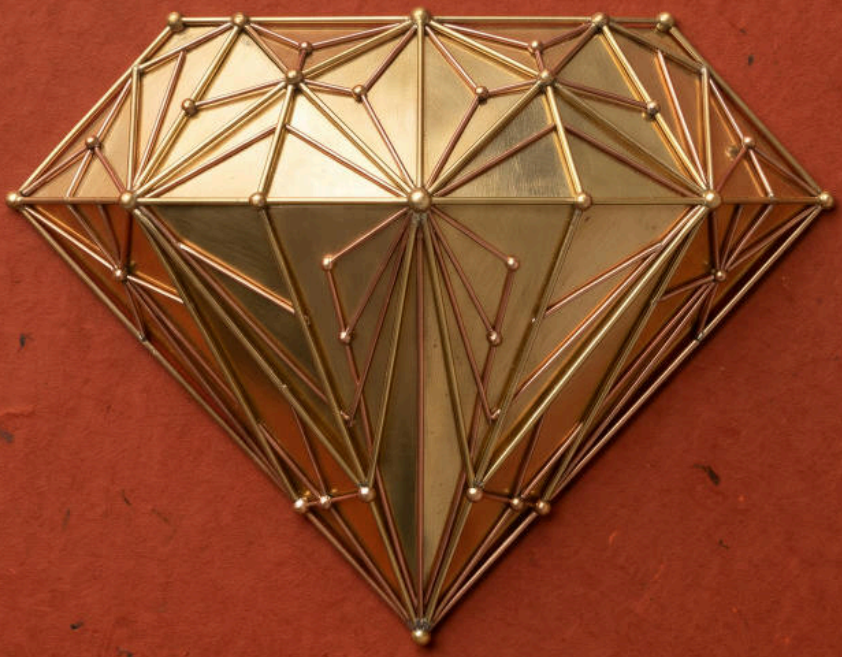
CLEVERINI SERIES

INTELLECT

PRACTITIONER GUIDE



Understanding problems and practising solutions

DAVID PETROSIAN MKERVALI

MINDCRAFT INC.

Intellect Practitioner Guide

Understanding, Developing and Preserving Your Intellectual Abilities

David Petrosian Mkervali

Contents

Author's preface 6

How to Use This Book 9

Module 1

Understanding Intellect 13

1.1 What We Mean by Intellect 14

1.2 The Essential Background 36

1.3 What Can Change? 67

Module 2

How Intellect Works with Attention, Memory and Creativity 95

2.1 Intellect and Attention: Holding the Pieces in View 97

2.2 Intellect and Memory: Knowledge Feeds the Task 128

2.3 Intellect and Creativity: Identified and Unidentified Variables 161

Module 3

Developing the Core Skills of Intellect 203

3.1 Understanding the Problem 204

3.2 Working Towards an Answer 221

3.3 Directing Your Own Intellectual Work 246

Module 4

Growing Through Learning and Practice 265

4.1 Building Knowledge You Can Use 266

4.2 Practising Effectively 284

4.3 Making Development Part of Life 312

Module 5

Sleep, Movement and Food 321

5.1 Sleep and Recovery 322

5.2 Physical Activity 332

5.3 Eating to Support the Brain 351
5.4 Stimulants and Enhancement Claims 372

Module 6

Protecting Intellectual Function Over Time 381
6.1 Managing Strain 382
6.2 Looking After the Conditions That Support the Brain 393
6.3 Staying Engaged and Recognising Change 412

Module 7

Intellectual Development at Different Ages 433
7.1 Childhood 434
7.2 Adolescence 444
7.3 Adulthood 454
7.4 Later Life 463
7.5 Individual Differences 472

Module 8

Technology, AI and Cleverini Games 483
8.1 Using Tools Well 484
8.2 Training Intellect with AI and Chatbots 493
8.3 Practising with Cleverini 528

Module 9

Your Practice Plan and Practitioner Levels 547
9.1 Establishing Your Starting Point 548
9.2 Putting the Plan into Action 566
9.3 Reviewing Progress and Practitioner Levels 574

Appendices

A. A Simple Weekly Practice Planner 603
B. Sleep, Movement and Meal Planning Worksheets 609
C. Cleverini Game Guide and Offline Alternatives 615
D. Practice Tasks with Worked Explanations 622
E. Progress Journal and Practitioner-Level Rubrics 627
F. A Short Glossary 633

G. Further Reading 638
References 643

Author's preface

WHEN I FIRST BEGAN thinking seriously about education, I pictured a glass of water beside a much larger container. You could pour the same water into both, but one had far more room to receive it.

That image captured something that bothered me. So much educational effort went into choosing the knowledge to be taught. I wanted to give equal consideration to the person who had to understand it.

The mind is more complicated than a container, of course. Still, the question stayed with me: could we make learning more effective by giving its underlying abilities a more deliberate place in education?

My family worked in science and education, so these questions felt natural to pursue. My father's early mental-training software gave them a practical form. A computer could present a task, let someone attempt it, and give them another opportunity to work at it. I became interested in what education might look like if that kind of practice had a place alongside conventional subjects.

In my PhD research, I proposed a hierarchy of learning. Foundational mental abilities would receive systematic attention first, helping prepare

the learner for the more specialized knowledge and competencies that followed.

Within that model, I distinguished the abilities involved in taking in and retaining information from those used to reason through problems. I also gave creativity its own place, because finding an approach to an unfamiliar problem can demand something different from applying a method we already know.

These distinctions helped me think about education. They also helped me make sense of my own experience.

At school, logical reasoning could be slow and difficult for me. My thoughts jumped around, and I struggled to keep the whole problem in view. I knew the discomfort of trying to understand something while feeling that I should already have understood it.

Learning tools and knowledge about mental abilities helped me work on those difficulties. Over time, I caught up. That experience is why I care about giving people a way to approach intellectual work without making them feel that every difficult task is a verdict on their ability.

The word intellect can sound intimidating. Here, I want to bring it close enough to work with. Take a problem and examine what it asks. Follow the reasoning. Find the point where you become uncertain and spend some time there.

For example, when an answer seems obvious, try explaining why it must be correct. When you can't solve a problem, identify the information you are missing. If an explanation loses you, write down the last step you understood and begin again from that point.

There is satisfaction in this kind of work. Understanding something that previously defeated you is a good reason to keep studying.

AI gives us another reason to pay attention to our own judgment. My interest in these tools comes with a question about how we use them: are they helping us understand the work, or are we accepting an answer we cannot examine? I want readers of this book to feel comfortable asking for an explanation and capable of questioning it.

Cleverini continues the educational work that began with my father's programs. It gives us a place to build exercises and make them freely available. This guide gives more space to the ideas behind the practice and to their use outside a game.

As you work through it, explain your thinking. Put it on paper when that helps. Revisit an answer you got wrong and see whether you can account for the mistake. Give a difficult idea enough time to become clear.

I would like you to finish this book more willing to engage with problems you once avoided. Keep one of those problems nearby as you read. It may turn out to be your best reason for continuing.

David Petrosian Mkervali

How to Use This Book

THIS BOOK IS ABOUT **understanding your intellectual abilities, developing them and keeping them over the years**.

> 🔑 **Key Concept:**
>
> Intellect and creativity. In this book, intellect is **solving specific tasks where the variables are identified**. A variable is any part of a task that can change. Creativity is solving tasks where the variables are not identified.

The nine modules move **from understanding to daily practice**.

1. Understanding Intellect
2. How Intellect Works with Attention, Memory and Creativity
3. Developing the Core Skills of Intellect
4. Growing Through Learning and Practice
5. Sleep, Movement and Food
6. Protecting Intellectual Function Over Time
7. Intellectual Development at Different Ages

8. Technology, AI and Cleverini Games
9. Your Practice Plan and Practitioner Levels

Module 1 explains what intellect is. **Module 2 shows how intellect works with attention, memory and creativity.** Modules 3 and 4 show how to train it.

Modules 5 to 8 cover the body, the years and the tools that support it. **Module 9 turns all of it into a plan of your own.**

A few boxes appear again and again, and each has one job. A Science Says box gives a research finding with its source. A Key Concept box defines a term. An Exercise box gives you steps to try. Each section ends with a Key idea line that sums up its main point.

Every section ends with an exercise you can do the same day. Most exercises ask you to bring a task from your own work or home, so the practice stays close to where you will use it.

> Exercise:
>
> Getting the most from each exercise.
>
> 1. Read the whole section first, then do its exercise.
> 2. Use a real task of your own wherever the exercise allows it.
> 3. Write down **what you did and what changed**.
> 4. Come back to the same exercise on another day and compare your notes.

The Practitioner Levels in Module 9 are a guide to your practice. They are this book's own tool and have not been tested. Use them to mark your progress, and keep in mind that they give no measured rank.

The first plan there runs for twelve weeks, and you can stretch or shorten it when life changes.

The book tells you **where each claim comes from and when the research is weak or mixed**.

Key idea:

Bring a real task of your own to each exercise, and compare your notes over time.



Module

1

Understanding Intellect

1.1 What We Mean by Intellect

1.1.1 Intellect, Intelligence, Thinking and Their Partners: Attention, Memory, Knowledge, Creativity

You have a flat-pack bookcase on the floor, a bag of screws and a leaflet with twelve steps. An hour later the bookcase stands up straight. I want to know which part of your mind did that work. **The answer is more than one part**, and each part had its own job.

Look back at the hour. You held **step four in your head** while you hunted for the right screw. You kept your eyes on the leaflet when the phone buzzed. You knew what a hex key was before you opened the box.

Back at the bookcase



Held step four in your head



Kept your eyes on the leaflet



Knew what a hex key was

In this book I give the word intellect a clear job. Intellect is **the part that works out the answer** once you know what the pieces are. The other jobs belong to its partners, and this section introduces them one by one.

First, a word about the science. “Intellect” is **not a technical term in psychology**. Most studies measure “intelligence” or “cognitive ability”,

the skills that tests can score. When I report a study, I say which of these it measured.

Intellect in this book

Definition

Intellect

The part that works out the answer

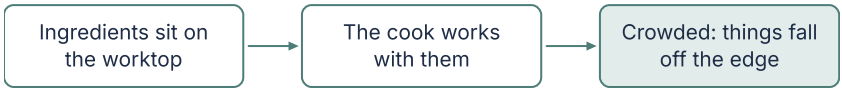
> **Key Concept:**
>
> Intelligence and intellect. Intelligence is what researchers measure with tests of reasoning, words, numbers and shapes. In this book, intellect is **the working part behind those scores**, the part that solves a task. The two overlap a lot, and they are not the same word.

Thinking is the third word in the title, and it needs its own place. You can be quick at test problems and still fall for a poor argument. Researchers found that "a large number of thinking biases are uncorrelated with cognitive ability" (Stanovich & West, 2008). Thinking well and scoring high are **partly separate skills**.

Memory is the first partner, because a task you cannot hold in mind is **a task you cannot solve**. The kind of memory at work here is working memory, the small space where you keep things for a few seconds while you use them.

Picture a kitchen, where intellect is the cook and working memory is the worktop. Ingredients sit there while you cook, and **a bigger, tidier worktop** lets you handle more at once. When it gets crowded, things fall off the edge. Working memory works the same way for the steps of a task.

The kitchen



> **Science Says:**
>
> Working memory and intelligence are **related but not the same**. One meta-analysis of 86 samples put the link at about .48 (Ackerman et al., 2005). Another team, using hidden scores built from many tests, found a typical link of about .72, sharing "approximately 50% of their variance" (Kane et al., 2005).

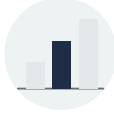
Those numbers are correlations. A correlation shows **how strongly two things go together**. It runs from -1 to 1. At 0 the two have nothing to do with each other, at 1 they rise in perfect step, and at -1 one rises in step as the other falls.

A correlation of .48 is **a fair link with many exceptions**. People high on one measure tend to be high on the other, and plenty are not. A correlation of .72 is a strong link, with fewer exceptions.

