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How to Learn Anything Deeply

Have you ever studied hard for an important test—reread notes, reviewed concepts, highlighted key parts—yet struggled on the exam?

Knowing how the brain learns will help you succeed with tests, and also help you build knowledge and skills that last. But learning doesn't take place in a vacuum. Physical exercise and sleep can allow your brain to more readily absorb what you're studying. In this chapter, we'll put all these ideas together. Let's go!

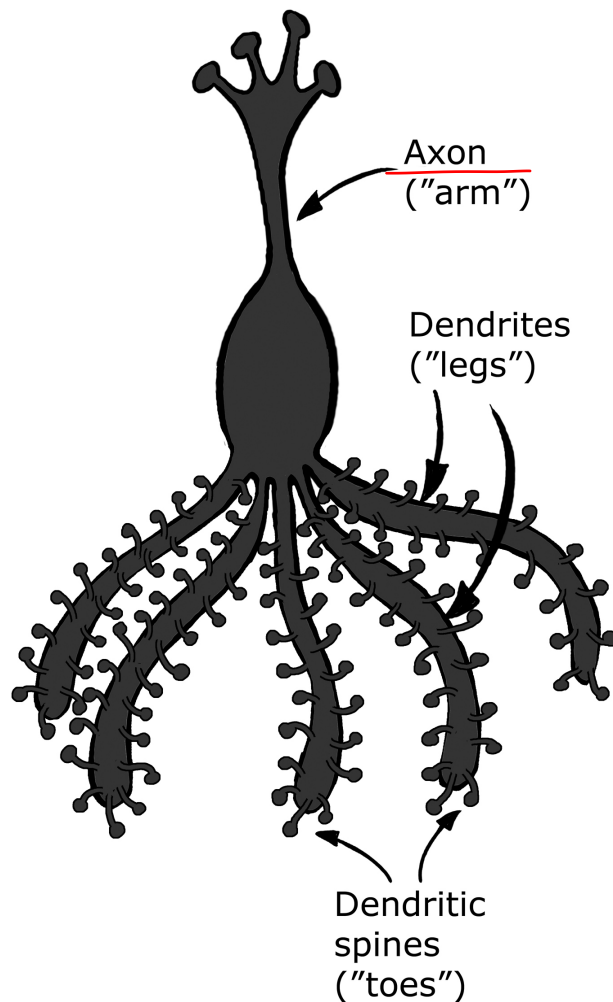
When You Learn, You Create Links

Whenever you learn something, you're simply connecting *neurons*—a basic “building block” cell in the brain. You have some 86 billion neurons—enough so you never need to worry about running out of capacity to learn.

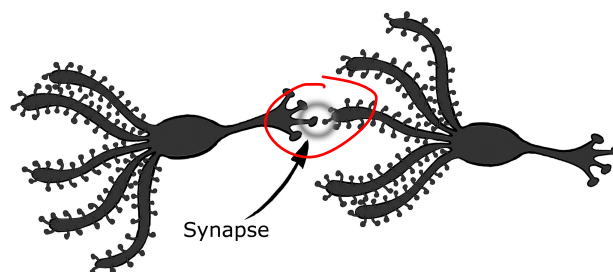
The connection point between two neurons is called a synapse. Just as a person can reach out with an arm to touch a toe on the leg of the next person, the “arm” (axon) of one neuron reaches out to touch the “toe” (a dendritic spine) of the next neuron.

New knowledge takes form in your brain because you have created a new set of links among a little group of neurons in your long-term memory.

This is true *whatever* you're learning—a new dance step, a new word in Latin, or a new mathematical concept.



Neurons are the brain's building blocks.

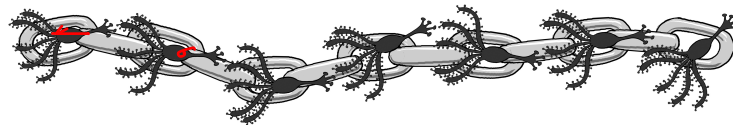


When you learn something, you form a link between neurons where the axon (the single arm) of one neuron snuggles up against the spine (a toe) of another neuron. This linking point is called a synapse.

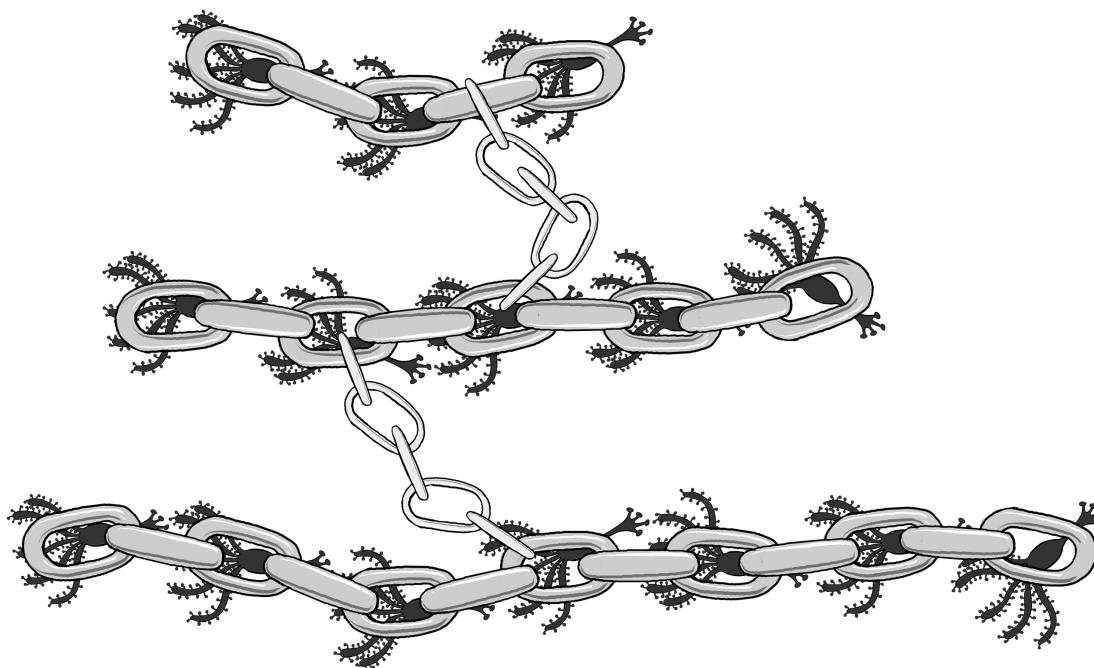


When you think about something you have already learned, such as how to solve a problem like 4×25 , or the Spanish word for “house,” or the meaning of the word “condensation,” signals travel between the neurons through the synapses you formed previously. Once you’ve learned something well, it’s easier to think about it because you’ve formed strong connecting pathways between neurons in your long-term memory. The more and stronger the neural connections, the better you have learned something. *→ repetition is —*.

When you learn something simple, you create a short set of links. As your learning grows more complex, the sets of links become much longer and more entangled with other links. So if you learn to play a chord on the guitar, you can think of your small bit of learning as creating a little set of links. But when you learn to play an entire song, you create a much bigger set of links. [Here’s another example: when you learn the definition of the word “metaphor,” you create a small set of links. But each time you see a new instance of a metaphor, you not only strengthen the set of links for the definition—you also make broader connections with other sets of links.]



The connected set of neurons here symbolizes something you’ve learned that’s stored in your long-term memory. Connected sets of neurons can remind us of sets of links (placed behind the neurons).



The more you practice, the thicker and stronger the neural connections become. Learning more complex information well also creates longer sets of links—you can see how a small piece of information has only a short set of links, symbolized by the three links at the top, while more complicated information creates longer and longer sets of links. As you learn more, you also discover the connections and differences between different concepts—these are shown by the light sets of links connecting the main “concept” links. The more sets of links and connecting links that you create through understanding and practice, the more expert you become. Of course, in real life, learning involves many more neurons and links than we are showing here!

For any subject, skill, or discipline, having “preformed” sets of links, created through practice in a variety of situations, can be invaluable. For example, if you’ve created broad, rich sets of links, you can find it much easier to solve math problems in a variety of contexts. Or you can express thoughts in a new language, draw a picture of whatever you see, or easily draw up an algorithm that does what you need.

