knowledge in long-term memory. *Consolidation* reorganizes and stabilizes memory traces, gives them meaning, and makes connections to past experiences and to other knowledge already stored in long-term memory. *Retrieval* updates learning and enables you to apply it when you need it.

Learning always builds on a store of prior knowledge. We interpret and remember events by building connections to what we already know.

Long-term memory capacity is virtually limitless: the more you know, the more possible connections you have for adding new knowledge.

Because of the vast capacity of long-term memory, having the ability to locate and recall what you know when you need it is key; your facility for calling up what you know depends on the *repeated use* of the information (to keep retrieval routes

strong) and on your establishing powerful *retrieval cues* that can reactivate the memories.

Periodic retrieval of learning helps strengthen connections to the memory and the cues for recalling it, while also weakening routes to competing memories. Retrieval practice that's easy does little to strengthen learning; the more difficult the practice, the greater the benefit.

When you recall learning from short-term memory, as in rapid-fire practice, little mental effort is required, and little long-term benefit accrues. But when you recall it after some time has elapsed and your grasp of it has become a little rusty, you have to make an effort to reconstruct it. This effortful retrieval both strengthens the memory but also makes the learning *pliable* again, leading to its *reconsolidation*. Reconsolidation helps update your memories with new information and connect them to more recent learning.

Repeated effortful recall or practice helps integrate learning into *mental models*, in which a set of interrelated ideas or a sequence of motor skills are fused into a meaningful whole that can be adapted and applied in later settings. Examples are the perceptions and manipulations involved in driving a car or in knocking a curveball out of the ballpark.

When practice conditions are varied or retrieval is interleaved with the practice of other material, we increase our abilities of *discrimination* and *induction* and the versatility with which we can apply the learning in new settings at a later date. Interleaving and variation build new connections, expanding and more firmly entrenching knowledge in memory and increasing the number of cues for retrieval.

Trying to come up with an answer rather than having it presented to you, or trying to solve a problem before being shown the solution, leads to better learning and longer retention of the correct answer or solution, even when your attempted response is wrong, so long as corrective feedback is provided.

Traditionally, IQ tests have been used to measure individuals' logical and verbal potential. These tests assign an Intelligence Quotient, which denotes the ratio of mental age to physical age, times 100. That is, an eight-year-old who can solve problems on a test that most ten-year-olds can solve has an IQ of 125 (10 divided by 8, times 100). It used to be thought that IQ was fixed from birth, but traditional notions of intellectual capacity are being challenged.

One countervailing idea, put forward by the psychologist Howard Gardner to account for the broad variety in people's abilities, is the hypothesis that humans have as many as eight different kinds of intelligence:

Logical-mathematical intelligence: ability to think critically, work with numbers and abstractions, and the like;

Spatial intelligence: three-dimensional judgment and the ability to visualize with the mind's eye;

Linguistic intelligence: ability to work with words and languages;

Kinesthetic intelligence: physical dexterity and control of one's body;

Musical intelligence: sensitivity to sounds, rhythms, tones, and music;

Interpersonal intelligence: ability to "read" other people and work with them effectively;

Intrapersonal intelligence: ability to understand one's self and make accurate judgments of one's knowledge, abilities, and effectiveness;

Naturalistic intelligence: the ability to discriminate and relate to one's natural surroundings (for example, the kinds of intelligence invoked by a gardener, hunter, or chef).

Gardner's ideas are attractive for many reasons, not the least because they attempt to explain human differences that we can observe but cannot account for with modern, Western definitions of intelligence with their focus on language and logic abilities. As with learning styles theory, the multiple intelligences model has helped educators to diver-

Be the one in charge. There's an old truism from sales school that says you can't shoot a deer from the lodge. The same goes for learning: you have to suit up, get out the door, and find what you're after. Mastery, especially of complex ideas, skills, and processes, is a quest. It is not a grade on a test, something bestowed by a coach, or a quality that simply seeps into your being with old age and gray hair.

Embrace the notion of successful intelligence. Go wide: don't roost in a pigeonhole of your preferred learning style but take command of your resources and tap all of your "intelligences" to master the knowledge or skill you want to possess. Describe what you want to know, do, or accomplish. Then list the competencies required, what you need to learn, and where you can find the knowledge or skill. Then go get it.

Consider your expertise to be in a state of continuing development, practice dynamic testing as a learning strategy to discover your weaknesses, and focus on improving yourself in those areas. It's smart to build on your strengths, but you will become ever more competent and versatile if you also use testing and trial and error to continue to improve in the areas where your knowledge or performance are not pulling their weight.

Adopt active learning strategies like retrieval practice, spacing, and interleaving. Be aggressive. Like those with dyslexia who have become high achievers, develop workarounds or compensating skills for impediments or holes in your aptitudes.

