

01

KNOW WHEN TO LEARN

Older adults have morning brains. A study on a group of people aged between 60 and 82 at the Rotman Research Institute at Baycrest Health Sciences in Toronto, Canada, found they were better able to focus and ignore distractions, and did better at memory tests, between 8.30 am and 10.30 am than between 1 pm and 5 pm. In fact, fMRI scans revealed that in the afternoon, these people's brains were "idling" – they had switched to the so-called default mode, associated with daydreaming. In younger adults, by contrast, areas related to the control of attention were still very active right into the afternoon.

However, to get the most from their efforts, younger people can time their learning, too. Another study found that 16 and 17-year-old girls performed better on tests of factual memory if they studied the material at 3 pm rather than at 9 pm, but acquired skills involving movements faster if they practised in the evening. "The results suggest it might be better to use the afternoon for studying languages, and the late evening for playing piano or another musical instrument," says Christoph Nissen at the University of Freiburg in Germany.

Why should timing matter? We know that sleeping after learning a new fact or skill helps consolidate memories. Nissen suspects that the "critical window" between learning and sleep is shorter for movement-related learning than for other types of memory. Whether adults can benefit as much as teenagers from these windows isn't clear. "There is evidence that adolescents have a higher capacity to learn – and they sleep better," he says.

KNOW IT ALL

It's never too late to learn something new, but what's the best way to go about it, wonders Emma Young

EVEN when school exams are just a distant memory, our thirst for knowledge goes on. Whether we are after a new skill or fluency in another language, want to play a musical instrument or explore a new passion, we are lifelong learners. Even if we simply need to bone up on trivia to win the pub quiz or impress someone we fancy, our need to know is never-ending. So you would think we'd have learning down to a fine art. In fact, some of the most common techniques are pretty useless (see "What doesn't work", page 32). But the good news is we can share some of the secrets of successful learning, and no matter what your age or ability, they can work for you.



PASCAL LAFAY

02

QUIZ YOURSELF

In a landmark study on the importance of self-testing, Jeffrey Karpicke at Purdue University in West Lafayette, Indiana asked students to learn the meaning of 40 Swahili words (see "Swahili 101", right). Those who had to repeatedly recall these words during the training session scored an average of 80 per cent in a test a week later, while those who just studied the words without actively testing themselves scored an average of just 36 per cent. Other work since then backs up the idea that self-testing is more effective than some other common learning strategies, such as drawing bubble diagrams to represent ideas in a passage of text.

If that sounds like too much hard work, take heart. Nate Kornell at Williams College in Williamstown, Massachusetts, and his colleagues have found that what matters is trying to retrieve the information you are learning, rather than succeeding. Being given the correct answer seems, counter-intuitively, to be as big a boost to later performance as remembering it by yourself.

"This finding was quite surprising," says Kornell. "Memory researchers have long assumed that there are 'paths' in memory from the question to the answer and - here's the part that appears to be wrong - that you learn more by travelling your own path than by travelling part way, or the wrong way, and then being told the answer." His finding suggests we may have to rethink how memory works. But it also offers hope to lackadaisical learners everywhere.

WHAT DOESN'T WORK

These common methods to boost learning are surprisingly useless

03

LEARN WITHOUT LEARNING

It sounds too good to be true, but learning needn't be hard work. You can even do it when your mind is on something else.

Beverly Wright at Northwestern University in Evanston, Illinois, asked one group of volunteers to practise distinguishing between sounds of a very similar frequency. Another group spent half the time in active practice, and the other half just hearing the sounds in the background while they performed a written task. Both groups scored about the same on a final test - but only if the passive learning happened within 15 minutes of the active session; the effect vanished entirely if the delay was longer than 4 hours.

What might be happening? Wright thinks active training puts the neural circuitry involved in a particular task into a state conducive to learning, and that this state continues for some time after the training ends. While it lasts, similar stimulations to those that were being learned will be processed by the brain "as though they are occurring during active training", she says.

So far, Wright and her team have investigated only the learning of a skill rather than facts or events. But Lynn Hasher at the University of Toronto, Canada, and colleagues have found that a spell of passive learning following active study can also help older adults learn a list of words. The volunteers in her study reported that during the passive phase, they didn't even notice that the words were being repeated.

If you want to give it a try, take note: passive learning is more effective while you are doing something relatively undemanding. So you might want to listen to foreign vocab as you get the dinner ready, rather than while writing emails.