Study Actively, Not Passively

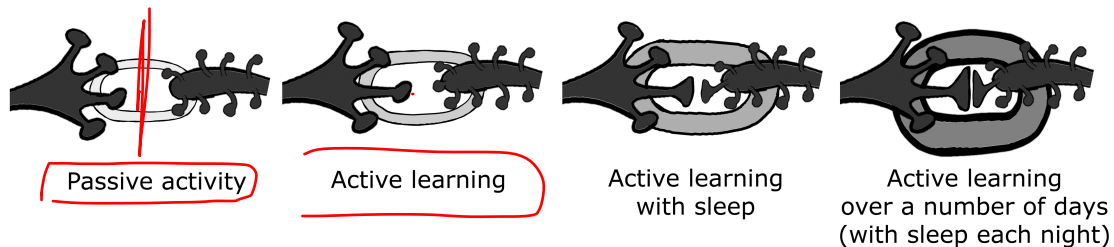


When you’re learning, it’s important to study *actively*, making your brain work hard or think hard. Don’t just look at a problem solution. Instead, actively work the problem yourself. Or try to remember the main points from a video you just watched, or a book section you’ve just read. The

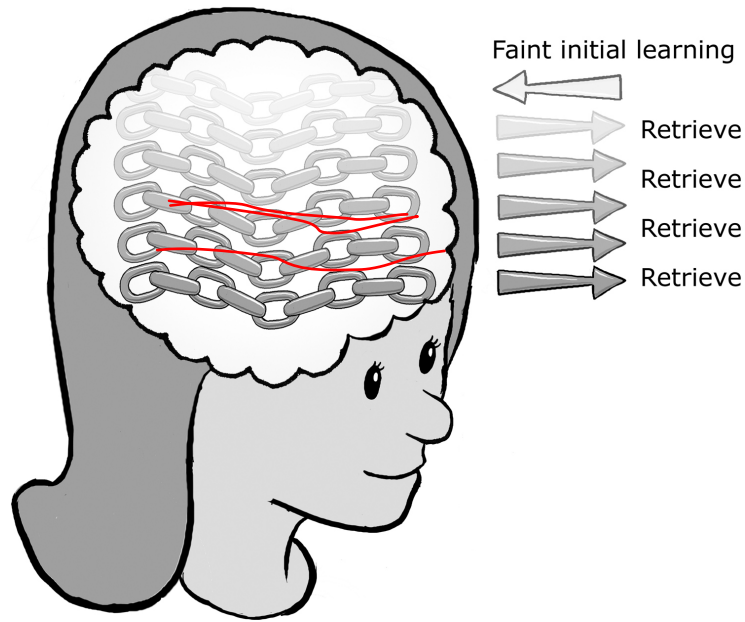
mental effort you spend will help pull spines out toward the axons so that strong neural links can form.¹ This linking process continues during sleep. *Passive learning*, on the other hand, such as effortless listening or reading, isn't very effective. Your neurons just sit still instead of sprouting new connections that form new links. (In case you wondered, passive learning might be thought of as an inefficient focused mode—don't confuse it with being in diffuse mode.) **It's important to note that if you've done your previous studies in an active fashion, this also reduces test anxiety.**²

→ At the heart of active learning lies something called “retrieval practice.” In other words, you want to see if you can pull information from your own memory, or work with it in your own mind, rather than simply looking at the material. The more you *retrieve* the material, and the broader the set of contexts you retrieve the materials in, the stronger and more broadly connected the neural links become.³

Oddly enough, the best way to put information *into* your long-term memory is to try to *retrieve* it from your own long-term memory instead of just looking at the answer.



When you *passively* glance at material, as on the left, you aren't encouraging new neural connections to form. However, when you *actively* work with the material, as with the three sets of neurons shown on the right, you're forcing new spines to emerge and connect with axons.⁴ The new strengthening connection is symbolized by the thickening and darkening link.



When you first learn something, it places a faint trace in your sets of links. The more you retrieve those sets of links, the more you strengthen them.

★ There's another reason why retrieval practice is so important. When you try to retrieve something from memory, you get feedback that tells you what you know well (the stuff you're easily able to retrieve) and what you need to spend more time on learning (what you cannot retrieve). This feedback also helps you evaluate whether you've been spending your time productively or if changes are needed in the way you study. Retrieval practice is therefore also a metacognitive strategy that helps you evaluate your own learning. We'll talk more about the vital importance of metacognition and other metacognitive strategies in the final chapter of this book.

↳ monitor
- & -
adjust

POPULAR DIGITAL FLASH CARD APPS

- Anki (Anki)
 - Quizlet (Quizlet)
 - Kahoot! (Kahoot!)
 - GoConqr (GoConqr)
 - StudyStack (StudyStack)
 - Brainscape (Brainscape)
-

General Techniques for Learning Actively

Here are some techniques that will help you approach your learning in an active way.

- Work out example problems *yourself*, without looking at the solutions. (If you have to peek partway through, after you finish the problem, go back and do the whole problem again.) 
- Try to recall the key points from a book, article, or paper. Look away and see if you can recall the key idea or ideas. If what you're reading is difficult, it's best to pause and try to recall after each page of what you're reading. 
- Formulate your own questions about the material. *→ 10-author*
- Take practice tests, preferably under time pressure that simulates the actual time constraints of the test.
- ☐ Find ways to re-explain key ideas from your notes or textbook in simpler terms, as if you're explaining them to a child.
- Work with others, either another person or a small group—meet and discuss the concepts, give mini-lectures, and compare approaches.
- Create flashcards, either by hand or using an app, such as Anki or Quizlet.
- Explain your thinking out loud to another person, or teach the key concepts to someone else.
- Ask a partner to quiz you. (The stress of being quizzed in front of a friend can mimic some of the stress of an actual quiz or test.)
- Take a practice test, even if you haven't studied much yet. (Guessing answers on practice questions has been shown to improve subsequent learning.)⁵
- Make your own practice test.

- Try to remember key points when you're doing mundane activities such as washing the dishes or going for a walk.

Challenge Yourself So You Can Advance More Quickly

Once you learn something, it feels good to practice it. It can feel so good that sometimes it tricks you. You can find yourself looking over older, easier stuff instead of digging deeper into the harder parts of the material. You can find yourself reviewing older vocabulary you've already learned in the new language you're expected to master, instead of tackling new words. Or you can find yourself practicing simple problems in data analysis instead of moving on to the more difficult materials, or singing a part of a song you already know instead of pushing on to the tougher part you haven't learned yet.

↳ You might think that reviewing older and easier stuff prevents your neural connections from withering. But often, when you push yourself to go deeper into the material, you're building on what you already know. In other words, even while you're building new connections, you're still practicing with the older ones. **So if you want to advance quickly in your learning, you need to continue forming new connections in long-term memory, and not just reinforce the connections you've already made. This means it's important to keep pushing yourself every day with harder material.**⁶

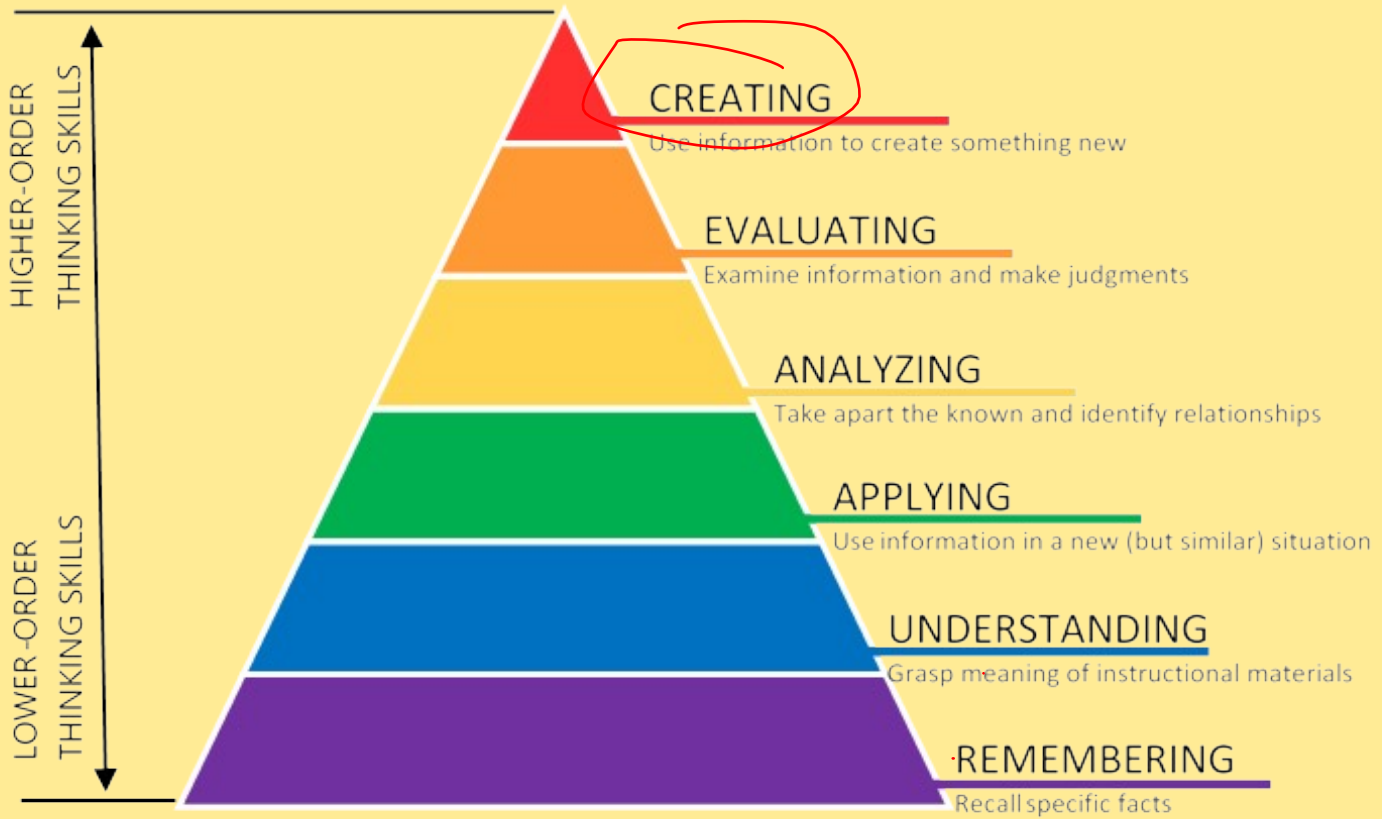
“持续学习是最好的复习”
How? { 学习 → 思考 → 阅读 → 写作 →

How to Deepen Your Learning

To learn difficult concepts well, it isn't enough to simply recall dates, definitions, and facts. You'll need a deep understanding that allows you to explain, synthesize, analyze, and apply the concepts in novel situations. You cannot do this by simply memorizing (although as we discuss in chapter 5, some memorization can be helpful). [To develop a profound understanding of what you're learning, it's important to actively connect what you're learning to other material you're learning or already know.] Your neural sets