Working memory and intelligence



One meta-analysis of 86 samples: about .48



Hidden scores built from many tests: .72



Related but not the same

A meta-analysis is **a study of many studies**. Researchers gather every good study on one question and combine the results. The "hidden scores" in the Kane team's work are averages built from several tests at

once, which **cuts down the noise** of any single test. That is why the two teams got different numbers from similar data.



Method changes the answer because each single test carries **a little random error**. Averaging many tests steadies the reading, so the link looks stronger. Both numbers are honest, and I report both.

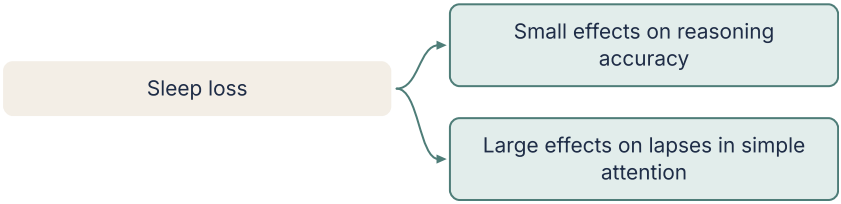
> **Science Says:**
>
> A strong memory is **a different thing from a strong intellect**. A study of people with superior memory found that their skill "was not driven by exceptional intellectual ability or structural brain differences" (Maguire et al., 2003). They "used a spatial learning strategy", tying each item to a place they could picture.

> **Key Concept:**
>
> Executive attention. Kane and colleagues see attention as **the core of working memory**. Their comment on Ackerman's work "clarifies the authors' 'executive attention' view" of working memory (Kane et al., 2005). It is one theory. Other researchers do not share it.

Attention is the second partner. Back at the bookcase, attention kept your eyes on the leaflet **when the phone buzzed**. Without it, step four would have slipped off the worktop before you used it.

Of the four partners, attention is often **the one that tires first**. A review of 70 articles on sleep loss found small effects on reasoning accuracy and large ones on lapses in simple attention (Lim & Dinges, 2010). The studies kept people awake for up to two days, so they show short spells of lost sleep.

Sleep loss, 70 articles

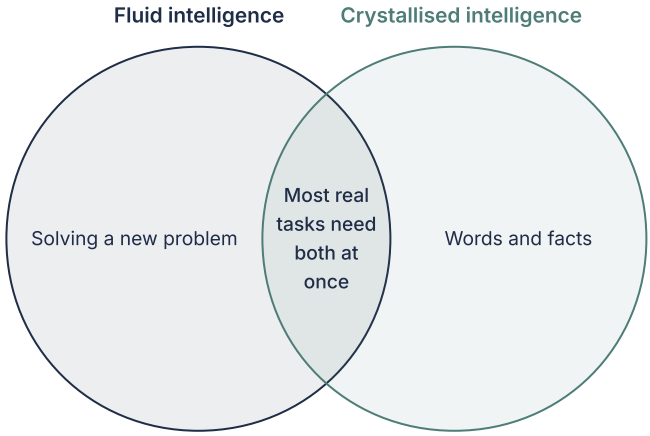


Knowledge is the third partner, and it is the one people most often **mix up with intellect**. Knowing what a hex key is helps you build the bookcase. Working out which screw goes where, from a drawing you have never seen, is a different job.

Psychologists drew this line long ago. Cattell split intelligence into **fluid and crystallised** kinds (Cattell, 1963). Ackerman later built a model of adult intellect from four parts, "process, personality, interests, and knowledge" (Ackerman, 1996).

> 🗝 **Key Concept:**
>
> Fluid and crystallised. Fluid intelligence is **solving a new problem** you have not met before. Crystallised intelligence is what you have learned and can use, such as words and facts. Fluid ability helps you build knowledge, and knowledge gives your fluid ability something to work on.

Fluid and crystallised



Back in the kitchen, the cupboards are your crystallised store, full of facts and words you have put away. The cook is the fluid part, **the one who picks the right jar** and puts it to work on today's dish.

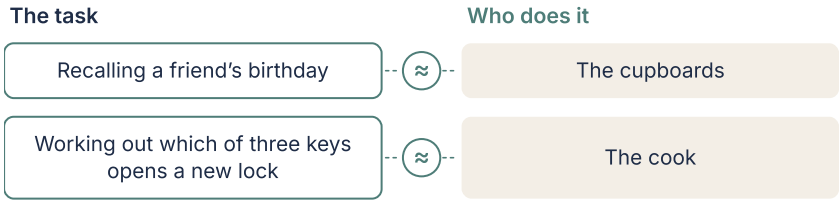
Ackerman's model adds two things the cupboards alone miss. **Personality and interests** decide what you stock. Someone who loves cars fills a whole cupboard on engines, and that store then makes car problems easier to solve.



A cook taking two jars from different cupboards to make one dish.

The split shows up in daily life all the time. Recalling a friend's birthday **draws on the cupboards**, because you either stored it or you did not. Working out which of three keys opens a new lock is a job for the cook, because nobody has told you the answer before.

The cupboards and the cook



Most real tasks **need both at once**. A doctor uses years of stored facts and then reasons about one new patient. A plumber knows how pipes are built and then works out why one house has no hot water. Intellect does its best work when knowledge gives it plenty to use.

> **Science Says:**
>
> The same broad ability **shows up at school and at work**. A review of one reasoning test found that it predicted results in both settings. The authors wrote that their findings "contradict the notion that intelligence at work is wholly different from intelligence at school" (Kuncel et al., 2004).

Creativity is the fourth partner. It comes in when **the pieces of the task are not clear yet**, and you must decide what the task even is. Designing a bookcase for an odd corner, with no leaflet, is that kind of job.

> **Science Says:**
>
> Creativity and intelligence **overlap only a little**. One review found a correlation of r = .174 between them (Kim, 2005). A later review found r = .25 (Gerwig et al., 2021). Both numbers sit at the loose end of the scale, closer to 0 than to 1.

Creativity and intelligence



Kim, 2005: r = .174



Gerwig et al., 2021: r = .25



Both sit at the loose end

A high scorer is **not always a strong creator**, and a strong creator need not top the tests. The two skills share a little ground and keep a lot of their own. In this book, creativity gets its own place beside intellect, and the two are never treated as one skill.

Each partner can be weak on one day and strong on the next. A tired evening **shrinks the worktop**, a noisy room pulls attention away, and a new subject leaves the cupboards bare. None of these says much about your intellect itself.

Performance will vary



On different occasions



In different domains



As judged by different criteria

Researchers have long accepted this. An overview by a team of psychologists says that a given person's "intellectual performance will

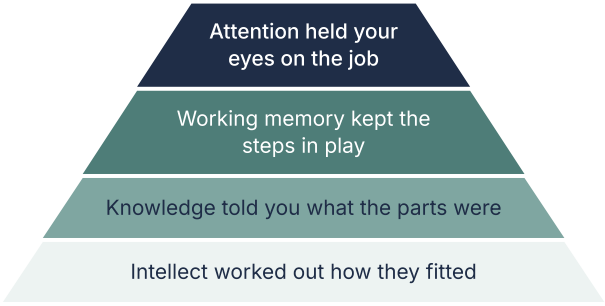
vary on different occasions, in different domains, as judged by different criteria" (Neisser et al., 1996). **One bad evening is no verdict** on your mind.

Weak on one day

On one day		The partner
A tired evening	≈	Shrinks the worktop
A noisy room	≈	Pulls attention away
A new subject	≈	Leaves the cupboards bare

Put the partners together and the bookcase makes sense. Attention held your eyes on the job, working memory **kept the steps in play**, knowledge told you what the parts were, and intellect worked out how they fitted. Creativity waited in reserve for the day there is no leaflet.

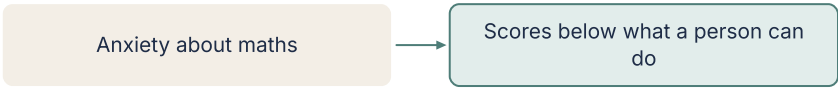
The partners together



> **Exercise:**
>
> Name the partner.
>
> 1. Pick one task you did today, such as cooking, a work report or fixing something.
> 2. Write down **which partner helped most**, choosing from attention, memory, knowledge and creativity.
> 3. Write down which partner let you down, if any, and what happened.
> 4. Ask whether intellect itself was the problem, or one of its partners.

Maths anxiety is one such case. Anxiety about maths can **pull scores below what a person can do** (Ashcraft, 2002). The sums have not got harder, and the person has not lost any ability. Something beside intellect has got in the way.

Maths anxiety



When a task goes wrong, it is easy to blame your brains. Very often the fault lies with **a partner that needs help**, such as a crowded worktop, a buzzing phone or a missing fact. Knowing which one failed tells you what to fix.

A partner that needs help



Key idea:

Intellect works with partners. **Attention and memory hold the task, knowledge feeds it**, and creativity steps in when the pieces are not clear.

Quick check:

Which partner keeps the steps of a task in mind for a few seconds? Answer: working memory.

1.1.2 Definitions Through the Ages, and This Book's Definition

Ask five friends what intellect is, and you may get five answers. One says being clever, another says being good at school, and a third says wisdom. The choice for this book is which one to stand on. **Each answer catches part of the word**, and a book needs one meaning it can use on every page.

People have argued about the word for well over two thousand years. Before I give you this book's answer, it helps to **walk through the older ones**. Each tried to name the same part of us.

The Greek writer Aristotle used the word nous. An encyclopedia of philosophy explains his view this way, saying "the mind or intellect (nous) may not be enmeshed in the body" (C. Shields, 2020). For Aristotle, then, **intellect might work without being tied to the body**, which set it apart from the rest of the mind.

Definitions through the ages



Far to the east, the Sāṅkhya school of Indian philosophy gave the same rank to a word called buddhi. One account says "the highest is intellect or buddhi : it is not conscious" (Ruzsa, n.d.). **Intellect sat at the top** of the list, and yet it was not conscious.

> **Key Concept:**
>
> Nous and buddhi. Two old words, from Greece and India, both **name intellect**. Nous is Aristotle's word, for an intellect that may not be bound up with the body. Buddhi is the word in Sāṅkhya, for the highest part of a list, a part that is not conscious.

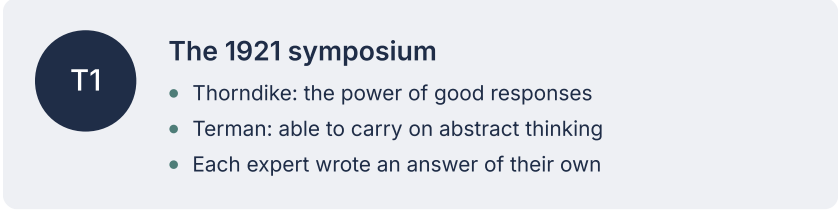
Centuries later, in Europe, Thomas Aquinas wrote a whole work called De unitate intellectus, **On the Unity of the Intellect**, in 1270

(Pasnau, 2022). The title alone shows that intellect was **a subject worth a whole book** to him.

In his larger work, the Summa Theologiae, Aquinas wrote, "This word 'intelligence' properly signifies the intellect's very act, which is to understand" (Aquinas, n.d., I, q.79, a.10). He drew **a neat line between the two words**. Intellect is the power, and intelligence is that power in use, "as act is from power".

Philosophers kept writing about the mind. Locke published his Essay in 1689, and Kant published his Critique in 1781, with a revised edition in 1787 (Uzgalis, 2022; Rohlf, 2024). **The big books on the mind** came long before any test.

The 1921 symposium



In 1921 a psychology journal asked a group of experts to write about **what intelligence is and how to measure it** ("Intelligence and its measurement", 1921). The contributors included Thorndike, Terman, Thurstone, Pintner, Henmon, Woodrow and Yerkes. **Each expert wrote an answer of their own.**

> **Key Concept:**
>
> The 1921 symposium. Two of the answers show **how far apart the experts stood**. Thorndike wrote, "we may then define intellect in general as the power of good responses from the point of view of truth or fact" (Thorndike, 1921). Terman wrote, "An individual is intelligent in proportion as he is able to carry on abstract thinking" (Terman, 1921).