04

USE DISTRACTIONS

Find your attention wandering? Use this to your advantage. "People have an underlying assumption that divided attention is bad," says Joo-Hyun Song at Brown University in Providence, Rhode Island. It's true that if you frequently break off from studying to send a text message or to focus on a tune on your headphones, odds are you won't learn as well as you would in uninterrupted silence. "But learning has a later, skill-retrieval part," she adds. "People hadn't studied the role of divided attention in memory recall later." Doing just that, Song found that distraction while learning can be beneficial - if you are also going to be distracted when you have to use what you have learned.

It is common knowledge that context can boost learning. If you study a list of words while smelling vanilla, for example, you will probably remember more of them if the scent of vanilla is in the air during recall. Song found that divided attention can itself act as a powerful context. In her studies, people who were distracted during learning and recall performed just as well as those who weren't distracted on either occasion, and better than people who were distracted in only one situation. It didn't matter whether or not the distractions were the same on both occasions, but the degree of distraction had to be similar. Intriguingly, Song also found that divided attention was a more powerful learning aid than environmental contexts such as a smell.

There are important implications, she says. "In training, people should consider where they will actually acquire and use their skills." If you are going to have to remember what you have learned in an environment where you are likely to feel distracted - in a packed foreign city or a noisy pub on quiz night - you would actually do better to have distractions while you are learning.

05

BUDDY UP

While solo studying is important, thrashing out difficult material with other people can pay dividends. Sandra McGuire, assistant vice-chancellor for learning and teaching at Louisiana State University, and chemistry Nobel prizewinner Roald Hoffman recommend you alternate group work with study time by yourself. Specifically, once you have tried to go it alone, you can benefit from the collective wisdom of a small study group of three to six people.

McGuire and Hoffman say that study groups need two key elements to promote "meaningful learning": discussion and problem-solving activities. If group members make up quizzes for each other, this can help them prepare for tests. However, after discussing the material, clarifying anything you are confused about, and using the opportunity to mock-test each other, you should then go back and work on the problems and get ready for any exams on your own, they say. ➤

SWAHILI 101

Practise your newfound self-testing technique to improve memory with these Swahili words

adhama	honour
adui	enemy
buu	maggot
chakula	food
dafina	treasure
elimu	science
fagio	broom
farasi	horse
fununu	rumour
goti	knee
kaputula	shorts
ndoo	bucket
pombe	beer
sumu	poison
tabibu	doctor
theluji	snow
tumbili	monkey
usingizi	sleep
yai	egg
ziwa	lake



⊗ HIGHLIGHTING AND UNDERLINING

⊗ KEYWORD MNEMONICS

⊗ RE-READING IMPORTANT TEXTS





06

PLAY VIDEO GAMES

This may come as a pleasant surprise to the parents of teenage gamers. Gaming is the ideal downtime activity if you are learning to type or play a new sport or instrument - anything, in fact, that involves a fairly constant and predictable structure and requires the coordination of sensory input and physical movements. Just make sure it's action video games you play.

A team led by Jay Pratt at the University of Toronto, Canada, found that people who played action video games, such as *Call of Duty*, for at least 6 to 8 hours a week were faster at learning a lab-based task that involved hand-eye coordination. They weren't any better at the start, they just improved more quickly. Pratt thinks this is because gaming speeds up a person's ability to form accurate brain "templates" for hand-eye-coordinated action. "Action games, which have harder levels as the game progresses, place a lot of demands on the visual, cognitive and sensorimotor systems to constantly improve the efficiency of all these systems," he says. This is why they are more likely to have an effect on other sensorimotor tasks than something like *The Sims*.

It's hard to be sure what difference regular gaming would have on performance in the real world, since there are so many variables, Pratt concedes. "But if one is in a new job that requires a high level of sensorimotor skill, say, then playing several hours of action video games each week could be a worthwhile investment."

07

CHILL OUT

If sleep consolidates memories, would taking a break from studying have a similar effect? To find out, Lila Davachi at New York University scanned people's brains while they looked at a series of images, then asked them to think about whatever they wanted. During this rest period, there was increased activity in the hippocampus (involved in memory) and "thinking" regions in the cortex. What's more, the greater the activity in both regions, the better an individual remembered the images they had seen when tested later. Davachi thinks her work shows the consolidation of memories during rest.