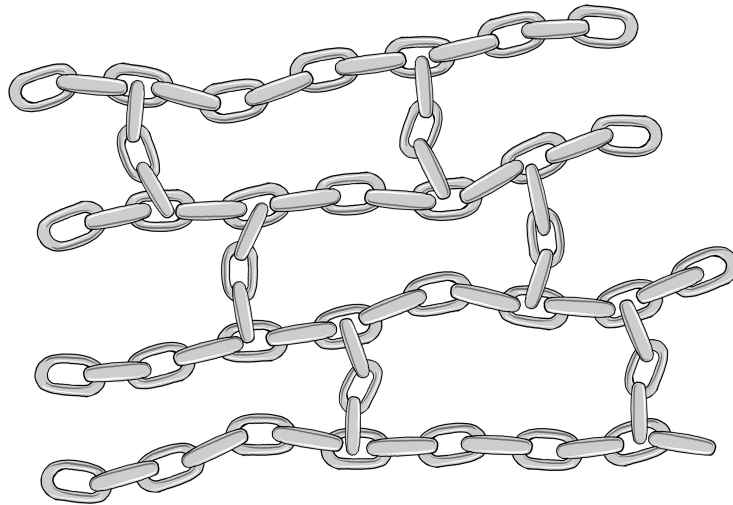


BLOOM'S TAXONOMY – COGNITIVE DOMAIN (2001)



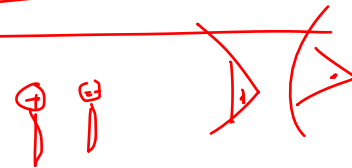
Remember	Understand	Apply	Analyze	Evaluate	Create
Retrieving relevant knowledge from long-term memory.	Determining the meaning of instructional messages, including oral, written, and graphic communication.	Carrying out or using a procedure in a given situation.	Breaking material into its constituent parts and detecting how the parts relate to one another and to an overall structure or purpose.	Making judgments based on criteria and standards.	Putting elements together to form a novel, coherent whole or make an original product.
<i>Example verbs:</i> Recognizing Recalling	<i>Example verbs:</i> Interpreting Exemplifying Classifying Summarizing Inferring Comparing Explaining	<i>Example verbs:</i> Executing Implementing	<i>Example verbs:</i> Differentiating Organizing Attributing	<i>Example verbs:</i> Checking Critiquing	<i>Example verbs:</i> Generating Planning Producing

of links should be connected to as many other sets of links as possible, to form a web of learning.



Developing deep understanding means forming long links that are also connected to other links.

Elaboration



You can broaden your sets of links by actively thinking about what you're learning, as well as by writing and talking about it. **A technique called self-explaining or elaboration can help.**⁷ With this technique, you actively try to explain, in your own words, what you're learning. When working on numerical problems, for example, stop at every step and ask the question "Why am I doing this step?" and then try to come up with an explanation. In one experiment, students who explained their steps when solving logical reasoning questions scored 90 percent on a later test. Students who didn't self-explain their steps scored only 23 percent.⁸ For concepts that you're reading about, try to explain them as if you were teaching. Make your explanations different from the one you've just read. Try to simplify, improve, and provide examples.

→ 以教为学 → paraphrase

Interleaving

Another important technique for broadening your sets of links is to interleave your studies. Interleaving helps you not only learn the concepts

you're studying, but also understand the *differences* between them.⁹ Interleaving means varying or mixing different concepts. It is the opposite of “blocked” practice, where you focus on plenty of practice with a single concept before dropping it to move on to the next concept.



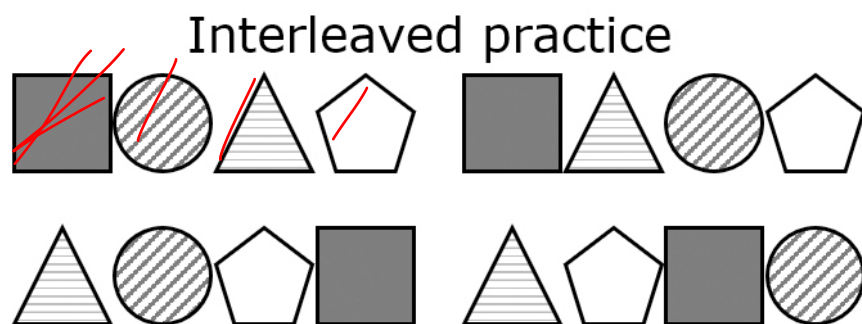
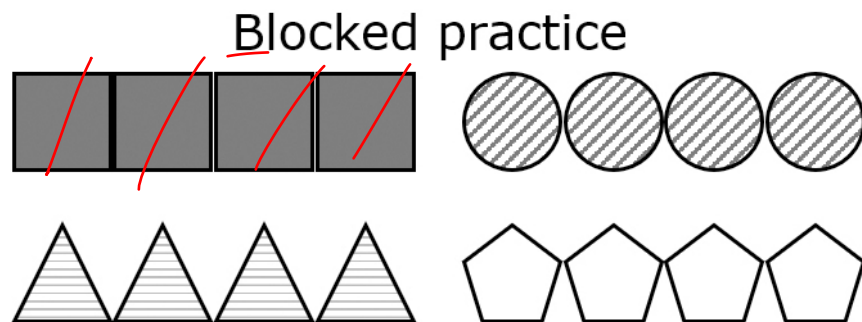
Interleaving gives you practice in choosing the right set of links.

For example, let's say you want to learn the styles of ten different artists. You could sit and view a dozen paintings by the first artist. Then you view a dozen paintings by the second artist, and so on.

But, tempting as it might be to study each artist in one blocked group, you should randomly *interleave* pictures by different artists. Look at a Manet, for example, then at a Van Gogh, then a Gauguin. This style of learning can seem more chaotic, but it gives you many more chances to contrast the differences *between* the styles, which helps you to much more rapidly develop your pattern recognition skills.¹⁰ Work through the initial feelings of frustration, and you'll find yourself learning much faster. → 主题阅读

It's similar in sports. Back in the old days, coaches used to expect their athletes to practice their skills in blocked format. In tennis, for example, forehand skills were practiced during one block of time, then backhands, then volleys. But researchers found that if players *interleaved* the different skills during their practice, randomly practicing forehand, backhand, and

volley skills, players ultimately did better in competition. (After all, part of playing tennis well means rapid pattern recognition: knowing which skill to employ as well as how to quickly alternate between those skills. Knowledge of interleaving has revolutionized some aspects of coaching.¹¹)



英语学习?

Unfortunately, many instructors and textbooks don't use interleaving. For example, when you're learning about different probability distributions in statistics, your book might have a block of ten binomial distribution problems for you to practice, and then ten geometric distribution problems. You get practice with each distribution, but not with choosing between the two different distributions. (So it's often up to you to interleave the different topics and techniques. One approach is to make your own list of problems from different chapters to work on. Another approach is to take pictures of problems, artists, techniques, or what have you from different chapters and create flashcards, so you can practice looking at the problems and seeing if you know the proper technique to solve them.)

Beware of Procrastination

You may think that procrastinating until right before a deadline creates stress, so you can focus better and learn more efficiently. Yes, such stress may help you complete straightforward tasks efficiently, but when it comes to learning, it can cause major problems. As we just saw, it takes brief periods of study each day over a number of days to grow a solid neural architecture of learning. If you procrastinate with something you're trying to learn, you're undercutting your ability to make progress. Give your brain the time it needs to learn a new subject. Remember, the Pomodoro Technique is golden!

Learning's Sweaty Little Secret: The Value of Physical Exercise

Researchers have long known that physical exercise helps us learn and form memories. Recently, researchers discovered a key reason why exercise is so helpful—it produces a chemical called BDNF (brain-derived neurotrophic factor) in the brain. BDNF is a protein that promotes sprouting of dendritic spines on neurons. Having spines available means it's easier to make new neural connections. Even a single exercise session can raise BDNF levels, but regular exercise raises the levels even more.¹²

Currently, there are no guidelines for exactly how much exercise you should do to benefit cognition, although researchers know that students who are physically active also perform better academically.¹³ One study found that exercise using high-intensity interval training for 20 minutes, three times per week, over six weeks, resulted in a 10 percent improvement in memory of college students.¹⁴ A meta-analysis found that even a single exercise session for 20 minutes can lead to immediate improvements in information processing, attention, and executive functions.¹⁵ If the cognitive task is done right after exercise, this study found that it is better to do a light to moderate workout. But if there is a delay after the exercise, higher-intensity exercise is also beneficial.

• **be 'golden**

(NAmE, informal) in a situation where you are successful or do not have any problems 大功告成；大获成功；一帆风顺

◆ *He thinks once he gets the money he'll be golden.* 🔊 🔊

他认为只要拿到钱就万事大吉了。



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golden 的用法在玩switch版《怪物猎人》学地道英语中就提到过，它常被表示 be likely to successful，也就是我们常说的...