Don't rely on what feels best: like a good pilot checking his instruments, use quizzing, peer review, and the other tools described in Chapter 5 to make sure your judgment of what you know and can do is accurate, and that your strategies are moving you toward your goals.

Don't assume that you're doing something wrong if the learning feels hard. Remember that difficulties you can overcome with greater cognitive effort will more than repay you in the depth and durability of your learning.

Distill the underlying principles; build the structure. If you're an example learner, study examples two at a time or more, rather than one by one, asking yourself in what ways they are alike and different. Are the differences such that they require different solutions, or are the similarities such that they respond to a common solution?

Break your idea or desired competency down into its component parts. If you think you are a low structure-builder or an example learner trying to learn new material, pause periodically and ask what the central ideas are, what the rules are. Describe each idea and recall the related points. Which are the big ideas, and which are supporting concepts or nuances? If you were to test yourself on the main ideas, how would you describe them?

What kind of scaffold or framework can you imagine that holds these central ideas together? If we borrowed the winding stair metaphor as a structure for Bruce Hendry's investment model, it might work something like this. Spiral stairs have three parts: a center post, treads, and risers. Let's say the center post is the thing that connects us from where we are (down here) to where we want to be (up there): it's the investment opportunity. Each tread is an element of the deal that protects us from losing money and dropping back, and each riser is an element that lifts us up a notch. Treads and risers must both be present for the stairs to function and for a deal to be attractive. Knowing the scrap value of boxcars is a tread—Bruce knows he won't get less than that for his investment. Another tread is the guaranteed lease income while his capital is tied up. What are some risers? Impending scarcity, which will raise values. The like-new condition of the cars, which is latent value. A deal that doesn't have treads and risers will not protect the downside or reliably deliver the upside.

Structure is all around us and available to us through the poet's medium of metaphor. A tree, with its roots, trunk, and branches. A river. A village, encompassing streets and blocks, houses and stores and offices. The structure of the village explains how these elements are interconnected so that the village has a life and a significance that would not exist if these elements were scattered randomly across an empty landscape.

The Takeaway

It comes down to the simple but no less profound truth that *effortful learning changes the brain,* building new connections and capability. This single fact—that our intellectual abilities are not fixed from birth but are, to a considerable degree, ours to shape—is a resounding answer to the nagging voice that too often asks us "Why bother?" We make the effort because the effort itself extends the boundaries of our abilities. What we do shapes who we become and what we're capable of doing. The more we do, the more we can do. To embrace this principle and reap its benefits is to be sustained through life by a *growth mindset*.

And it comes down to the simple fact that the path to complex mastery or expert performance does not necessarily start from exceptional genes, but it most certainly entails *self-discipline, grit, and persistence*; with these qualities in healthy measure, if you want to become an expert, you probably can. And whatever you are striving to master, whether it's a poem you wrote for a friend's birthday, the concept of classical conditioning in psychology, or the second violin part in Hayden's Fifth Symphony, *conscious mnemonic devices* can help to organize and cue the learning for ready retrieval until sustained, deliberate practice and repeated use form the deeper encoding and subconscious mastery that characterize expert performance.

Remember that the most successful students are those who take charge of their own learning and follow a simple but disciplined strategy. You may not have been taught how to do this, but you *can* do it, and you will likely surprise yourself with the results.

Embrace the fact that significant learning is often, or even usually, somewhat difficult. You will experience setbacks. These are signs of effort, not of failure. Setbacks come with striving, and striving builds expertise. Effortful learning changes your brain, making new connections, building mental models, increasing your capability. The implication of this is powerful: Your intellectual abilities lie to a large degree within your own control. Knowing that this is so makes the difficulties worth tackling.

Following are three keystone study strategies. Make a habit of them and structure your time so as to pursue them with regularity.

Practice Retrieving New Learning from Memory

What does this mean? "Retrieval practice" means self-quizzing. Retrieving knowledge and skill from memory should become your primary study strategy in place of rereading.

How to use retrieval practice as a study strategy: When you read a text or study lecture notes, pause periodically to ask yourself questions like these, without looking in the text: What are the key ideas? What terms or ideas are new to me? How would I define them? How do the ideas relate to what I already know?

Many textbooks have study questions at the ends of the chapters, and these are good fodder for self-quizzing. Generating questions for yourself and writing down the answers is also a good way to study.

Set aside a little time every week throughout the semester to quiz yourself on the material in a course, both the current week's work and material covered in prior weeks.

Space Out Your Retrieval Practice

What does this mean? Spaced practice means studying information more than once but leaving considerable time between practice sessions.

How to use spaced practice as a study strategy: Establish a schedule of self-quizzing that allows time to elapse between study sessions. How much time? It depends on the material. If you are learning a set of names and faces, you will need to review them within a few minutes of your first encounter, because these associations are forgotten quickly. New material in a text may need to be revisited within a day or so of your first encounter with it. Then, perhaps not again for several days or a week. When you are feeling more sure of your mastery of certain material, quiz yourself on it once a month. Over the course of a semester, as you quiz yourself on new material, also reach back to retrieve prior material and ask yourself how that knowledge relates to what you have subsequently learned.