If you have just studied a list of vocabulary or perhaps tried to memorise some key historical dates, then taking a proper break afterwards should help you to remember this information, she says. "This is something we don't appreciate much, especially when today's information technologies keep us working round the clock."

But what counts as a "proper break"? Davachi has been working on this too. What she has found, but not yet published, is that a rest can help consolidate memories as long as it activates different populations of neurons in the brain, or whole brain regions, from those that were active during the learning period. So if you have just put in some hard mental study, going off to practise your tennis backhand should do the trick. Having said that, a little lie-down might seem more tempting and may be even more productive. We still don't know the relative benefits of chilling versus taking a nap, when it comes to learning.

08

PRETEND TO TEACH

You are likely to remember something better if you think you might have to teach it later. Kornell discovered this when he gave students at Williams College 10 minutes to study a 1500-word passage about *The Charge of the Light Brigade*. Those who were told beforehand that they would have to pass on what they had learned to someone else later remembered more points from the text, and their memories were better organised, than those who thought they were simply going to be tested on the text.

Better yet, independent learners can trick themselves into reaping the benefits of this insight. "Our research shows that pretending

that you'll have to teach will help you learn in the same way," says Kornell. And if you actually then do the teaching, all the better. There are many well-known cognitive benefits to asking yourself whether you can recast what you are learning in your own words, he adds. "It leads to active retrieval from memory, and helps with organising one's thoughts as well as identifying knowledge gaps that one needs to fill." Kornell and his team note that teachers often instruct their students to prepare for a test, but this doesn't encourage them to pick the learning strategy that should ultimately lead to a better score.



PATRICK ZACHMANN / MAGNUM PHOTOS

09

DO INTERVAL TRAINING

You've just learned a series of brilliant chess openings, so when should you go back and revise them to maximise your chances of actually remembering them when it counts? "The longer you wait the better," says Kornell. "There are limits on how long you should wait, but they are very, very long." It's true that waiting makes it harder to remember the information when you come back and test yourself, so it makes your life difficult and can feel like a bad thing. "But the harder it is, the more you learn. So when you need the information later, for example, when actually piloting that airplane or playing that chess match, you'll do better," Kornell says.

Refining this idea, Hal Pashler at the University of California, San Diego, and his team recommend spacing the intervals between revisions as a proportion of the time between initial learning and when you want to remember the information. They have discovered that the best interval to use depends on how long you want to remember something for. To maximise recall a week later, you should revise the info about two to three days after learning. "If you want to remember for a long time, it's good to have quite a lot of spacing, maybe at 10 per cent of the time," says Pashler. So if you need to recall something in a year, revise it about a month after learning and then monthly thereafter. To remember something for 10 years, you should ideally review it once a year. No one knows what brain mechanisms underpin this. But having long gaps between learning, revision and retrieval might tell your brain that this is knowledge you will probably need in the long term, he says.

Pashler's team is now trying to develop practical learning tools, based on their research. They have developed an algorithm that can generate personalised study spacing plans. The formula uses measures of how difficult the material is and how well a particular student is performing based on early test results. In one study of people learning Spanish, the team found that individualised plans improved retention at the end of the semester by 16.5 per cent, compared with 10 per cent for a one-size-fits-all spacing plan.

10

JUST DO IT

All is not lost - if you do find it hard to sit down and study, and you do badly in an exam or a performance as a result, don't beat yourself up about it.

Michael Wohl at Carleton University in Ottawa, Canada, and colleagues found that students who had forgiven themselves for procrastinating before an initial set of exams performed better in the next set and procrastinated less than students who hadn't. They also said they felt more positive.

Wohl thinks self-forgiveness allows us to shrug off negative feelings about ourselves, so helping to improve our performance in future. However, he stresses that this doesn't work for serial procrastinators. "We've found that self-forgiveness for chronic, unhealthy behaviour can help maintain the status quo - that is, continued unhealthy or poor behaviour."

If this sounds like you, you may need to take more drastic action. Learning requires willpower - self-control in the moment. Willpower is like a muscle, argues Roy Baumeister at Florida State University, so the more you use it, the stronger it gets. What's more, he has found that by exercising willpower in one area, you can boost it in another. By making an effort to do anything from keeping your house tidier to sitting up straight instead of slouching, you should also enhance your ability to just sit down and study or practise. What are you waiting for? Why not start right now? ■

Emma Young is based in Sheffield, UK. Links to studies appear in the online version of this article at bit.ly/learnonweb