英语学习笔记 2021-11-22

玩Switch版《怪物猎人》学地道英语



golden 在这里表示「有希望了」，一般用作 xx is **golden** 表示「某人就有戏了」。这段话因此可以理解为「只要你把平时...

英语学习笔记 2021-3-29

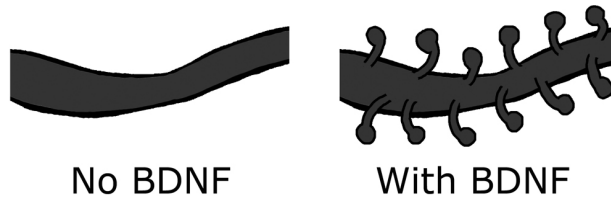
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英语学习笔记 >

📺 ...



golden 的用法在玩Switch版《怪物猎人》学地道英语中就提到过，它常被表示 be likely to successful，也就是我们常说的「一帆风顺」「前途似锦」。



Exercise helps form a substance called BDNF in the brain. When you “sprinkle” BDNF on a neuron as shown above at right, dendritic spines emerge. BDNF is like a fertilizer for spines!

The recommended guidelines for exercise in the United States are at least 30 minutes of moderate-intensity physical activity five days of the week, for a total of at least 150 minutes.¹⁶ (Anything that gets your heart beating faster than usual counts as moderate.) Additionally, muscle-strengthening activities that involve all the major muscle groups should be performed on at least two days. Both types of exercise raise BDNF levels and make a myriad of other physiological changes that can assist with learning.¹⁷

A few very brief but intensive workouts during the day also help with fitness—and thus perhaps with cognition—for those who are restricted in both time and gym or outdoor access. One study found that warming up with a few jumping jacks, squats, and lunges and then climbing sixty steps (three flights of stairs) as quickly as possible, three times a day, increased aerobic fitness by 5 percent.¹⁸ Incidentally, music can indeed make a grueling workout more pleasant.¹⁹

Cognitive Enhancements from Diets and Supplements

There’s a natural tendency to want to try the latest faddish nutritional supplement, even if there’s no research to support it. Ginseng and ginkgo biloba, for example, haven’t panned out as effective cognitive enhancements.²⁰ But here are some dietary substances and practices that, as research has shown, have a small but positive effect on learning:

- **Caffeine (coffee, tea, guarana)** will act within 10 to 15 minutes to boost your attention.²¹ The half-life of caffeine (the length of time it

takes for half of what you took in to leave your body) is about five hours, so you can expect a bit of a lift during that time and even afterward, although people's metabolism varies. The drawback is that caffeine can inhibit sleep if you take too much close to bedtime, which in turn can inhibit learning.

- **Carbohydrates** such as those in a donut or a bit of sugar in your coffee can also make a minor boost in cognition within about 15 minutes after ingestion. This is because it provides glucose, a fuel used by the brain.²² But be aware, too many carbs can make you sleepy. (Overeating in general disengages signaling pathways involved in cognition.²³)
- **Intermittent fasting** with two days a week of roughly 500 calories a day may also be useful in sharpening cognition.²⁴
- **Flavonoids such as cocoa, green tea, and curry powder (curcumin)** can improve molecular architecture responsible for learning and memory.²⁵ But it can take up to six months before effects become noticeable.

Interestingly, **caffeine and carbs can combine synergistically** to have a more powerful impact on cognition than either substance alone.²⁶ Similarly, **a healthy diet, when coupled with exercise**, can improve cognition better than either diet or exercise alone.²⁷ Make sure your diet includes vegetables from the onion and cabbage family, a sprinkling of nuts, dark chocolate with little sugar, and fresh fruits of different colors.²⁸ For long-term physical health, processed foods are best avoided (so much for the donut before a test).²⁹

Cognitive Enhancements from Drugs and Electrical or Magnetic Stimulation

A promising research area involves using drugs to get the brain to reopen the window of plasticity that made learning so easy when you were younger.³⁰ Certain drugs, it seems, can reset the brain so that it can

temporarily become more plastic. But research in this area is in its infancy so this is very much a “do not try this at home” at present.

Some students might think that turning to synthetic cognitive stimulants such as amphetamines and modafinil can help, but they are often less beneficial than potential users think they are—and of course, they come with side effects and potent hazards related to addiction.³¹

Do-it-yourself noninvasive* electrical or magnetic brain stimulation might seem safe and helpful—if you were to believe companies that sell these products. But the truth is that the cognitive benefit (if any) of these devices is so small, and the set-up process so time-consuming, that even neuroscientists don’t bother to use it on themselves. There are also important concerns about safety.³² People who try it typically only use it for a little while before quitting.³³

Surprise! Learning *Really* Happens When You Sleep

Learning means linking dendritic spines with adjacent axons to form neural connections in long-term memory. Interestingly, although a spine begins to bud when you start learning, that spine *really* connects with an axon when you’re sleeping.³⁴ This is similar to how muscles grow during rest. And it’s why you want to get a decent eight-hour sleep after a day of learning.

IDEAL SPACING INTERVALS

The golden rule of spacing is to wait until you’ve almost forgotten something before you return to the same topic.

➞ This is also why it’s so important to ***space out your learning***. Ten hours of learning crammed into one day are not nearly as effective as ten hours of learning spaced out over ten days. This is because cramming forms initial connections but doesn’t allow for them to be moved to long-term memory, where they can be strengthened and consolidated. The result? Those weak connections can quickly be forgotten. It’s a lot like sports practice. No coach is going to say, “Let’s practice ten hours today, and then meet this weekend for the tournament game!”

There's another reason sleep is important. During the day, your hard-at-work brain releases metabolites—toxic products. These build up as the day goes by, but they can't be washed away because your brain cells are like big boulders, blocking fluid flow. But when you go to sleep, your brain cells shrink. Voilà! Now cleansing fluids can flow through. Toxins get cleared out, which refreshes your brain for new learning.³⁵

This also explains why naps appear to help with learning. One study of Singaporean students found that if they took a 1½-hour nap during the day, while sleeping 1½ hours less at night, they retained more and learned better in their afternoon studies.³⁶ Sleep researchers recommend eight hours of sleep (including the time it takes to actually fall asleep), so try to ensure you get that amount. (There is a special, rare “short sleep” gene—people with this gene tend to need only four to six hours of sleep at night. Odds are you do not have this gene—especially if you feel tired when you're running low on sleep.³⁷)

↳ why we sleep?

How to Fall Asleep More Easily

Long ago, during World War II, stressed-out pilots learned techniques to put themselves to sleep within about two minutes—here is a set of tips so you can do the same. First, as you're decompressing toward sleep, spend a couple of minutes writing a **to-do list** for the next day. This clears your mind. Also, avoid bright light from mobile phones, computers, or television screens before sleep by turning on night mode in your device settings.³⁸ If there is light in the room when you're sleeping, a sleep mask can be surprisingly useful. If possible, set the temperature of your room to around 65°F (18°C). Be sure to put your mobile phone in another room.³⁹ Remember that some physical exercise during the day—not right before you go to sleep—will allow you to better relax and sleep at night. [There's also good scientific evidence that weighted blankets can help you sleep better.⁴⁰]

POPULAR TO-DO LIST APPS

- Todoist
- Trello

Finally, once you're in your bed, follow the steps below.⁴¹

- **Start with thinking the word “calm.”** This word will become your method of initiating the ability to relax.
- **Close your eyes and consciously relax all your muscles.** Start with your brow, which is often tense without you realizing it. The many muscles surrounding the eyes can also be tense too—relax them.
- **Breathe deeply and regularly.** Let your jaw, along with your tongue and lips, sag with complete relaxation. Try to breathe through your nose, keeping your mouth closed if at all possible. (The more you breathe through your nose, the easier you will find it to breathe through your nose. In other words, use it or lose it!)⁴² Breathe in deeply, into your lower chest, for four seconds (that is, for a slow count of four). Then hold for four more seconds, and breathe out for six (this will really empty your lungs). Finally, hold for two seconds on empty. Then repeat the cycle, breathing in deeply for four seconds, and so on. This type of breathing balances both the oxygen and carbon dioxide levels in your body, and allows you to relax more deeply.
- **Your shoulders are often full of tension—let them go.** Let your chest feel like a relaxed jellyfish.
- **Tell each arm muscle—upper and lower, left, then right—to relax. Then your thigh and calf muscles in your legs—first left, then right.** Feel the relaxation happening.
- **Once you've relaxed your muscles, try to hold your focus on one mental object**—for example, a still cloud in the sky. Make sure you don't imagine yourself moving—in fact, the more you imagine yourself moving, the more it can wake you up. Alternatively, imagine a blank screen and let your imagination begin populating that screen with whatever dreamlike imagery begins to come to mind. You can nudge this a bit by consciously encouraging a positive scene of you in a safe

place—a happy hero in your own phantasmagorical story. (But no thinking about your day job!)

- **Let your fears and worries go—mentally blank them out.** Some effective sleepers have a rule that they are not allowed to think between the hours of 10 p.m. (or whenever you go to bed) and 5:30 a.m., because they can't really solve life's problems before 5:30 anyway. If you wake up worrying about something and it's not time to wake up, remind yourself that you're not allowed to think about it yet and activate your “buzzer” to blank out your thoughts.

With practice (remember the importance of practice in learning!), you should also be able to use these steps to quickly fall asleep and stay asleep. If you wake up in the night, don't begin thinking. Just go back through your relaxation routine.