Wechsler's book on testing adults first came out in 1939, and a fourth edition followed in 1958 (Wechsler, 1939; Wechsler, 1958). In its third edition he called intelligence an "aggregate or global" ability that lets a person **"act purposefully"** (Wechsler, 1944). Later, Sternberg offered a theory of his own (Sternberg, 1999), and H. Gardner proposed many separate intelligences (H. Gardner, 1983).

Wechsler's book on testing adults



> **Science Says:**
>
> H. Gardner's theory of many separate intelligences has **weak support from the evidence** (Waterhouse, 2006). H. Gardner's intelligences are often mixed up with "learning styles", the idea that each person learns best through one sense. The two ideas are separate (Pashler et al., 2008).

Later in the century, researchers **tried to agree on one definition**. A statement first printed in a newspaper in 1994, with 52 signatures, begins, “Intelligence is a very general mental capability that, among other things, involves the ability to reason, plan, solve problems, think abstractly, comprehend complex ideas, learn quickly and learn from experience” (Gottfredson, 1997).

The definition goes on, “It is not merely book learning, a narrow academic skill, or test-taking smarts” (Gottfredson, 1997). Parts of that statement are disputed, and **I quote only its definition**.

> **Science Says:**
>
> A review by another team described **how people differ**, “Individuals differ from one another in their ability to understand complex ideas, to adapt effectively to the environment, to learn from experience, to engage in various forms of reasoning, to overcome obstacles by taking thought” (Neisser et al., 1996).

The same review admitted that **the experts still disagree**. When “two dozen prominent theorists were recently asked to define intelligence, they gave two dozen somewhat different definitions” (Neisser et al., 1996; Sternberg & Detterman, 1986). In the review’s words, no definition “commands universal assent”.

What it is and what it does

The old writers	The scientists
What intellect is	What intelligence does
Where it sits in the mind	How a test could catch it

Looking back over this list, a pattern shows. The old writers talked about **what intellect is** and where it sits in the mind. The scientists talked about what intelligence does, and how a test could catch it. Neither group drew a firm line between solving, creating and thinking.

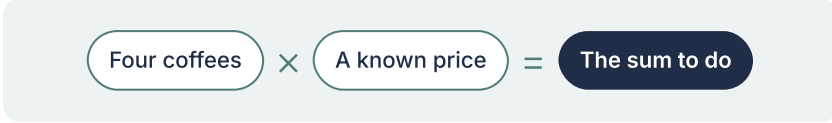
Every definition above packs **several jobs into one word**. Thorndike's "good responses", Gottfredson's list and Neisser's list mix solving, learning and adapting together. I pull those jobs apart, so each one can be seen and trained on its own.

The line this book draws is my own, and it is **the working definition for every page** that follows. It has three parts, one for intellect, one for creativity and one for thinking.

> Definition:
>
> **INTELLECT:** solving tasks where the variables are identified.

A variable is **one of the pieces a task depends on**. Think of a shopping list. A list that says **four coffees at a known price** has clear pieces. You have the price, the number of cups and the sum to do.

Four coffees at a known price



Creativity is the partner that handles the other case. In this book, creativity is **solving tasks where the variables are not identified**. Before you can solve the task, you must work out what its pieces even are.



Two shopping notes side by side. On the left, a list with every item and amount. On the right, a note that says “get what we need for Sunday”.

A list with every item and amount is **an intellect task**. The variables are all there, and you need to follow them well and spot the problem when the shop has run out of one item. “Get what we need for Sunday” is a creativity task, because nobody has told you what Sunday needs.

The second note turns into the first once you name the pieces. You decide **who is coming, what they will eat and what is already in the house**. Then the note becomes a list, and the list is a task your intellect can finish.

From note to list

If	Then
You name the pieces	→ The note becomes a list your intellect can finish

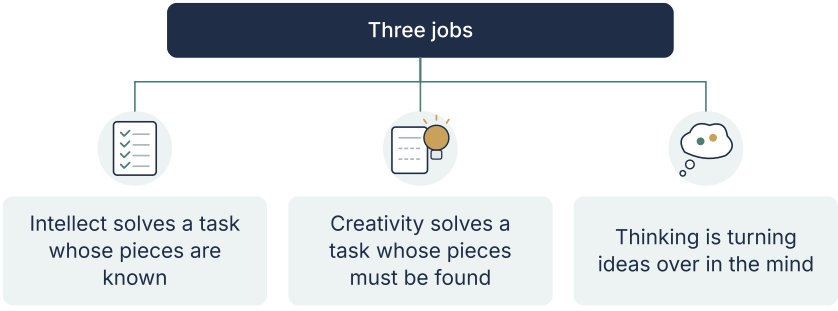
The last part of the definition is the one people find strangest. **Thinking is not intellect.** You can think all day, turning a worry over

in your head, and solve nothing. You can solve a sum quickly with very little reflection at all.

Confucius saw thought and learning as partners long ago. "The Master said, 'Learning without thought is labour lost; thought without learning is perilous.'" (Confucius, n.d., 2.15). **Thought and learning need each other**, and neither one is the same job as solving.

> **Key Concept:**
>
> Three jobs. Intellect solves a task whose pieces are known. Creativity solves a task whose pieces must be found. Thinking is **turning ideas over in the mind**, and it can happen with or without solving anything. Some researchers study thinking dispositions, the habits a person brings to a task, such as checking a claim before accepting it (Perkins et al., 1993; Tishman et al., 1993).

Three jobs



My definition is a working tool. It sits **close to some science and apart from other science**. The closest match is Simon's split between well-structured and ill-structured problems (Simon, 1973). A well-structured problem has clear pieces, and an ill-structured one does not.

> **Science Says:**
> Simon himself wrote that "the boundary between well structured and ill structured problems is vague, fluid and not susceptible to formalization" (Simon, 1973). He saw it as **a feature of problems and the people solving them**. Guilford counted divergent thinking, the kind that finds many answers, as part of intellect (Guilford, 1950).

The thinking line has support, with limits. Many thinking biases show no link with test scores (see 1.1.1). Yet the same study found that ability "does correlate with the tendency to avoid some rational thinking biases" (Stanovich & West, 2008). **The two are partly separate**, and the evidence allows no stronger claim.

> **Key Concept:**
> Thinking biases. The study tested biases such as **"anchoring effects", "myside bias" and the "sunk-cost effect"** (Stanovich & West, 2008). Anchoring is when the first number you hear pulls your guess towards it. Myside bias is judging an argument by whether it agrees with you.

Thinking biases



Anchoring effects



Myside bias



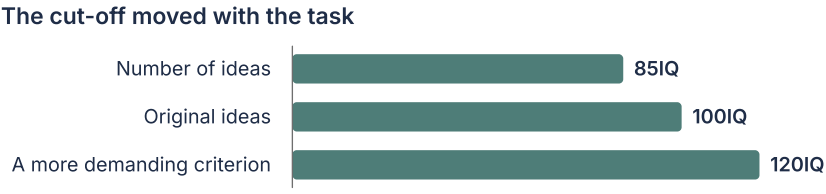
Sunk-cost effect

The sunk-cost effect is **sticking with a plan because of what you have already spent** on it, such as sitting through a dull film because the

ticket cost money. Clever people can fall for all three. **Higher ability protects against some biases**, and the protection is only partial (Stanovich & West, 2008).

The creativity line has the same shape. The **small overlap between creativity and intelligence** (see 1.1.1) fits a book that treats them as two partners.

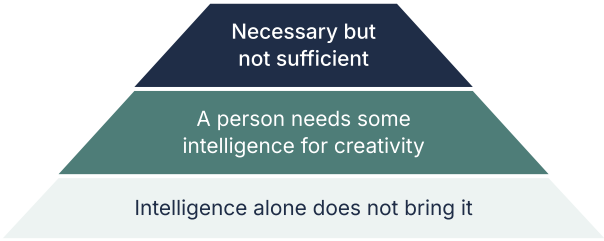
Some researchers proposed a threshold, a cut-off above which more intelligence stops helping creativity. IQ is **the score from an intelligence test**. One team found "no compelling reason why the threshold should be fixed at an IQ of 120" (Jauk et al., 2013). They found thresholds for creative potential "but not for creative achievement". **The cut-off idea is still open.**



In that study of 297 people, **the cut-off moved with the task**. For the number of ideas, it sat at "an IQ of around 85 IQ points". For original ideas, "a threshold was detected at around 100 IQ points", and "a threshold of 120 IQ points emerged when the criterion was more demanding" (Jauk et al., 2013).

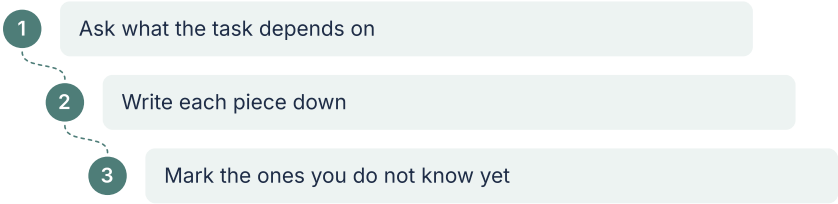
> **Science Says:**
>
> A larger project ran "eight studies (total N = 12,255)", where N is the number of people tested. It found "a consistent pattern that supports the necessary-but-not-sufficient relationship" (Karwowski et al., 2016). **Necessary but not sufficient** means a person needs some intelligence for creativity, and intelligence alone does not bring it. The study gives no single cut-off score.

Necessary but not sufficient



Naming the pieces is a skill you can use straight away. Ask **what the task depends on**, write each piece down, and mark the ones you do not know yet. A task with every piece named is ready for intellect. A task with pieces missing needs some creative work first.

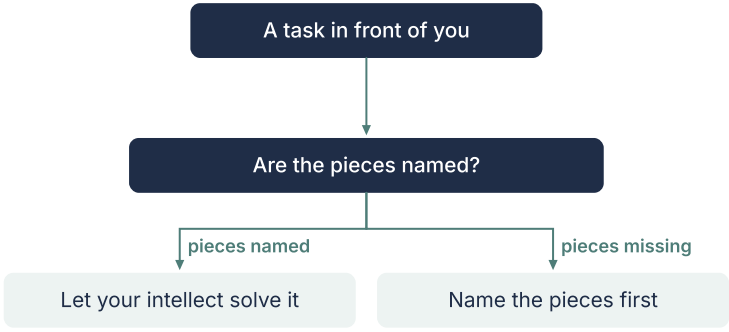
Naming the pieces



> **Exercise:**
>
> Sort the tasks.
>
> 1. List eight tasks from your week.
> 2. For each one, write "pieces named" if you knew what the task depended on, or "pieces missing" if you had to work that out first.
> 3. Circle the task that took the most effort, and note **which kind it was**.
> 4. For one "pieces missing" task, write down the pieces you found. You have just turned a creativity task into an intellect task.

The final step of the exercise is the reason I use this definition. Once you can see **which kind of task is in front of you**, you know what to do next. Name the pieces first, and then let your intellect solve it.

Which kind of task?



Tasks set out this way are very old. An early example is **the Rhind papyrus**, an Egyptian scroll that the British Museum calls "probably a mathematics textbook", with eighty-four problems (British Museum,

n.d.). A textbook problem arrives with its pieces named, which makes it the clearest kind of intellect task.

Key idea:

In this book, intellect solves a task once its pieces are named, creativity works where they are not, and thinking is a separate job.

Quick check:

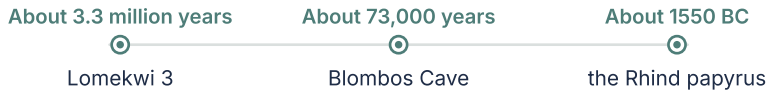
A friend asks you to plan a party with no budget, date or guest list. Is that an intellect task or a creativity task? Answer: a creativity task, until the pieces are named.