If you use flashcards, don't stop quizzing yourself on the cards that you answer correctly a couple of times. Continue to shuffle them into the deck until they're well mastered. Only then set them aside—but in a pile that you revisit periodically, perhaps monthly. Anything you want to remember must be periodically recalled from memory.

Another way of spacing retrieval practice is to interleave the study of two or more topics, so that alternating between them requires that you continually refresh your mind on each topic as you return to it.

What your intuition tells you to do: Intuition persuades us to dedicate stretches of time to single-minded, repetitive practice of something we want to master, the massed "practice-practice-practice" regime we have been led to believe is essential for building mastery of a skill or learning new knowledge. These intuitions are compelling and hard to distrust for two reasons. First, as we practice a thing over and over we often see our performance improving, which serves as a powerful reinforcement of this strategy. Second, we fail to see that the gains made during single-minded repetitive practice come from short-term memory and quickly fade. Our

Interleave the Study of Different Problem Types

What does this mean? If you're trying to learn mathematical formulas, study more than one type at a time, so that you are alternating between different problems that call for different solutions. If you are studying biology specimens, Dutch painters, or the principles of macroeconomics, mix up the examples.

How to use interleaved practice as a study strategy: Many textbooks are structured in study blocks: They present the solution to a particular kind of problem, say, computing the volume of a spheroid, and supply many examples to solve before moving to another kind of problem (computing the volume of a cone). Blocked practice is not as effective as interleaved practice, so here's what to do.

When you structure your study regimen, once you reach the point where you understand a new problem type and its solution but your grasp of it is still rudimentary, scatter this problem type throughout your practice sequence so that you are alternately quizzing yourself on various problem types and retrieving the appropriate solutions for each.

If you find yourself falling into single-minded, repetitive practice of a particular topic or skill, change it up: mix in the practice of other subjects, other skills, constantly challenging your ability to recognize the problem type and select the right solution.

Harking back to an example from sports (Chapter 4), a baseball player who practices batting by swinging at fifteen fastballs, then at fifteen curveballs, and then at fifteen changeups will perform better in practice than the player who mixes it up. But the player who asks for random pitches during practice builds his ability to decipher and respond to each pitch as it comes his way, and he becomes the better hitter.

What your intuition tells you to do: Most learners focus on many examples of one problem or specimen type at a time, wanting to master the type and "get it down cold" before moving on to study another type.

Why interleaved practice is better: Mixing up problem types and specimens improves

Other Effective Study Strategies

ELABORATION improves your mastery of new material and multiplies the mental cues available to you for later recall and application of it (Chapter 4).

What is it? Elaboration is the process of finding additional layers of meaning in new material.

For instance: Examples include relating the material to what you already know, explaining it to somebody else in your own words, or explaining how it relates to your life outside of class.

A powerful form of elaboration is to discover a metaphor or visual image for the new material. For example, to better grasp the principles of angular momentum in physics, visualize how a figure skater's rotation speeds up as her arms are drawn into her body. When you study the principles of heat transfer, you may understand conduction better if you imagine warming your hands around a hot cup of cocoa. For radiation, visualize how the sun pools in the den on a wintry day. For convection, think of the life-saving blast of A/C as your uncle squires you slowly through his favorite back-alley haunts of Atlanta. When you learned about the structure of an atom, your physics teacher may have used the analogy of the solar system with the sun as the nucleus and electrons spinning around like planets. The more that you can elaborate on how new learning relates to what you already know, the stronger your grasp of the new learning will be, and the more connections you create to remember it later.

Later in this chapter, we tell how the biology professor Mary Pat Wenderoth encourages elaboration among her students by assigning them the task of creating large "summary sheets." Students are asked to illustrate on a single sheet the various biological systems studied during the week and to show graphically and through key words how the systems interrelate with each other. This is a form of elaboration that adds layers of meaning and promotes the learning of concepts, structures, and interrelationships. Students who lack the good fortune to be in Wenderoth's class could adopt such a strategy for themselves.

GENERATION has the effect of making the mind more receptive to new learning.

What is it? Generation is an attempt to answer a question or solve a problem before being shown the answer or the solution.

For instance: On a small level, the act of filling in a missing word in a text (that is, generating the word yourself rather than having it supplied by the writer) results in better learning and memory of the text than simply reading a complete text.