Learning anything deeply is a challenge—but part of the challenge involves making sense out of and retaining your learning. That's what we'll tackle in the next chapter.

KEY TAKEAWAYS

FROM THE CHAPTER

- **Learning means connecting neurons in your brain. To make learning deep and lasting, you have to make those connections strong.**
- **Actively engage with the material** to jump-start those neural connections, using **retrieval practice** whenever possible:
 - Work problems yourself—avoid looking at the solutions.
 - Test yourself.
 - Try to recall main ideas from a text.
 - Explain key concepts in simple ways to yourself, or to someone else.
 - Work with another person or small group that is as interested as you are in the material.

- Create study materials—flash cards, study guides, anything that requires you to process the information and put it into a new format.
- **Break up your learning into several shorter sessions over several days, instead of one ultralong session.**
- **Challenge yourself to progress faster.** When learning becomes easy, increase the level of difficulty.
- **To learn difficult concepts well, you need to actively connect what you're learning to other material you're learning or already know.** You can do this through *elaboration* or *interleaving*.
- **Don't procrastinate when you're trying to learn—it takes many days to build the solid neural architecture of good learning. The Pomodoro Technique can be very helpful here.**
- **Exercise regularly.** Exercise has been shown to help you more easily form neural connections.
- **Cautious use of cognitive enhancements such as coffee or tea, along with a healthy diet, can improve your ability to learn.**
- **Regularly get enough sleep.** Sleep is when your neural architecture grows. Spacing out your learning over several days will give more sleep periods, which will strengthen your learning.

4

How to Maximize Working Memory—and Take Better Notes

Genius mathematician John von Neumann was famous for performing extraordinarily complex mathematical operations in his head. Even at age six, he could do complex division with eight-digit numbers—once, when he spotted his mother staring aimlessly into space, he innocently asked her, “What are you calculating?”

Von Neumann could perform such remarkable feats in his head because he had an extraordinary working memory—the temporary mental space where you can hold and manipulate information.^{*1} Working memory plays a key role in learning. It’s what you use to solve problems and to make sense of material—an important prerequisite for storing that information in long-term memory.

Let’s start this chapter with a quick overview of working memory. Then we’ll move on to how your working memory impacts your ability to take in new information and take notes. Differences in your working memory capacity, as it turns out, can require different approaches to get the most out of your learning and note-taking.

Working Memory—Master Trickster

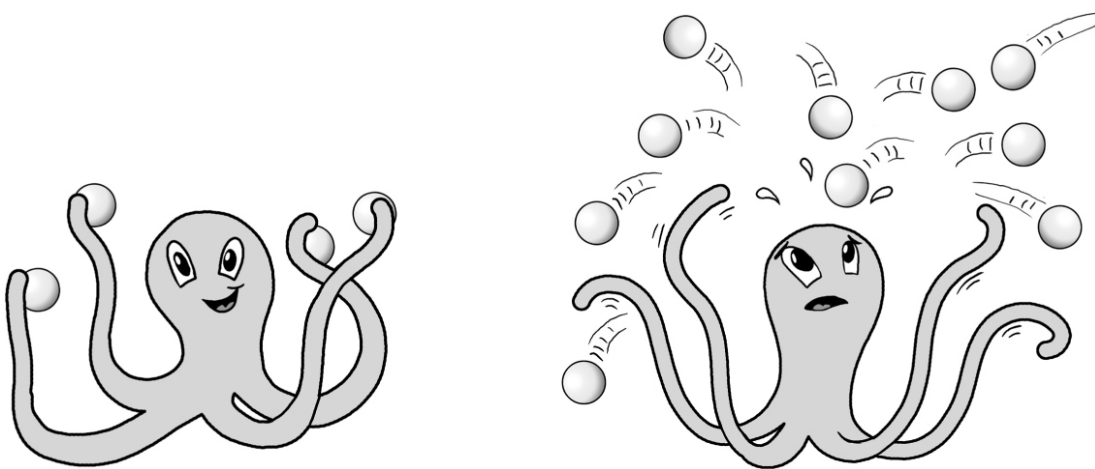
You can think of working memory as an “attentional” octopus. When you focus on something, your octopus uses its arms to connect your thoughts. It can reach into long-term memory, for example, to connect sets of links there with the information that your eyes, ears, and other senses are currently taking in.

KEY POINT

The brain has two separate types of memory: *working memory*, which only holds information temporarily, and *long-term memory*, which is more permanent. True learning only takes place when information has been moved from working memory into long-term memory.

Normally, your working memory can hold about three or four thoughts or concepts—in other words, your attentional octopus has three or four arms.² But people can differ quite a bit in their working memory capacity—some can hold five or more pieces of information at once, while others can hold only two or three.

The arms are slippery—meaning the octopus can’t hold on to thoughts for very long. For example, let’s say you’re taking a course in public speaking and are asked to give a two-minute impromptu speech about an embarrassing moment.



Your working memory can only hold up to about four pieces of information in mind at once. If it gets too many thoughts, it becomes overwhelmed. Information and thoughts can fall out.

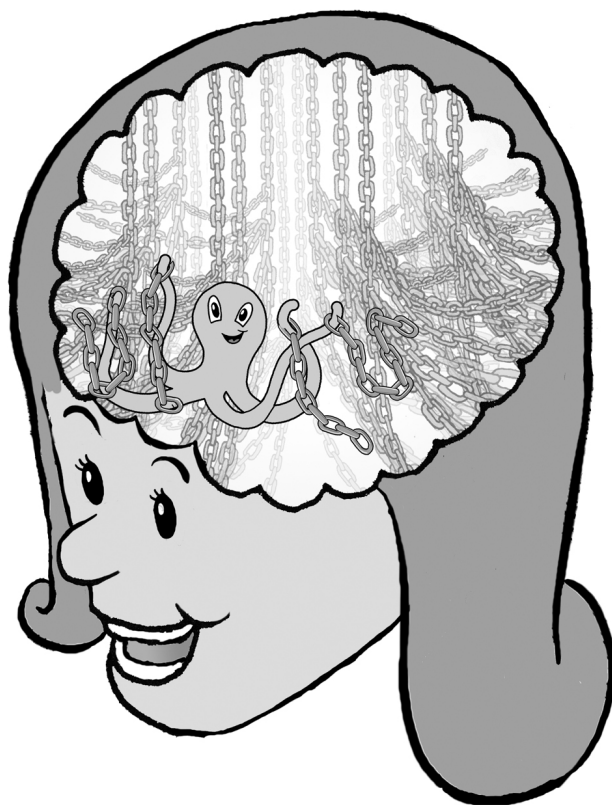
juggle

Your working memory kicks in immediately. You hold the topic of your speech with one arm of your attentional octopus, silently repeating “embarrassing” to help you focus your thoughts. Your nervous awareness of the audience takes another arm of your attentional octopus. You send yet another octopus arm into long-term memory to search for embarrassing moments. It finds the memory of that time you spilled your drink all over your date on your first dinner together. That’s a set of links that’s easy to follow—you begin to talk about that night. Now you don’t need to devote an arm to reminding yourself of the topic anymore, so instead you use that to touch on sets of links that you’ve practiced before to *look at the audience, smile, and gesticulate*.

Sets of Links in Long-Term Memory Enhance Your Working Memory

As we mentioned in chapter 3, whenever you learn anything—*really* learn it—you have created sets of links in your long-term memory. Your attentional octopus (working memory) can then grab these sets of links whenever you need to think about or use the ideas. Neural links that your working memory can access are what enable you to quickly create a pivot table in Excel, say a long sentence in Chinese, or solve that tough problem in circuit analysis, even though at first all of these activities might have seemed impossibly difficult.

→ 即興的能力？



The number of sets of links you can have in long-term memory is virtually limitless. But the number of arms of your attentional octopus—that is, what you can pull into your immediate attention—is quite limited. Sets of links serve as “preworked” extensions of the arms of your attentional octopus—these links boost the power of your working memory.

Let’s give you a trivially easy example. If you were given the letters “aueiutlbl,” which you’ve probably never encountered before in that order, it would be hard to hold all the letters in your working memory. But if you’re given the word “beautiful,” which has the same letters, just rearranged into a form you’ve already learned, that word is easy to hold as one piece of information in your working memory.