1.2 The Essential Background

1.2.1 From Early Humans to the First Writers on Intellect

On a dry hillside in Kenya, at a site called Lomekwi 3, researchers dug up a set of chipped stones. Someone had struck them on purpose, flake by flake, to make an edge. A stone can tell us about a mind. **The edge itself holds the clue**, because it shows a plan carried out by hand.

From stones to scrolls



A sharp edge does not happen by luck. To make one, a toolmaker had to **see the result in mind before striking**, choose a good stone and hit it at the right angle. Each of those steps is a small task with named pieces, the kind of task this book calls intellect.

The Lomekwi stones are **about 3.3 million years old** (Harmand et al., 2015). They are older than Homo, the group of species that our own species belongs to. Tool-making began before anyone who looked like us was alive.

The long story of intellect starts in places like this. It moves from stones to marks on rock, then to **counting on clay and papyrus**, and at last to the first people who wrote about the mind itself. This section walks that path in order.

The revolution that wasn't

The human mind		A town
The signs of modern behaviour built up slowly	≈	One house goes up, then a shop, then a road, then a school
No one sudden moment	≈	No single day marks the moment

> **Key Concept:**
> Homo. Scientists sort living things into groups. Homo is **the group that our species belongs to**, Homo sapiens. The Lomekwi tools are older than the oldest known members of the group.

Much later, people began to make marks that seem to stand for something. In Blombos Cave, on the coast of South Africa, researchers found **an abstract drawing** in layers about 73,000 years old

(Henshilwood et al., 2018). An earlier paper reported finds from the same cave (Henshilwood et al., 2002).

Calling these marks "symbolic" is **an interpretation**. Nobody left a note to say what they meant. Even so, a mark that stands for an idea is a big step, because it lets one mind hand an idea to another.

Many people imagine **one sudden moment** when the human mind switched on, about 50,000 years ago. McBrearty and Brooks argued against that picture in a paper titled "The revolution that wasn't" (McBrearty & Brooks, 2000). In their view, the signs of modern behaviour built up slowly over a much longer time.

Two pictures of the modern mind

	One sudden moment	A gradual build-up
Who	Many people imagine it	McBrearty and Brooks
The claim	The human mind switched on about 50,000 years ago	A gradual build-up of modern behaviour

A town grows in a similar way. One house goes up, then a shop, then a road, then a school. **No single day marks the moment** it became a town. Looking back, you can only say that at some point it clearly was one.



A small town at four moments in time, from one lone house to a shop, a road and a school.

> **Science Says:**
>
> McBrearty and Brooks argued for **a gradual build-up** of modern behaviour (McBrearty & Brooks, 2000). The debate is still live, and their paper is one side of it. Any single date for the start of the modern mind is doubtful.

Brains changed over the same long stretch. Studies have traced **how human brain size and shape changed** over time (Du et al., 2018; Neubauer et al., 2018). Size, though, is a weak guide to intellect. A bigger brain does not by itself mean a better problem solver.

What counts is **how well a brain is used**, and size alone cannot show that. One paper looks at stone tools, language and the brain together, as parts of human evolution (Stout & Chaminade, 2012).

Brains over time



Size is a weak guide to intellect



What counts is how well a brain is used



Stone tools, language and the brain together

Language is the other big change, and it has gathered its own myths. One paper set out what is special about the human ability for language (Hauser et al., 2002). A gene called FOXP2 is **often called "the language gene"**, and that label is wrong.

FOXP2 has been studied closely (Enard et al., 2002). A later team published a paper called "No Evidence for Recent Selection at FOXP2" (Atkinson et al., 2018). Selection here means a gene spreading through

a population because it helped people survive. Its title says it plainly. **No single gene gives us language.**

Some of the clearest evidence of early intellect comes from people who never wrote it down. In 1976 a voyaging canoe called Hōkūleʻa sailed from Hawaiʻi to Tahiti. Its navigator was **Mau Piailug, from Satawal in Micronesia** (Polynesian Voyaging Society, n.d.).

The canoe left on 1 May, reached the atoll of Mataiva on 1 June and arrived in Papeʻete on 4 June. An atoll is a ring of coral islands around a lagoon. **Mau navigated the outward leg by traditional wayfinding.** The return leg was sailed by "modern means" (Finney, n.d.).



The voyage shows that knowledge can live in people, passed from one navigator to the next. Lewis wrote about this kind of knowledge in a book called We, the Navigators (Lewis, 1972). Finney studied the voyaging canoes themselves. Wayfinding means **finding the way at sea without instruments**, by reading the stars, the waves and the wind.

Rebuilt double canoes, Finney found, "can make good a course to windward up to approximately 75 degrees off the wind on long ocean voyages" (Finney, 1977). **Sailing to windward** means making headway towards the side the wind blows from, by sailing at an angle to it. A crew that sails this way can plan a trip home.

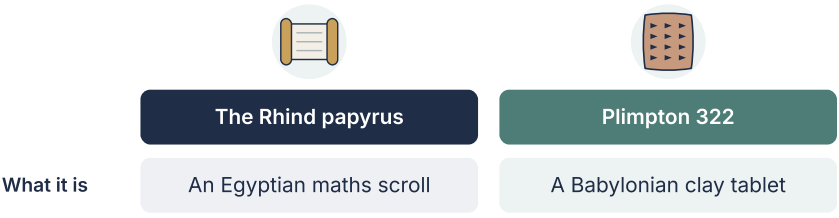
Writing gave intellect a new tool. The Egyptian maths scroll called the Rhind papyrus shows **when this tool was in use**. Papyrus is a writing sheet made from a reed that grows by the Nile. The scroll was copied

about 1550 BC, in “year 33 of Apophis”, a ruler of the time (British Museum, n.d.).

> **Key Concept:**
>
> The Rhind papyrus and Plimpton 322. The Rhind papyrus is **an Egyptian maths scroll** with worked problems (British Museum, n.d.; Imhausen, 2016). Plimpton 322 is **a Babylonian clay tablet** of advanced mathematics, and what it was for is contested.

Some writers have claimed that Plimpton 322 is **an early table of trigonometry**, the maths of triangles and angles. One paper says, “We trace the origins of trigonometry to the Old Babylonian era” (Mansfield & Wildberger, 2017). Robson read the tablet differently (Robson, 2001; Robson, 2002). The claim is contested, so this book does not make it.

Maths in writing



Writing about the mind itself came next, and it came from **many places at once**. No single people or place invented reasoning. Greek, Chinese and Indian writers, and later Islamic, Jewish and West African ones, each built their own ideas about intellect.

In Greece, Plato and Aristotle wrote about the mind (Kraut, 2026). Aristotle’s word nous is one of the oldest names for intellect (see 1.1.2).

The Greek writers asked what knowing is, and how the mind reaches it.

> **Science Says:**
>
> In China, the Mohist Canons are "a set of brief statements on a variety of philosophical and other topics by anonymous members" of the Mohist school (Fraser, 2024). To test a doctrine, the Mohists compared it with **"three models"**, the deeds of the sage-kings, what people perceive and what brings benefit (Fraser, 2024). Confucius, Xunzi and the Daoist writers added their own views (Csikszentmihalyi, 2024; Goldin, 2025; Hansen, 2025), and Confucius tied learning to thought.

The Mohists **reasoned by likeness**. In logic, their theory "yields a model of analogical argumentation" (Fraser, 2024). An analogy argues from one case to a similar one, on the grounds that cases alike in some ways tend to be alike in others.

The Mohists reasoned by likeness



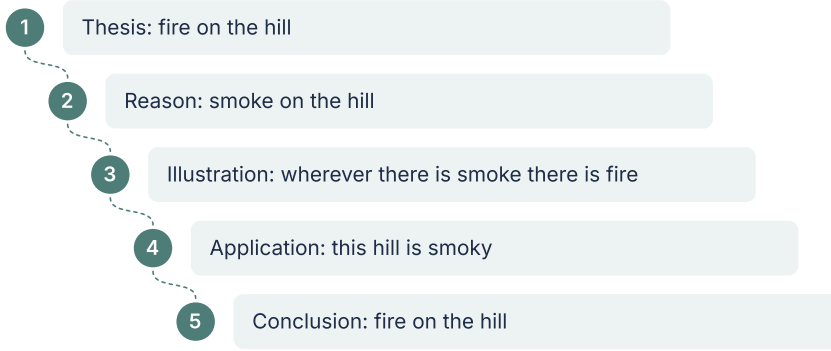
In India, a text called the Nyāya-sūtra, **Aphorisms on logic**, is credited to Gautama, whose other name is Akṣapāda, around the 2nd century CE (Gillon, 2023). An aphorism is a short saying that packs a rule into a few words. The same tradition of Indian thought gave intellect the name buddhi (see 1.1.2).

Nyāya writers made inference **a step-by-step job**. Their standard case runs, “There is fire on that mountain, since there is smoke on it,” backed by the awareness “that fire is invariably concomitant with smoke” (Dasti, n.d.). Invariably concomitant means that the two always come together, so where you see smoke you can infer fire.

Indian logicians called the linking rule **pervasion**, or vyāpti. One thing pervades another when, wherever the second is found, the first is found with it (Gillon, 2023). Early Buddhist examples include the inference of fire from smoke and “of the presence of a lion from its roar”.

Every piece of that reasoning is named, the smoke, the fire and the rule. In the terms of this book, **an inference of this kind is an intellect task**. Nyāya writers set it out in a fixed form, which “is often truncated into three steps” in practice (Dasti, n.d.).

The five-step argument



> **Key Concept:**
>
> The five-step argument. Nyāya set out an inference in **five steps**, with a stock example (Dasti, n.d.). The thesis says there is fire on the hill. The reason says there is smoke on the hill. The illustration gives the rule, wherever there is smoke there is fire, “like a kitchen hearth and unlike a lake”. The application says this hill is smoky. The conclusion says there is fire on the hill.

Another school kept **the same five-part form**. The writer Praśastapāda “retains the five members for the syllogism, in keeping with the five members of the analogical syllogism set out by Vātsyāyana” (Gillon, 2023). His own example was different, “Wind is a substance ... because it possesses action”.

Writers on intellect



al-Fārābī wrote a treatise called On intellect



Ibn Sīnā wrote on the mind

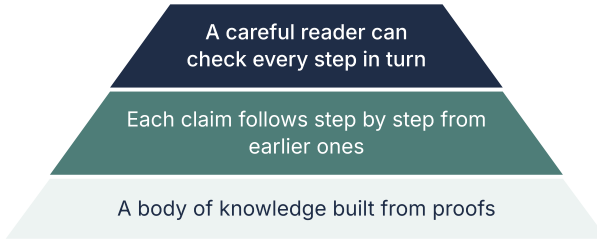


Ibn Rushd wrote long commentaries

> **Science Says:**
>
> Greek learning reached the Islamic world through translation. The ‘Abbasids were a ruling family of the Islamic world, based in Baghdad. Early ‘Abbasid rulers backed **a great movement to put Greek works into Arabic** (D’Ancona, 2026; Gutas, 1998). Syriac Christian scholars “took part” in the work (D’Ancona, 2026), and Greek philosophy found new readers in Arabic. Syriac is a language of the Middle East, written by many Christian scholars of the time.

In the Islamic world, al-Fārābī wrote a treatise called “On intellect” (Druart, 2024). **Ibn Sīnā wrote on the mind** in the same tradition (Gutas, 2025). The “physician and judge Ibn Rushd (1126-1198)”, known in Europe as Averroes, wrote long commentaries on Aristotle (Ben Ahmed & Pasnau, 2025). His work became “a foundational source for post-classical European thought”.

Demonstrative science



> **Key Concept:**
> Demonstrative science. In his commentaries, Ibn Rushd “attempts to develop philosophy as a demonstrative science” (Ben Ahmed & Pasnau, 2025). A demonstrative science is **a body of knowledge built from proofs**, where each claim follows step by step from earlier ones. A careful reader can check every step in turn. A commentary is a book that explains another book, passage by passage.