Many people perceive their learning is most effective when it is experiential—that is, learning by doing rather than by reading a text or hearing a lecture. Experiential learning is a form of generation: you set out to accomplish a task, you encounter a problem, and you consult your creativity and storehouse of knowledge to try to solve it. If necessary you seek answers from experts, texts, or the Web. By wading into the unknown first and puzzling through it, you are far more likely to learn and remember the solution than if somebody first sat you down to teach it to you. Bonnie Blodgett, an award-winning gardener and writer, provides a strong example of generative learning in Chapter 4.

You can practice generation when reading new class material by trying to explain beforehand the key ideas you expect to find in the material and how you expect they will relate to your prior knowledge. Then read the material to see if you were correct. As a result of having made the initial effort, you will be more astute at gleaning the substance and relevance of the reading material, even if it differs from your expectation.

If you're in a science or math course learning different types of solutions for different types of problems, try to solve the problems before you get to class. The Physics Department at Washington University in St. Louis now requires students to work problems before class. Some students take umbrage, arguing that it's the professor's job to teach the solution, but the professors understand that when students wrestle with content beforehand, classroom learning is stronger.

REFLECTION is a combination of retrieval practice and elaboration that adds layers to learning

CALIBRATION is the act of aligning your judgments of what you know and don't know with objective feedback so as to avoid being carried off by the illusions of mastery that catch many learners by surprise at test time.

What is it? Everyone is subject to a host of cognitive illusions, some of which are described in Chapter 5. Mistaking fluency with a text for mastery of the underlying content is just one example. Calibration is simply the act of using an objective instrument to clear away illusions and adjust your judgment to better reflect reality. The aim is to be sure that your sense of what you know and can do is accurate.

For instance: Airline pilots use flight instruments to know when their perceptual systems are misleading them about critical factors like whether the airplane is flying level. Students use quizzes and practice tests to see whether they know as much as they think they do. It's worth being explicit here about the importance of answering the questions in the quizzes that you give yourself. Too often we will look at a question on a practice test and say to ourselves: Yup, I know that, and then move down the page without making the effort to write in the answer. If you don't supply the answer, you may be giving in to the illusion of knowing, when in fact you would have difficulty rendering an accurate or complete response. Treat practice tests as tests, check your answers, and focus your studying effort on the areas where you are not up to snuff.

MNEMONIC DEVICES help you to retrieve what you have learned and to hold arbitrary information in memory (Chapter 7).

What are they? "Mnemonic" is from the Greek word for memory, and mnemonic devices are like mental file cabinets. They give you handy ways to store information and find it again when you need it.

For instance: Here is a very simple mnemonic device that some schoolchildren are taught for remembering the US Great Lakes in geographic order, from east to west: Old Elephants Have Musty Skin. Mark Twain used mnemonics to teach his children the succession of kings and queens of England, staking the sequence and length of their reigns along the winding driveway of his estate, walking it with the children, and elaborating with images and storytelling. Psychology students at Bellerbys College in Oxford use mnemonic devices called memory palaces to organize what they have learned and must be prepared to expound upon in their A-level essay exams. Mnemonics are not tools for learning per se but for creating mental structures that make it easier to retrieve what you have learned.

Brief stories follow of two students who have used these strategies to rise to the top of their classes.

Michael Young, Medical Student

Michael Young is a high-achieving fourth-year medical student at Georgia Regents University who pulled himself up from rock bottom by changing the way he studies.

Young entered medical school without the usual foundation of premed coursework. His classmates all had backgrounds in biochemistry, pharmacology, and the like. Medical school is plenty tough under any circumstances, but in Young's case even more so for lack of a footing.

Tips for Lifelong Learners

The learning strategies we have just outlined for students are effective for anyone at any age. But they are centered around classroom instruction. Lifelong learners are using the same principles in a variety of less-structured settings.

In a sense, of course, we're all lifelong learners. From the moment we're born we start learning about the world around us through experimentation, trial and error, and random encounters with challenges that require us to recall what we did the last time we found ourselves in a similar circumstance. In other words, the techniques of generation, spaced practice and the like that we present in this book are organic (even if counterintuitive), and it's not surprising that many people have already discovered their power in the pursuit of interests and careers that require continuous learning.

Retrieval Practice

Nathaniel Fuller is a professional actor with the Guthrie Theater in Minneapolis. We took an interest in him after a dinner party where the Guthrie's renowned artistic director, Joe Dowling, on hearing of our work, immediately suggested we interview Fuller. It seems that Fuller has the capacity to so fully learn the lines and movements of a role for which he is understudy that he can go onstage at the last moment with great success, despite not having had the benefit of learning and rehearsing it in the normal way.

Fuller is a consummate professional of the stage, having refined his techniques for learning roles over many years. He is often cast in a leading role; at other times, he may play several lesser characters in a play while also understudying the lead. How does he do it?

When he starts with a new script, Fuller puts it into a binder, goes through it, and highlights all of his lines. "I figure out how much I've got to learn. I try to estimate how much I can learn in a day, and then I try to start early enough to get that learned."[3] Highlighting his