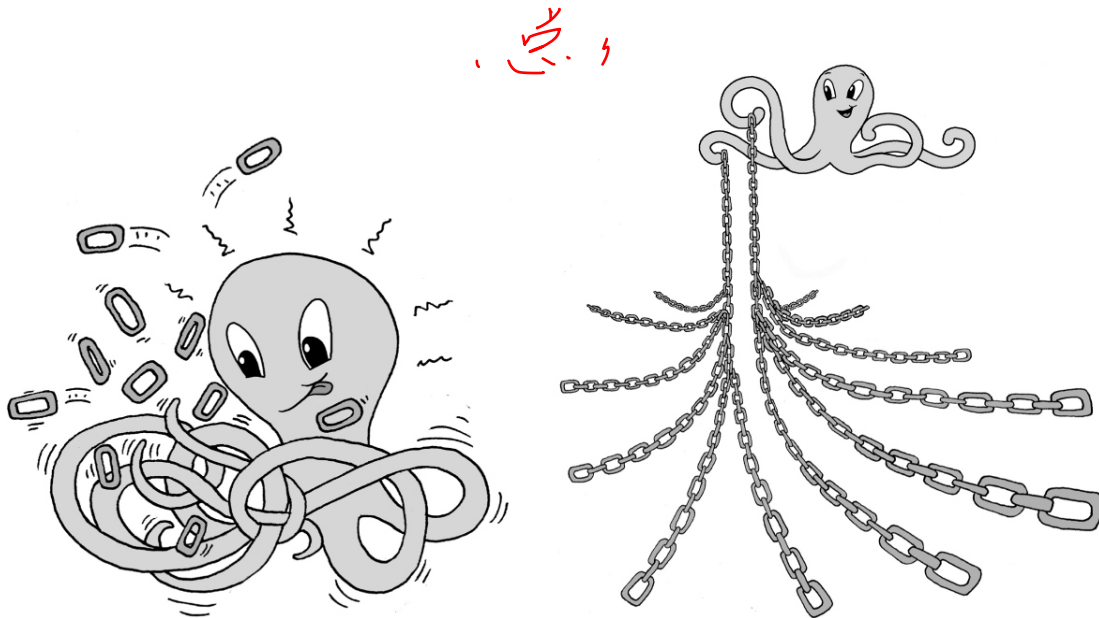
In other words, with interconnected sets of well-learned links, you can effectively hold more in working memory at one time, since each one of the octopus’s four arms can grab a piece of information that you’ve already learned.

Making the Best Use of Your Working Memory

If you struggle to understand the material, it's likely because your working memory is overwhelmed—it cannot handle all that difficult information at once. Here's what you should do:

Simplify 🧠🔑

As you study books and articles, try to synthesize the key ideas, which are often surprisingly simple. Don't become overwhelmed with lesser details. If you are watching an instructor live or on a video, you might need to find ways to simplify what they are saying, as well, since even the experts can struggle with this. (Also remember that you can often find brilliant instructors on YouTube or platforms like edX or Coursera who are famous in part for their ability to make complex material seem easy.)



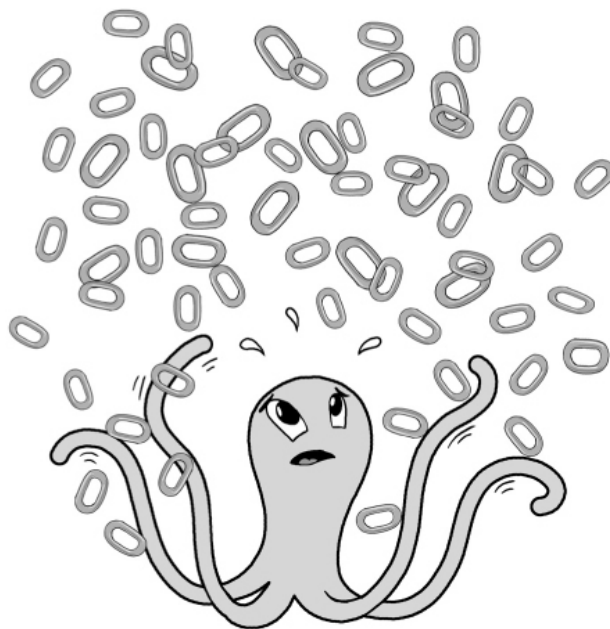
Your working memory may have to work hard to eventually create the set of links in long-term memory that can be easily accessed and used to solve problems and understand concepts.

Break Material into Chunks

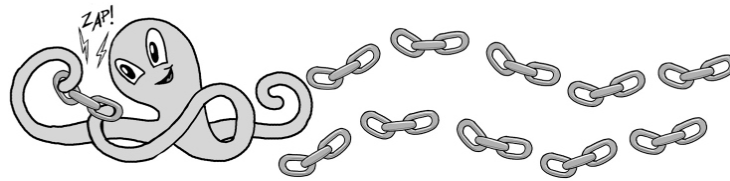
Find a way to break your learning down into smaller chunks. Try to focus on the fundamentals.

Later, group the chunks of knowledge to form larger sets of links. For example, if you're trying to understand a difficult section in a physics textbook, pick the *easiest* example problem from the book and work it all the way through on your own, peeking at the solution only if you need to. Then work another example, and another, gradually moving toward more complex problems. This process will start placing foundational sets of links in your long-term memory—links that other links can attach to as you continue to master the material. Remember, if you get stuck, take a break or use your overnight rest to allow the diffuse mode to work in the background.

→ If you're overwhelmed in studying a language, try to focus on tiny bits at a time—a few words, which you can then put together into a sentence. When studying accounting, focus on understanding the profit and loss statement before you move to the balance sheet and cash flow statement. When playing a musical instrument, try mastering individual short passages before linking them together to play the entire passage. And in karate, your teacher will have you practice with a sequence of smaller movements before you put them together into a seamless spinning kick.



A. Too much information at once can overwhelm your attentional octopus—this is called “cognitive overload.”



B. Find ways to put the information together in smaller chunks (sets of links). Your octopus can begin to gradually put those pieces together.



C. Eventually, you can hook the smaller sets of links together to form a large set of links that relates to the concept as a whole.

Translate into More Understandable Terms 深入浅出

Another trick you can use to reduce the demand on working memory is to swap a fancy technical term for one that’s easier to understand. For example, a “torque” might become a “twist.” Or try to see and hear an explanation simultaneously. This makes it easier to understand, which is why videos are often easier to learn from than instruction manuals.³

In a greater sense, the challenge is to try to attach what you’re learning to something you already know or are familiar with.

Make a Task List

When you’re studying, try to clear your working memory of any thoughts that aren’t directly related to the task at hand. Making a task list is a way to help with this. A task list allows you to transfer your thoughts from transient working memory to a safer place. Instead of trying to remember a dozen or more tasks, the only thing you need to remember is that you have a task list.



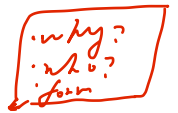
Put Something on Paper

Putting a key word, number, or formula on paper extends your working memory to the paper. Storing such information temporarily on paper instead of in working memory frees up capacity that can be used for other thoughts.

How to Take Better Notes

When you take in information from books, videos, or lectures, what you hear and see makes its way into working memory. But the information will disappear within seconds unless you deliberately focus on getting it into long-term memory. This is why note-taking is so powerful—it allows you to process the information, organize it, summarize it, and store it for further review and practice in order to create sets of links in long-term memory. Which brings us to an important question—what’s the best way to take notes?

Prepare



If you’re taking notes from a chapter or article, **start by getting a rough idea of how the text is organized** (As we discuss more deeply in chapter 9, even a minute or two of looking at bolded text and pictures with their captions can help.) If you’re taking notes from a class lecture, you should read through or at least scan any associated material or assigned readings ahead of time. If you’re watching a video, subtitles (closed captions) are sometimes available as a document you can glance through ahead of time. Such preparation will give you a structure that will help you make better and more organized notes.

Extract and Organize the Essence

Good note-taking—whether from books, videos, classes, or training sessions—demands that your brain be truly focused so you can extract the essence of what you’re learning into your notes. The latest research says that typing and handwriting are each effective methods for note-taking.⁴ So how do you take good notes? Here are two recommended ways:

ERIC's class

- CONTENT -

· 1 (key words) → my version

· _____

· _____

★ _____

↓↓

my Questions / Enricher

·

·

·

- LANGUAGE -

· I / knew _____

· aha! 2

· to consult 2

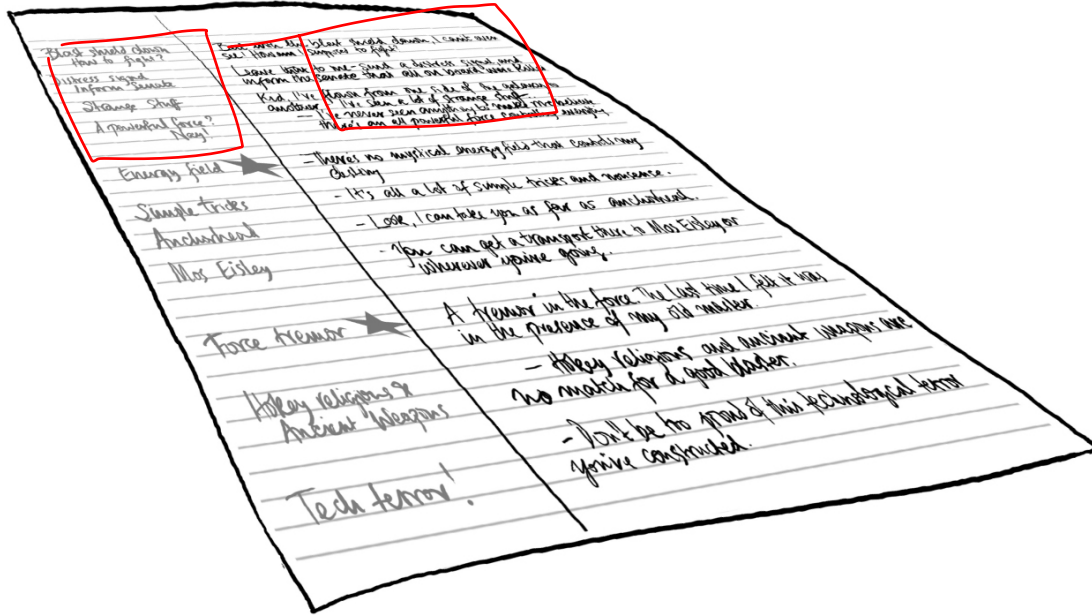
↓↓

复习

学习

联想

- TAKEAWAYS -
In a nutshell



Example of split notes: Notes are written down in the right field and are later supplemented by summarizing key words or headings on the left.