The Jewish writer Maimonides, who lived from 1138 to 1204, **completed The Guide of the Perplexed in 1190** (Seeskin, 2024). The Guide “seeks to resolve the conflict between religious knowledge and secular” (Seeskin, 2024). Reason and faith, for him, had to be made to fit.

Ibn al-Haytham wrote about optics, the science of light and sight (Sabra, 1989; O'Connor & Robertson, 1999). He built his study of light **on experiments**, and he urged "that we seek the truth and not be swayed by opinions" (O'Connor & Robertson, 1999).

Ibn al-Haytham



Ibn al-Haytham

- Built his study of light on experiments
- The Book of Optics ran to seven volumes
- Translated into Latin in 1270

His Kitab al-Manazir, the Book of Optics, ran to seven volumes. It was "translated into Latin as Opticae thesaurus Alhazeni in 1270", so **European readers could study it** (O'Connor & Robertson, 1999). He is sometimes called "the first scientist", and that title is an overstatement.

> Exercise:
>
> Pass it on without paper.
>
> 1. Choose one method you know well, such as a route across town or the way to fold a shirt.
> 2. Teach it to a friend **by talk alone**, with no notes or drawings.
> 3. Ask your friend to do it back to you.
> 4. Write down which parts were hard to pass on, and why.
> 5. Teach it again with **one drawing allowed**, and note what changed.

In West Africa, **UNESCO lists Timbuktu as a World Heritage site**. Its page calls the city "an intellectual and spiritual capital and a centre for the propagation of Islam throughout Africa in the 15th and 16th centuries" (UNESCO World Heritage Centre, n.d.). The page names the University of Sankore and notes a trade in manuscripts.

Each centre added a house



Each of these centres **added a house to the town**. The Mohists added tests for a claim, Nyāya writers a rule for inference, Ibn Rushd a science of proof and Ibn al-Haytham the habit of checking by experiment. Once written down, each idea could travel across the old world.

Looking back over the whole path, one pattern stands out. Intellect did not appear in one place on one day. **It built up slowly**, from a struck stone to a scratched mark, from a scroll of sums to a written theory of the mind, and on to the old manuscript libraries of Timbuktu.

The pattern is good news for anyone who wants to grow their own intellect. **Small steps added up** for the human race, the way a town grows house by house, and they add up for one person in the same way. Each new tool, mark and method gave the next person more to work with.

Small steps added up



Key idea:

Intellect grew slowly, and people in many parts of the world wrote about it.

Quick check:

Which island was Mau Piailug from? Answer: Satawal, in Micronesia.

1.2.2 How People Trained and Measured Intellect

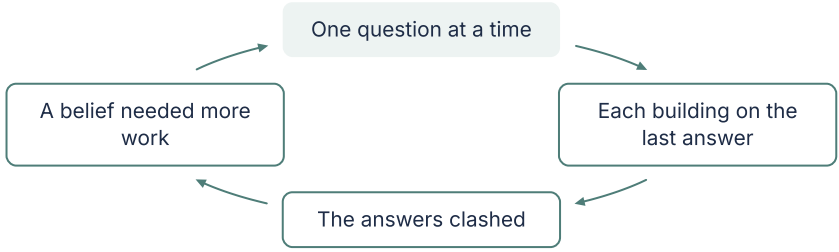
A FRIEND SAYS A NEW phone is the best on the market. You ask how they know, and they name a review they cannot remember. The real issue is whether plain questions like these can train a mind the way exercise trains a muscle. **Questions were among the first training tools**, and people have used them for thousands of years.

The oldest training methods were **conversations, lessons and drills**, and the newest are tests that try to put a number on the result. This section looks at both, and at what the evidence says about them.

Socrates questioned people about what they thought they knew. Step by step, his questions led his partners towards **"realizing their own ignorance"** (Nails, 2022). Scholars call this method the elenchus.

A line is often pinned on him, "I know that I know nothing". **The line is not found in that form** in Plato's writing (Fine, 2008). What the dialogues show is the questioning itself, one patient step after another.

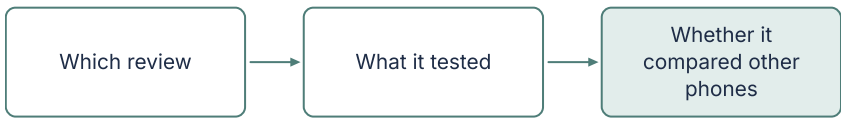
The elenchus



> **Key Concept:**
> The elenchus. Socrates asked **one question at a time**, each building on the last answer. When the answers clashed, the speaker saw that a belief needed more work. The method trains the habit of checking a claim before you lean on it.

A good question works like a torch in a dark room. It does not fix anything by itself, and **it shows where the furniture is**. Once you can see the gaps in a belief, you know what to learn next.

Three questions about the review



Back to the friend and the phone. Three questions might run from which review, to what it tested, to whether it compared other phones. By the third answer, **your friend can see the gap** in the claim, and the next step is clear, to go and find that review.



A torch beam crossing a dark room and landing on one chair.

Medieval schools in Europe built a full course around training the mind. They taught **the seven liberal arts**, made of "the trivium: grammar, logic, rhetoric; the quadrivium: arithmetic, geometry, astronomy, music" (Marenbon, 2024).

> 🗝 **Key Concept:**
>
> The trivium and the quadrivium. The trivium is **the three arts of words**, grammar, logic and rhetoric. The quadrivium is the four arts of number and pattern, arithmetic, geometry, astronomy and music. Logic is the study of good reasoning, and rhetoric is the art of speaking to persuade. Together they made the seven liberal arts.

The seven liberal arts



Trivium: grammar, logic, rhetoric



Quadrivium: arithmetic, geometry, astronomy, music



Logic: the study of good reasoning

Students practised arguing, alongside reading. One kind of formal debate, called obligationes, a Latin word for obligations, set up **rules at the start** that a speaker had to follow. In these debates, "explicit deviation from truth was allowed through some specific additional obligation laid down at the beginning" (Yrjönsuuri, 2022).

Nobody pretended the odd starting point was true. **The odd rule was the point**, because it made students reason carefully from a given start.

Other teachers trained memory. A historian traced **the old memory arts** across many centuries in a book called The Art of Memory (Yates, 1966). A modern study found that mnemonic training, the use of memory tricks, "reshapes brain networks to support superior memory", as its title puts it (Dresler et al., 2017).

Memory training improves memory for the kind of material trained. The hard question for any training is **transfer**, whether a skill learned in one place helps in another. As early as 1901, a study found clear limits to transfer between tasks (Thorndike & Woodworth, 1901).

Memory gains of this kind can last. After **six weeks of mnemonic training**, people new to the methods still showed gains "up to 4 months after training" (Dresler et al., 2017). The study reports better memory, with no claim of higher general intelligence, and the spatial

method it builds on appears in 1.1.1. Both memory studies used small groups.

Mnemonic training



Most mind training **helps the trained skill most**. The gain is real, and it stays with tasks like the one trained.

> **Science Says:**
> The abacus is a clear case. Mental abacus is doing sums on an imagined abacus, a frame of beads on rods. A study of mental abacus in a group of children in India describes it as "a nonlinguistic format for exact numerical computation" (Frank & Barner, 2012). **The finding is specific to sums**, the trained skill.

> **Key Concept:**
> Near and far transfer. Near transfer is **a skill helping on a similar task**, such as abacus practice helping with sums. Far transfer is a skill helping on a very different task, such as a maths class helping you plan a trip.

Abacus users carry **a picture of the frame in the mind**. Mental abacus "is represented in visual working memory by splitting the abacus into a series of columns" (Frank & Barner, 2012). Practised users are "relatively insensitive to verbal interference", which means words heard during a sum barely throw them off.

Near and far transfer





	Near transfer	Far transfer
What it is	A skill helping on a similar task	A skill helping on a very different task
Example	Abacus practice helping with sums	A maths class helping you plan a trip

Some teachers aimed straight at problem solving. In 1945 Pólya wrote How to Solve It, **a guide to solving problems** (Pólya, 1945). Training of this kind targets the skill of solving itself.

Measurement came much later than training. Binet and Simon published **one of the early papers on testing**, usually dated 1905, though the journal volume is dated 1904 (Binet & Simon, 1904). Their purpose was a down-to-earth one, to pick out children with serious learning difficulties who needed special teaching (Neisser et al., 1996).

Binet's tests gave each child a mental age. In 1912 Stern turned the gap between mental age and real age into **a ratio, the intelligence quotient** (W. Stern, 1912; Kovacs & Pléh, 2023). He later wrote of the time "when I introduced the concept of the 'intelligence quotient'". His 1912 book on testing methods has a chapter called "Der Intelligenzquotient".

> **Key Concept:**
> Mental age and the quotient. Mental age is **the age whose typical child scores the way you do**. A seven-year-old who scores like a typical nine-year-old has a mental age of nine. Stern's quotient compares the two ages by dividing one by the other, in place of taking one away from the other.

In the same years, Spearman wrote about **"general intelligence"**, which he said could be "objectively determined and measured", in the American Journal of Psychology (Spearman, 1904). Terman published The Measurement of Intelligence, which **uses the quotient throughout**, with chapters such as "Analysis of One Thousand Intelligence Quotients" and "The validity of the intelligence quotient" (Terman, 1916).

Measurement

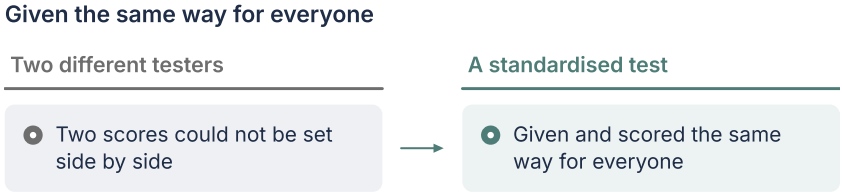


Testing then grew to a huge scale in the First World War. "A grand total of 1,726,966 men had been given psychological examination prior to January 31, 1919", about 42,000 of them officers (Yerkes, 1921). The work was "organized finally in 35 army training camps", with tests known as **Army Alpha and Beta**.

Army testing, First World War



Raven's Progressive Matrices followed, "Prepared for experimental work 1936, revised and standardised series published 1938" (Raven, 1941; Wellcome Collection, n.d.). Each item is a grid of patterns with one piece missing. One analysis traced score differences to **"the ability to induce abstract relations"** (Carpenter et al., 1990). To induce a relation is to work out the rule from examples.



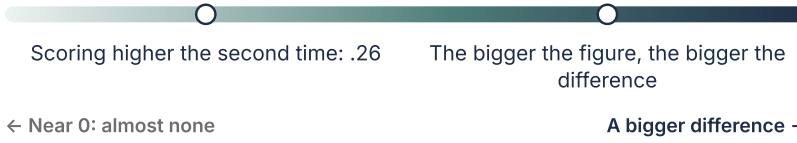
Wechsler's 1939 book (see 1.1.2) **carried testing on to adults**, and its third edition came out in 1944 (Wechsler, 1944). A standardised test, like Raven's 1938 series, is given and scored the same way for everyone. Without that sameness, two scores from two different testers could not be set side by side.

> Exercise:
>
> Three Socratic questions.
>
> 1. Write down one belief you hold firmly, such as a view about food, money or work.
> 2. Ask a friend to question it three times, **one question at a time**, each built on your last answer.
> 3. After each answer, note whether you felt sure, less sure or ready to change.
> 4. Write one thing you would need to learn to hold the belief with good reason.

> **Science Says:**
> Tests brought a new problem with them. People who sit the same kind of test twice **tend to score higher the second time**. One review measured the gain as an effect size, a number that says how big a difference is so studies can be compared, at an "adjusted overall effect size of .26", larger "when identical forms were used" (Hausknecht et al., 2007). Identical forms means the very same questions a second time.

With effect sizes, **the bigger the figure, the bigger the difference**, and a figure near 0 means almost none. A practice paper before a real test is fair, and it explains part of a higher second score.