• Split notes

- Before you start taking notes, make a vertical line one-third of the way across the page, as shown in the example. Then, try to capture the main ideas (not the word-for-word verbiage) in the space to the right of the vertical line. Use contractions and omit the tiny words your brain would fill in: the, a, like, thus. Use symbols ($\rightarrow$ $+$ $=$ $\neq$ $\#$ $\checkmark$ Δ), abbreviations (e.g., etc.)—whatever you can to make the task faster without losing material. Then, either as you're writing or when you're done, put summarizing words or brief phrases in the left-hand column.⁵
- Later, when you review your notes, cover up the right-hand side and quiz yourself to see whether you can recall the deeper meaning from the summary words.
- ★ If something seems particularly important, or involves material that might be on the test, put a star next to it.

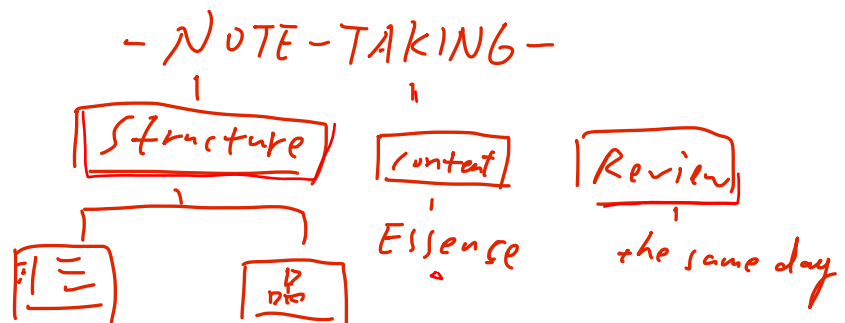
• Concept mapping

Concept mapping is an approach to organizing information to see how ideas and concepts relate to one another. It's used for brainstorming (as when you're planning a project) and for taking notes. A concept map is created by writing down a few words with arrows between them to show relationships.

POPULAR NOTE-TAKING APPS

- Evernote
- OneNote
- Coggle (for mind mapping)
- SimpleMind (for mind mapping)

• obidian
• Mindmap
• Xmind
• Flomo



Sometimes it can be tempting to rewatch video lectures to try to better grasp the materials. But research has found that those who simply watch video lectures again without synthesizing and internalizing their main ideas don't do well.⁸ And students who don't review any notes before exams perform the poorest.



Above all, remember that it's not the note-taking—it's what you get into your brain that matters. Even the best notes are worthless if they're not used as the study tools they were meant to be.

Partnering in Note-Taking

Taking notes is important because it helps you stay focused, especially if you're in a class or workshop. But for some, it can be difficult to follow an instructor while simultaneously taking notes because it may be too much for your working memory. In this case, a workable approach is to borrow notes from someone else or use shared docs to take notes collectively. Then you can help each other fill in the gaps. Research has shown that students who use other students' notes to review before exams do almost as well as students who have produced their own notes.¹⁰

MISSING CLASSES

If you must take a live class, and you have a long commute to get to that class, or you're taking a class where the instructor can't teach well, you might consider skipping class and instead watching lecture videos (if available), studying borrowed notes, and working problems yourself. Over the years, we've met many learners who have boosted their studying efficiency this way. Dr. David Handel, for example, who lived off campus and had a long commute to school, skipped many of his medical school classes, and used the extra three to six hours this gave him to learn more effectively.⁹ He graduated number one in his medical school class. But do not try this unless:

- You are disciplined or motivated enough to self-study.
- You know how to self-study and what to do.
- You'll learn more by self-studying—either because you'll save a lot of time, or because the instructor is problematic.
- You won't miss any essential information—in other words, you can get the information you need from slides, friends, or written transcripts.
- You're not required to attend class, or penalized for your absence.



In this chapter we've described how to maximize your working memory to make sense of and retain your learning. In the next, we'll go deeper into techniques to help you *remember* your learning.

KEY TAKEAWAYS

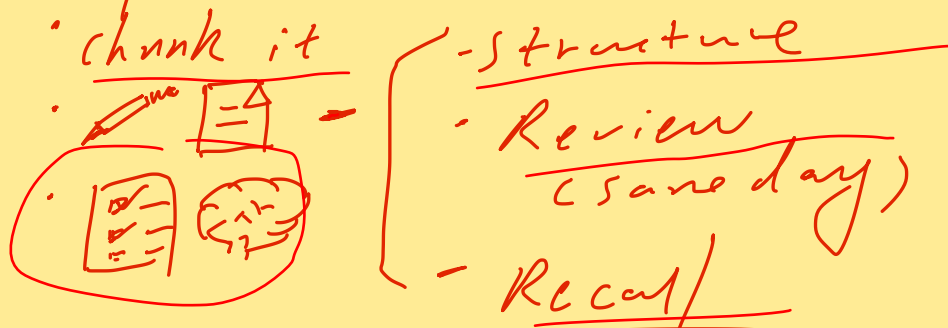
FROM THE CHAPTER

- **Working memory is only a temporary holding place for thoughts and information.** When you put something in working memory, it can seem as if you've truly learned it. But learning only happens when you secure the idea, concept, or technique in long-term memory.
- **You can typically hold perhaps four pieces of information in your mind at once,** because your working memory has only a few "arms."
- **You can compensate for the small size of your working memory by building sets of links in long-term memory.**
- **To make the best use of your limited working memory:**
 - Break material into chunks.
 - Translate what you're learning into more understandable terms.
 - Make a task list to clear your working memory.
 - Put ideas on paper to extend your working memory.
- **To take good notes:**
 - Use the split notes system or make a concept map.
 - Do a first-time review of your notes the same day you take them.
 - Make sure you actively practice with and try to recall the key ideas of the notes.

Working memory  [Flakey]

Long-term memory  [Solid]

↳ Learning → space out
(WM → LM)





1 [PHRASAL VERB 短語動詞] 開始生效；起作用；If something kicks in, it begins to take effect.
[V P]

As discounts kicked in, bookings for immediate travel rose by 15%...

由於開始實行打折，近期旅行的預訂量上升了15%。

When you're confronted with the problem, emotions kick in, fear kicks in, and you don't always do the rational and thought-out approach.

當面臨這個問題時，人會變得情緒激動、恐懼不安，你不一定總能採取理性且慎重的方法。

Dictionary

Definitions from [Oxford Languages](#) · [Learn more](#)



and what have you

phrase of what

INFORMAL

and/or anything else similar.

"for a binder try soup, gravy, cream, or what have you"

13 [VERB 動詞] 使竭盡所能;使全力以赴;使拿出全部本領; If you say that a job or task stretches you, you mean that you like it because it makes you work hard and use all your energy and skills so that you do not become bored or achieve less than you should. [V pron-refl] [V n]
[approval]

I'm trying to move on and stretch myself with something different...

我正想換工作，想嘗試點不一樣的事情來挑戰一下自己。

They criticised the quality of teaching, claiming pupils were not stretched enough.

他們批評教學質量太差，聲稱沒有使學生們發揮出潛質。



1 [PHRASAL VERB 短語動詞] 取得進展；有成果；成功； If something, for example a project or some information, pans out, it produces something useful or valuable. [V P] [Informal]

None of Morgan's proposed financings panned out.

摩根建議的籌資方法均未奏效。

kaili 啊 20:29

at the heart of active learning lies something called
"retrieval practice".

阿拉伯土著 阿拉伯土著 20:30

At the heart of active learning lies something called
retrieval practice

miaaya 20:31

at the heart of active learning lies something called
"retrieval practice".

Qian Chen 20:31

At the heart of active learning lies something called
"retrieval practice"



Extract the sentence structure out of "At the heart of active learning lies something called 'retrieval practice'" and make more example sentences.



The sentence "At the heart of active learning lies something called 'retrieval practice'" can be broken down into the following structure:



Subject: "something called 'retrieval practice'"

Verb: "lies"

Prepositional phrase: "at the heart of active learning"

Here are some additional example sentences using similar sentence structures:

1. At the center of the debate lies a fundamental question about the role of technology in education.
2. In the depths of the forest lies a hidden treasure waiting to be discovered.
3. At the core of the issue lies a lack of communication between the two parties.
4. In the heart of the city lies a bustling marketplace filled with vendors and shoppers.
5. At the root of the problem lies a misunderstanding that needs to be addressed.

In these sentences, the subject is introduced by a prepositional phrase that describes its location or nature, followed by the verb "lies" to indicate its position or existence.



what's the difference between at the heart of and in the heart of



The phrases "at the heart of" and "in the heart of" are similar in meaning and can often be used interchangeably, but there can be subtle differences in usage and connotation.



1. "At the heart of": This phrase suggests a central or essential aspect or element of something. It implies that the described element is crucial, fundamental, or deeply connected to the core of the subject. It emphasizes the significance or importance of that particular aspect.

Example: At the heart of every successful team lies effective communication.

1. "In the heart of": This phrase typically refers to a physical location or position within something. It describes being situated or located at the center or core of a place or object.

Example: In the heart of the city, you can find the main shopping district.

While the distinction is not always rigid, "at the heart of" is commonly used in more abstract or figurative contexts to discuss essential qualities, principles, or concepts. On the other hand, "in the heart of" tends to be used for literal or physical locations within a specific area or object. However, both phrases can convey a sense of centrality or importance.