Reading an effect size



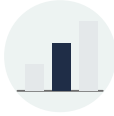
A second try feels easier because **the format is no longer new**. You know how the questions look and how fast to work. The gain comes from the test itself, and a fair measure has to allow for it.

Once tests existed, people could track scores across years. Flynn showed that **average scores rose by a large amount** in the United States between 1932 and 1978 (Flynn, 1984). A later review of many countries found that the gains "have decreased in more recent decades" (Pietschnig & Voracek, 2015).

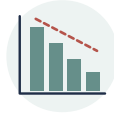
> **Science Says:**
>
> A large review pulled together **285 studies of rising scores**. It put the average gain at "2.31 ... standard score points per decade" (Trahan et al., 2014). A standard score point is one point on the scale a modern test reports, the familiar IQ number. A decade is ten years, so each decade added a couple of points on average.

The review's figure is **a long-run average**, worked out across many groups and tests. Single studies in the review differed from it, some higher and some lower, as any pooled figure does. How a rising average can shift one person's score comes later, with norms (see 1.3.3).

Rising average scores



1932 to 1978: a large rise in the United States



2.31 points per decade

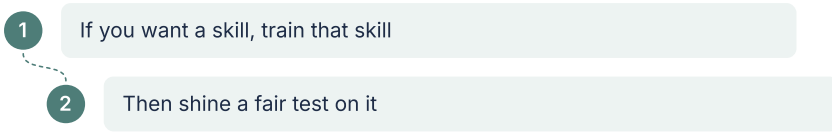


285 studies of rising scores

Those rising scores describe whole populations over decades. **They say nothing about one person's training.** Nobody in those studies took a course and came out higher, and later sections of the book keep that line clear.

Put training and testing side by side and a lesson shows. **Old methods mostly improved the skill they trained**, and the tests that came later gave a way to check. If you want a skill, train that skill. Then shine a fair test on it, the way **the torch shows where the furniture is**.

Train, then test



Key idea:

Old training methods mostly improved the skill they trained, and modern tests grew out of efforts to measure it.

Quick check:

Abacus practice helps with sums. Is that near or far transfer? Answer: near transfer, because the trained skill and the task are close.

1.2.3 One Ability or Several, and the Brain Behind Them

Many parents notice a pattern in school marks. A child with good marks in maths **tends to have fair marks in reading and science**, though rarely the same in every subject. Whether a child who is good at maths will be good with words turns on one point, whether the mind runs on one ability or on several.

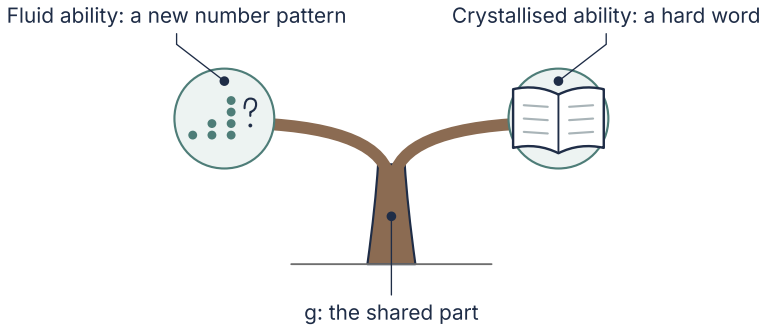
Psychologists have argued about this for over a hundred years. One side says there is **one general ability** behind all the marks. The other side says there are several separate abilities. The best answer today keeps a place for both.

The first big idea came from Spearman (see 1.2.2). The general ability he argued for, shared across many tests, is **now called g** (Spearman, 1904).

> **Key Concept:**
>
> g. The letter g stands for **general intelligence**, the part that is shared across many different tests. When scores on word, number and shape tests all rise and fall together, g is the name for what they have in common.

Cattell's fluid and crystallised kinds of intelligence (see 1.1.1) **both sit under g** (Cattell, 1963). Working out the rule in a new number pattern uses **fluid ability**. Knowing the meaning of a hard word uses crystallised ability, because you learned it some time ago.

Both sit under g



Picture a tree. **The trunk is g**, the shared part. A few big branches grow from it, such as reasoning, words and memory. Many small twigs grow from the branches, each one a single skill, like spelling or mental sums.



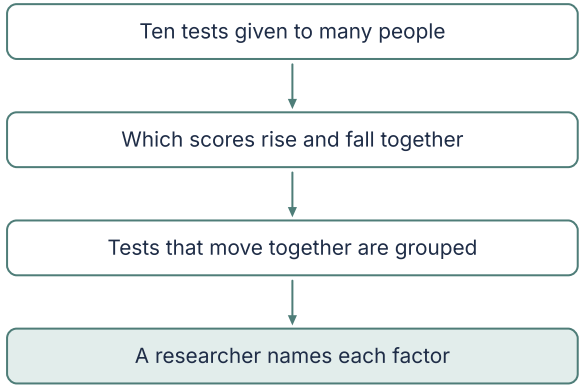
A tree with a thick trunk labelled g, a few big branches for broad abilities and many twigs for single skills.

Carroll built that tree from a large body of data. His book, Human Cognitive Abilities, was a survey of **"factor-analytic studies"** of human abilities (Carroll, 1993). From them he drew a model in layers, with g on top, broad abilities in the middle and narrow skills at the bottom.

Factor analysis is **a way to find hidden groups in test scores**. If ten tests are given to many people, the method checks which scores tend to rise and fall together. Tests that move together are grouped, and each group is called a factor.

The method does not name the groups. **A researcher names each factor** after looking at which tests landed in it.

Factor analysis



> **Science Says:**
>
> Carroll's layered model rests on his survey of factor-analytic studies (Carroll, 1993). In this book, the model with g at the top and broad abilities below it counts as **the best-supported view** of human abilities, and the tree is how I draw it. Later writers joined Carroll's model with Cattell's ideas into a combined model called CHC theory. McGrew's paper on it is titled "Standing on the shoulders of the giants of psychometric intelligence research" (McGrew, 2009).

Before Carroll, Thurstone argued for the other side. His 1938 book called itself "the first major application of the theory of factor analysis that was described in The Vectors of Mind" (Thurstone, 1938). From a battery of 56 tests, a set of tests given together, he found **"about the first seven primary factors"**, and even "two distinct verbal factors".

Key Concept:

Primary abilities. Thurstone's factors included space, perception, number, verbal relations, memory, word fluency and induction (Thurstone, 1938). Induction is **working out a rule from examples**. Word fluency is how quickly words come to mind, such as listing words that start with one letter. On the tree in this book, abilities like these sit as branches under the trunk.

His reasoning tests split into two factors, "that we have called 'induction' and 'deduction,' the latter being less clearly indicated" (Thurstone, 1938). Deduction is **working from a rule to a case**, such as using the rule that ice melts in warmth to say a sunlit cube will melt. The visual tests "collapsed into a single visual space factor".

Thurstone's reasoning tests



Induction: working out a rule from examples



Deduction: working from a rule to a case



A battery of 56 tests

Science Says:

Thurstone was careful about what he found. He wrote that "the number factor is highly restricted". Two more factors, "denoted R and D", stayed tentative, because **he could not yet say what they measured**. The book came out in 1938, and a second impression followed in 1957 (Thurstone, 1938).

The argument is still open. One team holds that the best branches are verbal, perceptual and image rotation, **turning a shape in the mind**.

Their title names the structure “verbal, perceptual, and image rotation (VPR)”, in place of fluid and crystallised (Johnson & Bouchard, 2005). Branch names change from model to model, while the trunk stays in every one.

Genes give a second look at the same tree. Different mental abilities “correlate phenotypically about 0.30 on average but correlate genetically about 0.60 or higher” (Plomin & Deary, 2015). **The genes behind different abilities overlap more** than the test scores do.

Abilities and their genes



A correlation shows **how closely two measures move together**, from -1 through 0 for no link up to 1 for a perfect match. “Phenotypically” means as measured on the tests themselves. A genetic correlation asks a different question, whether **the same genes push two abilities** up or down.

H. Gardner’s many separate intelligences would be a forest of separate trees with no shared trunk (H. Gardner, 1983). **The evidence does not back a forest** of that kind (Waterhouse, 2006).

> 🗝 **Key Concept:**
>
> P-FIT. P-FIT stands for the Parieto-Frontal Integration Theory. It says that **a network spread across the brain**, linking areas at the front and towards the back, supports intelligence. Jung and Haier built it from “37 modern neuroimaging studies” (Jung & Haier, 2007).

Neuroimaging means **taking pictures of the living brain**, with scanners that show its shape or which parts are busy. Jung and Haier found that "variations in a distributed network predict individual differences found on intelligence and reasoning tasks" (Jung & Haier, 2007). **P-FIT is a theory**, and it may change as new studies arrive.

In P-FIT, **no single area runs intelligence**. The work is shared across linked areas, and the links count as much as the areas themselves. A later review pooled imaging studies to test **where smart brains are different** (Basten et al., 2015).

P-FIT



Areas at the front



Areas towards the back



The links count as much as the areas

Brain size has some link to intelligence. A review pooled studies of brain volume and intelligence (Pietschnig et al., 2015), and an overview set out what neuroscience knows about intelligence differences (Deary et al., 2010). **Size is a weak guide** to how well a person solves problems.

> **Science Says:**
>
> Some brain myths need clearing away. Many teachers believe neuromyths, wrong ideas about the brain, such as the claim that we use only 10% of it (Dekker et al., 2012). People are not "left-brained" or "right-brained" (Nielsen et al., 2013). Einstein's brain has been studied, but **it is a single case** and proves nothing about others (Witelson et al., 1999). One review calls the story a "Neuromythology of Einstein's brain" (Hines, 2014).

The same overview reported that “Molecular genetic studies have yet to identify reliably reproducible contributions from individual genes” (Deary et al., 2010). Molecular genetic studies **read the DNA itself**, the chemical code that genes are written in, looking for single genes tied to a trait. None has yet held up for intelligence when the study is repeated.

Brain scans gave **a firmer result**. The overview found “differences in brain pathways, especially parieto-frontal pathways”, the same front-and-back links that P-FIT names. Parietal areas sit towards the back and top of the head, and frontal areas sit behind the forehead.

The overview added that “brain efficiency correlates positively with intelligence” (Deary et al., 2010). A positive correlation means **the two measures tend to rise together**.

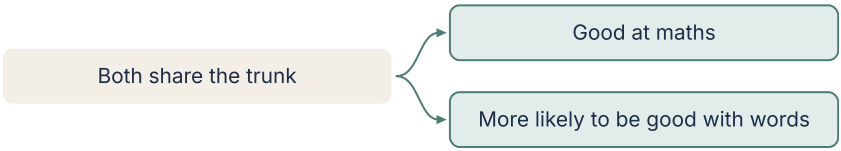
Working memory links the two halves of this section. It is **closely tied to g and to the fluid intelligence** described above, so it sits near the base of the tree, where trunk meets roots.



The ability tree again, with working memory marked at the spot where the trunk joins the roots.

Put the pieces together and the opening pattern has an explanation. A child good at maths is **more likely to be good with words**, because both share the trunk. She may still be stronger on one branch than another, and that is normal.

Sharing the trunk



> Exercise:
>
> Easy and hard.
>
> 1. List three tasks that feel easy to you and three that feel hard.
> 2. Mark each one “new problem” if it asks you to work something out fresh, or “known facts” if it rests on what you have learned.
> 3. Look for a pattern, and note whether **your easy tasks lean one way**.
> 4. Pick one hard task and write down which branch of the tree it uses.

The two old sides of the argument were each partly right. **One shared ability is real**, and so are the broad branches. Kuncel’s review of a single reasoning test, across school and work, points to “the broad importance of general cognitive ability (g)” (Kuncel et al., 2004).

Knowing your own branches helps you plan. A hard task on a weak branch needs **more time and more support**, and a task on a strong branch can move faster. Neither tells you how far you can grow.

Knowing your own branches

A weak branch	A strong branch
⊕ A hard task needs more time and more support	⊖ A task can move faster

Key idea:

Abilities form a tree with one shared trunk, g, and broad branches, and a theory links them to a network across the brain.