6 [ADV 副詞] (用於數目前)大約; **You can use some in front of a number to indicate that it is approximate.** [ADV num] [vagueness]

I have kept birds for some 30 years...

我養鳥大約有 30 年了。

He waited some 80 to 100 yards from the big pink villa...

他在距離那座粉紅色的大別墅約 80 到 100 碼的地方等候著。

The headquarters is some 30 miles due west.

總部位於正西大約 30 英里處。

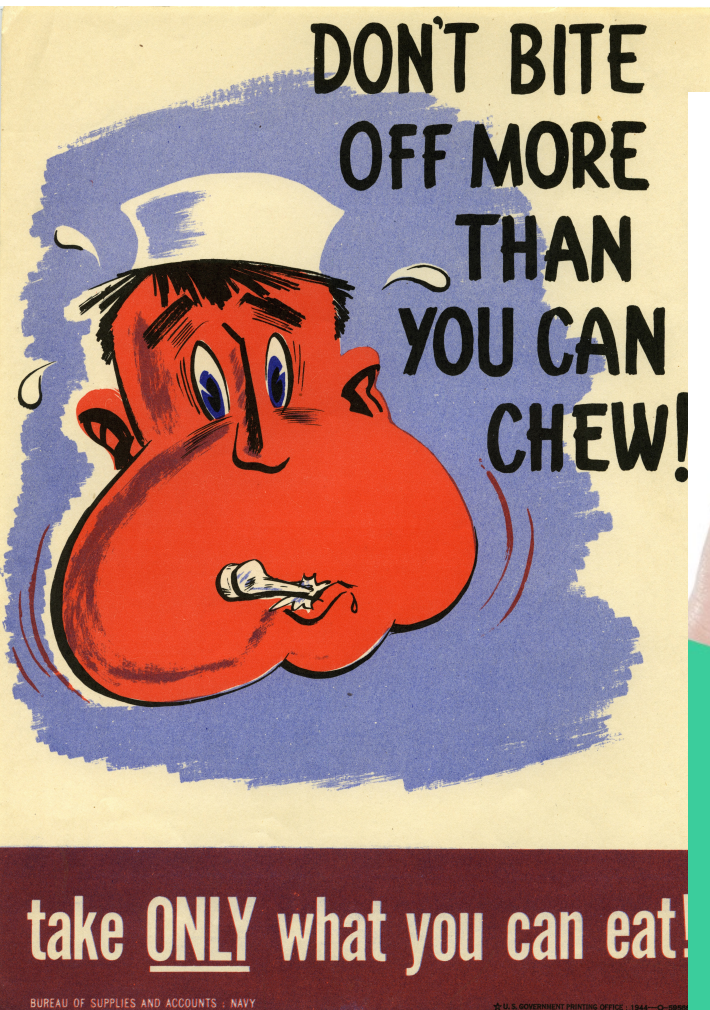
2 [ADV-GRADED 副詞] 迅速地; 容易地; 輕鬆地; **You also use readily to say that something can be done or obtained quickly and easily. For example, if you say that something can be readily understood, you mean that people can understand it quickly and easily.** [ADV adj]

The components are readily available in hardware shops...

這些零件很容易在五金商店買到。

I don't readily make friends.

我不輕易交友。



Idiom
Land



IDIOMLAND.COM

YOUR EYES ARE BIGGER
THAN YOUR STOMACH



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.



⚡ GPT-3.5

🧩 GPT-4



AskYourPDF

Unlock the power of your PDFs!, dive into
your documents, find answers, and bring
information to your fingertips.

2/3 Enabled



Ai PDF



Prompt Perfect



AskYourPDF



ChatWithPDF





Sum up the main
extract the essence with plain language from this PDF:

https://drive.google.com/file/d/1RdyD2B_-z5xbl6QQM0q6mq9UybDve8wH/view?usp=share_link

Here's a simplified summary of the PDF, which is a guide on how to learn vocabulary effectively:

1. **Expressions and their meanings** (Page 3): The document lists a bunch of expressions like "head-scratcher", "no-brainer", "low-hanging fruit", and explains what they mean and how to use them in sentences.
2. **How to Learn Deeply** (Pages 14-21): The guide explains that learning is about making connections in your brain. The more you practice and recall information, the stronger these connections become. It also suggests using flashcard apps like Anki, Quizlet, Kahoot!, GoConqr, StudyStack, and Brainscape to help with this.
3. **Active Learning** (Pages 20): The guide recommends active learning techniques like working out problems yourself, recalling key points from a book or article, making your own questions about the material, taking practice tests, explaining ideas in simpler terms, working with others, creating flashcards, explaining your thinking out loud, asking a partner to quiz you, taking a practice test even if you haven't studied much yet, and making your own practice test.
4. **Push Yourself** (Pages 21): The guide advises you to challenge yourself with harder material every day. This helps you form new connections in your brain and not just reinforce the ones you've already made.
5. **Deepen Your Learning** (Pages 21-23): The guide suggests actively connecting what you're learning to other stuff you're learning or already know. Techniques for this include elaboration (actively explaining what you're learning in your own words) and interleaving (mixing different concepts).

🔄 Regenerate response

Remember, these are the main points

detail in the document. What

Learn Deeply

- Active learning (retrieval practice)--"At the heart of active learning lies something called retrieval practice." Why retrieval practice? self-monitoring, feedback, metacognitive strategy, "the testing effect" "reflexive"
- Stretch yourself, go beyond the low-hanging fruits. 知新而温故，最好的复习就是持续学习。
- - Interleaving, self-explaining (elaboration, 以教为学), space out, 喜新念旧
- Sleep, diet, coffee help.

Maximize working memory

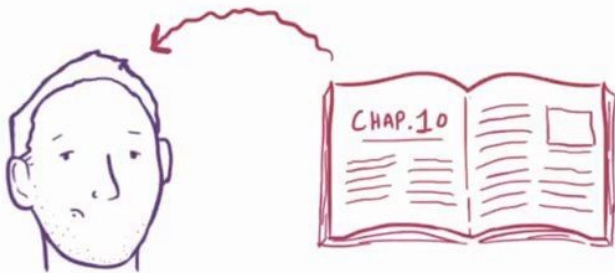
- Learning=working memory morphs into long-term memory
- working memory has limited juggling capacity (4 tops) so: chunk, simplify, use down-to-earth, lucid language, to alleviate the cognitive overload.
- take to-do list off your mind, focus on the task per se.
- take notes to give your working memory a leg up.

|

TESTING EFFECT

(TEST-ENHANCED LEARNING)
(RETRIEVAL PRACTICE)

PASSIVE LEARNING < ACTIVE LEARNING



Google

interleaving in language learning



Examples

Exercises

Images

Videos

Books

News

Shopping

Maps

Flights

About 658,000 results (0.39 seconds)

A simple example of interleaving appears in the case of language learning, where someone who's learning new vocabulary words can mix together words pertaining to different topics instead of learning only words from a single topic at a time.



Effectiviology

<https://effectiviology.com> › interleaving

Interleaving: How Mixed Practice Can Boost Learning



张海露 Eric 🎺

关于背单词，结合这两天上课内容，有一些新角度。

我最开始背四级单词书时，用一本正序的一本乱序的一起背，这是当时的直觉做法，主要考量是：

- 增加新鲜感，按字母背太无趣了；
- 增加他乡遇故知的惊喜，增加早晚会遇到的期待；
- 用不同的词条释义和例句解释加深理解；
- 在背单词中加入“主动考自己”

从脑科学角度看，这种混合式背单词更有效，可能的原因是 1) interleaving；2) space out; 3) retrieval practice。

后来水平有进步，提升词汇的主要途径不再依赖单词书，而是阅读，在语境中学习词汇，加深对这个词的理解。这样做会再不断 recall 和 “学更难的素材”中给 long-term memory 添砖加瓦，让知识之间联系更紧密。这样做一段时间，会发现阅读的速度和质量都有提升，说明 long-term memory 对 working memory 有了“反哺作用”。

Show Less



学习单词时我们要注意些什么？

Basically, whether you're grappling with the consequences of globalization or solving tough astrophysics problems, it's difficult to succeed without some memorization. What you need is quick and easy access to information from *inside* your head—that is, you want to have strong sets of links already established in your long-term memory about key information. Having these links readily available frees up working memory and enables higher-level thinking.¹

Let's say, for example, you're asked to answer an exam question like "Compare and contrast the French and Russian revolutions." This question involves higher-order thinking—it's not just a trivial regurgitation of facts. But how could you even begin to formulate an answer if you haven't locked into long-term memory the key elements of both the French and the Russian revolutions, including such seemingly trivial concepts as the timeframes of the revolutions and the key concerns and unmet needs of the differing peoples?²

KEY POINT

Not all memory techniques work for all kinds of material. When you need to memorize something, quickly consider different memory techniques and pick the one most suited to what you're trying to remember.

In chemistry, memorizing formulas for different acids will make it easier to make sense of information about those acids. And in physics, memorizing Bernoulli's or Poisson's equations supports your understanding of the relationships those equations represent. This "memory-understanding" relationship goes both ways: **It's easier to memorize information when you understand it well, but it's also easier to understand information that you have memorized.**^{3, 4}

How to Memorize Information with Memory Tricks

The most inefficient way to memorize is to simply look at information over and over again. **You should instead, at the very least, use the recall**