Quick check:

What is the trunk of the ability tree called? Answer: g, general intelligence.

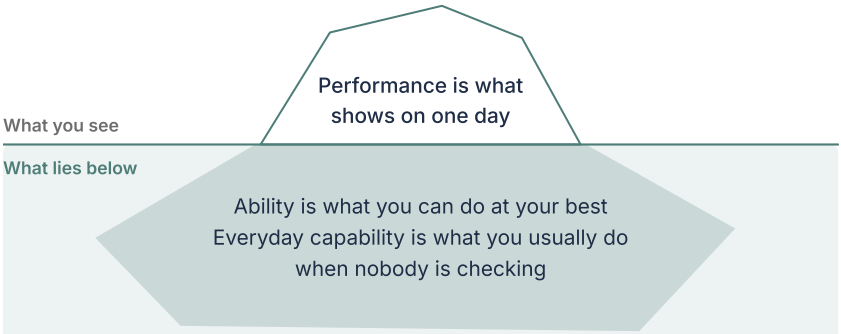
1.3 What Can Change?

1.3.1 Ability, Performance and Everyday Capability

At home, with a cup of tea, you can work out a tip on a restaurant bill in seconds. In an exam hall, with a clock on the wall, the same kind of sum can turn to fog. The two results seem to disagree about what you can really do. **Both results are real**, and they measure different things.

Three ideas get blurred here, and this section pulls them apart. **Ability** is what you can do at your best. Performance is what shows on one day. Everyday capability is what you usually do when nobody is checking.

Three ideas pulled apart



The linguist Chomsky drew a similar line for language. He split **competence, what a speaker knows**, from performance, what comes out on a given day, in his book Aspects of the Theory of Syntax (Chomsky, 1965). A fluent speaker can still trip over a sentence when tired, and the slip says little about what they know.

Competence and performance



> **Key Concept:**
>
> Competence and performance. Competence is **what you know how to do**. Performance is what you do at one moment, with all the noise of that moment. Chomsky used the pair for language, and this book borrows it as an analogy for intellect.

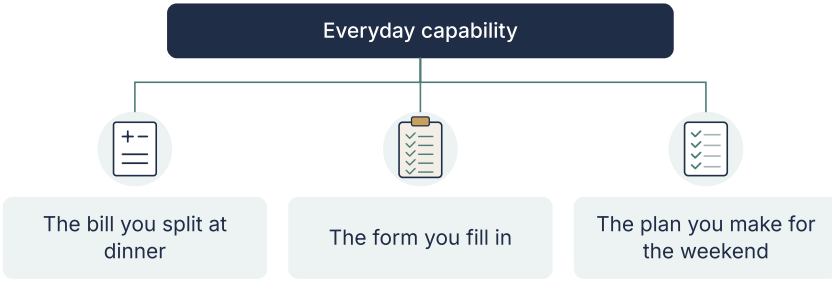
A car makes the gap easy to see. The maker lists a top speed, the most the car can do on an open road. On the school run it moves much slower, and on an icy morning slower still. **The top speed has not changed**, only the conditions.



One car on three roads, an open road, a school run and an icy morning.

Everyday capability sits beside both. It is what you **actually bring to normal life**, the bill you split at dinner, the form you fill in, the plan you make for the weekend. Nobody scores it, and yet it shapes most of your days.

Everyday capability



Real-life skill can **beat the school version of the same skill**. A study of working youngsters in Recife, Brazil, found their maths "embedded in real-life contexts was superior to that on school-type word problems and context-free computational problems involving the same numbers" (Carraher et al., 1985). Context-free problems are bare sums with no story around them.

The study was small, and it still makes a plain point. **A sum done for a real customer** can come out right while the same sum on a worksheet goes wrong. The worksheet measured performance on one kind of page, and the street showed a skill the page missed.

Sackett and colleagues found a similar split at work. They compared measures of **"typical and maximum job performance"** for the same people (Sackett et al., 1988). In plain words, maximum performance is **a person's best effort**, and typical performance is an ordinary day's work.



The two are **related and not the same**. An exam measures something close to maximum performance, because you know it counts. Daily life runs on typical performance, the effort you bring when the stakes are low. Both deserve attention if you want to grow.

Tests aim at the top of the range on purpose. **A test tries to catch your best**, so it asks you to work hard for a short time. The score tells you something about ability, and much less about how you use it on a Tuesday afternoon.

> **Key Concept:**
>
> Validity. In hiring research, a selection procedure is any method for choosing whom to hire. Its validity is **how well it predicts later job performance**, given as a correlation (see 1.1.1), a number where higher means a closer link. A large review found that many earlier validity figures were overestimates, "reduced by .10-.20 points" once corrected (Sackett et al., 2022).

Tests are only one way to judge people at work. The same review found that **"Structured interviews emerged as the top-ranked selection procedure"** (Sackett et al., 2022). A structured interview asks every candidate the same planned questions and scores the answers the same way. If you ever hire, that habit is easy to copy.

Ackerman's four parts



Knowledge adds a third layer. Ackerman's model of adult intellect, with **knowledge as one of its four parts** beside ability, personality and interests, explains why (Ackerman, 1996). Two people with the same raw ability can show very different results, because one has built up far more knowledge in the area being tested.

Science Says:

Heuristics are mental shortcuts, and biases are the errors they can lead to. Some people **stop to check a quick first answer**, and some go with it. One paper's title calls a short test of that habit, the Cognitive Reflection Test, "a predictor of performance on heuristics-and-biases tasks" (Toplak et al., 2011).

Key Concept:

Reasoning well and scoring well. Rational thinking and intelligence are **partly separate**. Stanovich and two colleagues later built a fuller measure, The Rationality Quotient (Stanovich et al., 2016). A clever person who makes a poor choice is showing that gap. Ability was there, and the way it was used let it down.

Pressure is one reason performance falls below ability. Maths anxiety is **one way a partner gets in the way**, and further studies have looked at it (Ramirez et al., 2013).

Test anxiety follows the same pattern. A review of 238 studies found it **"significantly and negatively related to a wide range of educational performance outcomes"** (von der Embse et al., 2018). The link was stronger for "high-stakes" tests, the ones that count most. The studies are correlational, so they show a link without proving the cause.

Test anxiety, 238 studies

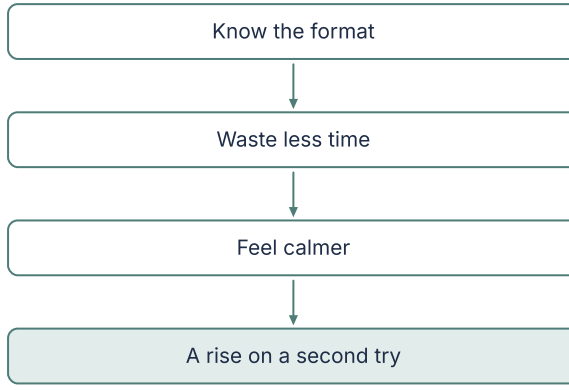


Skilled people are not safe from it either. One study, titled **"On the fragility of skilled performance"**, looked at what governs choking under pressure (Beilock & Carr, 2001). Choking means doing worse than usual because the moment feels big. The skill is still there, and the pressure gets in its way.

Anxiety is **one factor among several**. It does not explain every low score, and a low score does not always mean anxiety. Many other things play their part on the day. Sleep is one, since a short night hits simple attention hardest (see 1.1.1).

> **Science Says:**
>
> Scores rise when people **take the same kind of test again**. The gains were larger after coaching, and larger when the very same test form came back (Hausknecht et al., 2007). A later review looked at retest effects across many ability tests (Scharfen et al., 2018).

The retest effect



The retest effect is the name for **that rise on a second try**. The person's ability has not grown in a week. They know the format, they waste less time and they feel calmer. The gain belongs to performance.

> **Key Concept:**
> Regression to the mean. A second reason scores move is regression to the mean. When a score is **unusually high or low** the first time, the next score tends to sit closer to the average (A. G. Barnett et al., 2005). Luck that pushed the first score one way rarely repeats in the same direction.

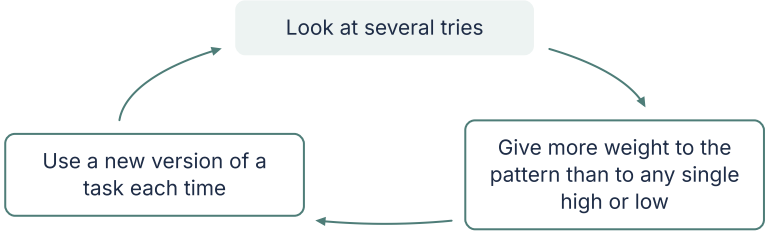
A very high first score usually had **some extra luck in it**. The next score drops back, and the person has not got worse. The second result is simply closer to their usual level.

Regression to the mean



Both effects count when you track your own progress. **Look at several tries** in place of one, and give more weight to the pattern than to any single high or low. If you can, use a new version of a task each time, so that knowing the format does not pass for growth.

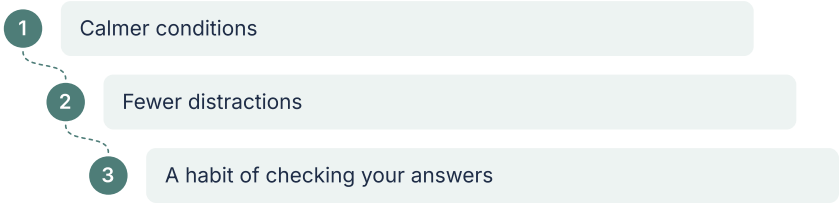
Track your own progress



> Exercise:
>
> Best day, usual day.
>
> 1. Choose one kind of task you do often, such as an email or a short sum.
> 2. Do it once at your best time of day, with no phone. Note how well it went.
> 3. Do the same kind of task at an ordinary moment, as you usually would.
> 4. Compare the two. The gap between them is **the room you can win back** without growing any new ability.

The gap is often the quickest place to improve. Raising the car's top speed takes years. **Bringing your usual day closer to your best day** can start this week, with calmer conditions, fewer distractions and a habit of checking your answers.

Bringing your usual day closer



Back in the exam hall, the tip sum turned to fog because of **the clock, the stakes and the worry**. None of those is ability. Your results will

always shift a little with the occasion and the subject, and your best day shows what there is to win back.

Key idea:

Ability is what you can do at your best, and performance is what shows on the day.

Quick check:

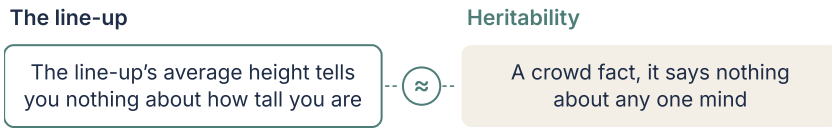
You score higher on a test the second time you take it. Has your ability grown? Answer: probably not, because retest gains are mostly performance.

1.3.2 Genes, Education and Experience

People often say that brains run in the family. A mother and son both pick up new languages with ease, and two sisters both breeze through maths. A pattern like that can make intelligence look fixed. **The short answer is that it is not**, and the long answer needs one tricky word.

The word is heritability, one of **the most misread ideas** in all of psychology. Once you see what it means, much of the worry about genes falls away.

The class line-up



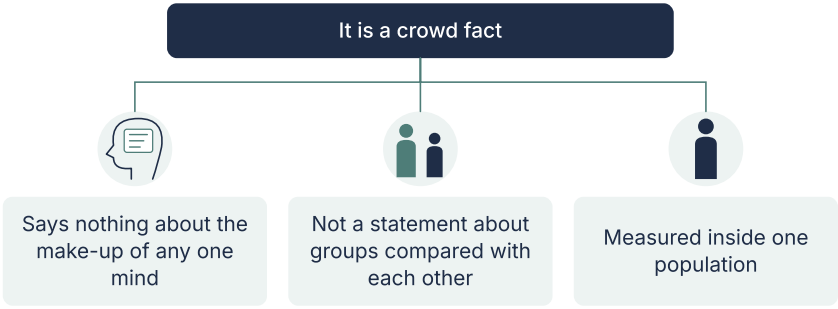
Picture thirty children in a class, lined up by height. Their heights all differ. Some of those differences go with their genes, and some go with everything else in their lives. Heritability asks **how much of the spread across the class** goes with differences in genes.

> **Key Concept:**
>
> Heritability. Heritability is **a figure about a group**, never about one person. It gives the share of the spread in that group that goes with genetic differences. It can differ from one group to another, and **it changes with age**.

The line-up's average height tells you nothing about how tall you are. **Heritability works in the same way.** A heritability of 50% does not mean half of your intelligence came from your genes. It is a crowd fact, and says nothing about the make-up of any one mind.

Heritability is **not a statement about groups** compared with each other, either. It is measured inside one population, the whole group a study draws from, and it cannot be carried across to explain gaps between populations. This book makes no claims of that kind.

It is a crowd fact



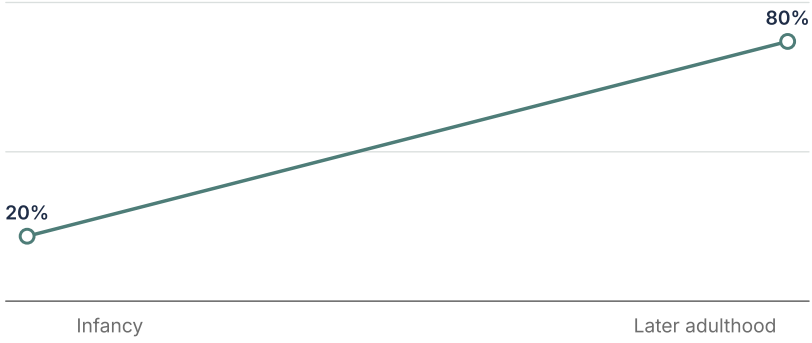
Most heritability figures come from **twin studies**. Identical twins share all their genes, and non-identical twins share about half, like ordinary brothers and sisters. If identical twins are more alike on a trait than non-identical twins, genes are likely to be part of the reason.



Twin studies cover far more than intelligence. One review pooled 2,748 publications on 17,804 traits and found that "across all traits the reported heritability is 49%" (Polderman et al., 2015). A trait is any feature that varies between people, from height to mood. **Almost every human trait** has some link with genes, and intelligence sits among them.

The main finding is about age. In a paper on genes and intelligence, two researchers wrote, "The heritability of intelligence increases from **about 20% in infancy to perhaps 80% in later adulthood**" (Plomin & Deary, 2015). Another study found that it "increases linearly from childhood to young adulthood" (Haworth et al., 2010), which means at an even pace.

Heritability of intelligence



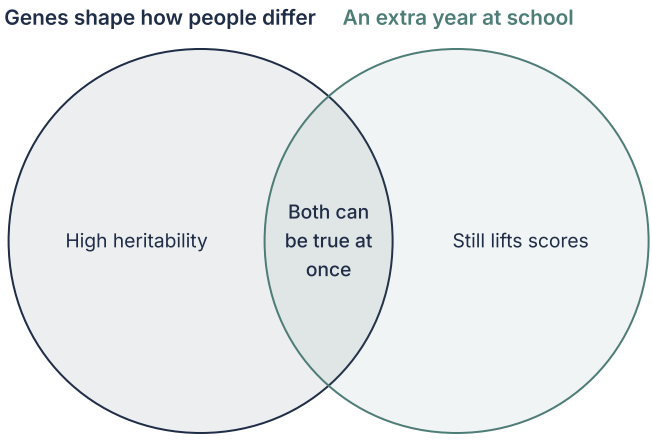
A rise with age surprises many people. It means that **differences between adults line up with genes** more closely than differences between babies do. It still says nothing about how far any one adult can learn and grow.

> **Science Says:**
>
> A review of 11,500 twin and sibling pairs asked why heritability rises. It found that "amplified influences account for increasing heritability following age 8 years" (Briley & Tucker-Drob, 2013). Amplified means **the genetic influences present in childhood grow stronger** as children get older.

> **Science Says:**
> Education raises intelligence. A review of 142 effect sizes from 42 data sets, with over 600,000 participants, found gains of **"approximately 1 to 5 IQ points for an additional year of education"** (Ritchie & Tucker-Drob, 2018). The authors called education the most consistent and durable method yet found for raising intelligence, meaning its gains showed up again and again and lasted.

A range of 1 to 5 IQ points can look vague. It is a range because **the studies in the review gave different answers**. Every part of the range is a gain. Whether the gains reach g itself, the general ability shared across tests (see 1.2.3), is not addressed in the abstract.

Both can be true at once



The schooling finding sits comfortably beside high heritability. **Both can be true at once.** Genes shape how people differ, and an extra year at school still lifts scores. A high heritability never means that the surroundings do not count.

Intelligence and school results are linked, as one study's title, Intelligence and educational achievement, signals (Deary et al., 2007). A link alone could run either way, so the review used **three kinds of study** to rule out easy explanations. Some followed people over time and allowed for their earlier IQ.

Others used changes in the law on how long children must stay at school, or the cut-off date for starting school (Ritchie & Tucker-Drob, 2018). Designs like these are called **quasi-experiments**, close to a true experiment but without random groups.

> **Key Concept:**
>
> Natural experiment. A natural experiment is **a real-world change that sorts people into groups**, much as a researcher would. In the 1960s Norway raised compulsory schooling, the years every child must attend, from seven to nine, and the reform had "a substantial effect on IQ scores" measured at 19 (Brinch & Galloway, 2012). The law, and no one's choice, decided which pupils stayed at school longer. The study's summary gives no size for the gain.

Norway, a natural experiment



The gains did not fade. The effects "persisted across the life span and were present on all broad categories of cognitive ability studied"

(Ritchie & Tucker-Drob, 2018). **A year of school leaves a mark** long after the classroom is gone.

Experience works through knowledge. In Ackerman's model of adult intellect, interests and personality steer **what knowledge you build up** (Ackerman, 1996). He sees knowledge as growing through investment, the time and effort you put into a subject. What you choose to learn shapes what you can later solve.

> **Science Says:**
>
> Partners tend to be **alike in intelligence**. Spouse correlations, the link between husbands and wives, sit at about 0.40 for intelligence, against about 0.10 for personality (Plomin & Deary, 2015). Scientists call this assortative mating, which means people tend to pair with partners like themselves.



Whole populations changed over the same century. Average scores rose for decades, and the rise has slowed more recently. **Schooling is one place** to look for part of that rise.

> **Key Concept:**
>
> The Flynn effect. The Flynn effect is **the rise in average test scores** across the last century. It is a trend for whole populations, over decades. It does not show that any one person can train their score up in the same way.

Training is a different story. A skill that spreads from one task to a very different one is rare. **The limits to transfer** were found more than a century ago (see 1.2.2), and they still shape what this book will claim (Thorndike & Woodworth, 1901).

Genes do not fix a person at birth. They **shape the starting point** and the spread across a group, and they leave plenty of room for what each person does next, starting with school.

Back to the mother and son with **a gift for languages**. Their likeness may come partly from shared genes and partly from a home full of talk in more than one tongue. Twin studies exist to pull those two strands apart, and neither strand fixes what the son, or his mother, learns next.



The class line-up again, with genes shaping where each child starts and the spread of heights across the group.

Practice makes you better at **the thing you practise**. It does not raise a general score in the way school does. This book makes no claim that any kind of practice raises IQ.

The full picture has three parts. **Genes shape the differences**, schooling raises scores, and practice builds the skill it targets. None of the three locks your intellect in place.

The full picture



> Exercise:
>
> One more term of learning.
>
> 1. Pick one subject you would like to know better, such as history, a language or basic statistics.
> 2. Set aside **a little time each week** for one school term, about twelve weeks.
> 3. Each week, write one thing you can now explain that you could not explain before.
> 4. At the end, read the list back. That list is knowledge your intellect can now use.

Learning is the lever the evidence supports best. You cannot change your genes, and you can **keep adding to what you know**. Each new piece of knowledge gives your intellect more to work with.

Adults should read the school evidence with care. The Norway gains were measured at 19, and the review found that school effects lasted

across the life span. **Learning as an adult is a different setting**, and the studies here are about school, so they point the way without proving the adult case.

School and adult learning

The school evidence	Learning as an adult
Norway gains measured at 19	A different setting
School effects lasted across the life span	The studies point the way

Key idea:

Genes shape differences between people, and schooling still raises measured intelligence.

Quick check:

Does a heritability of 50% mean half of your intelligence comes from your genes? Answer: no, heritability is about the spread across a group.

1.3.3 What an IQ Score Can and Cannot Tell You

A FRIEND TAKES AN ONLINE test and tells you the number at the end. Another friend took a proper test at school years ago and still remembers the score. Neither of them can be sure how much one number from one test says about a person. **One number says something real**, and far less than most people think.

People **easily over-read** an IQ score. This section shows how to read the number well, what it can predict about health and work, what makes it move and what it leaves out.

The first thing to know is that an IQ score is **a comparison**. Your raw result is set against the results of a large group who took the same test earlier. That group is called the norm group, and their results are the norms.

> **Key Concept:**
>
> Norms. Norms are **the scores of a large comparison group**, gathered when a test is built. An IQ score tells you where you stand against that group. A score means little until you know which group it was compared with.

Norms age, because average scores have shifted over the decades (see 1.2.2). **A test with old norms** compares you with a group from another time, and the score drifts for that reason alone.

The person has not changed, and **the comparison has**. An old norm group sets the score against people from another time.

With the right norms, scores are **fairly stable over a lifetime**. A follow-up of the 1932 Scottish Mental Survey looked at the same people from childhood to old age (Deary et al., 2000). People who scored high as children tended to score high again much later.

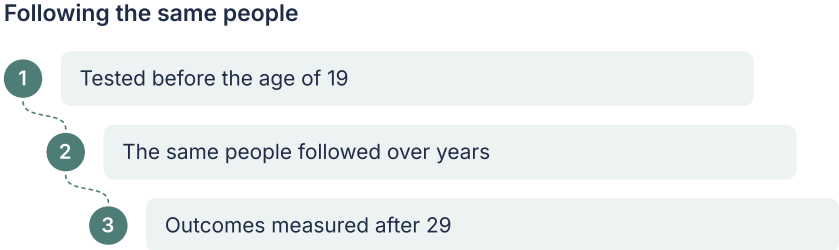
The 1932 Scottish Mental Survey



A stable score does not mean a fixed mind. **People still learn**, and a year of school still adds to measured intelligence. Stability means that people tend to keep their place in the line, even as the whole line moves.

> **Science Says:**
> Intelligence predicts a lot. It is "one of the best predictors of important life outcomes such as education, occupation, mental and physical health and illness, and mortality" (Plomin & Deary, 2015). Mortality means the risk of dying. Reviews have linked it to **school results and to social and economic success** (Deary et al., 2007; Strenze, 2007).

A predictor is **something that helps you guess an outcome** before it happens. It does not cause the outcome, and it does not settle it. A score that predicts school results well still leaves room for surprises in both directions.



One review pooled longitudinal research, which follows **the same people over years**. Its best studies tested people before the age of 19 and measured outcomes after 29 (Strenze, 2007).

> **Science Says:**
>
> After the review's adjustments, the best studies gave links of ".56, .45, and .23 between intelligence and education, occupation, and income" (Strenze, 2007). Across all its studies, the figures were .56, .43 and .20. **Income shows the weakest link**, and .23 leaves most of the differences in pay unexplained.

Strenze, best studies



Education: .56



Occupation: .45



Income: .23

A review of 16 health studies, with 1,107,022 participants and 22,453 deaths, found that a one-standard-deviation advantage in childhood test scores went with **a 24% lower risk of death** (Calvin et al., 2011). The 95% confidence interval, the likely range for the true figure, ran from 23 to 25%. The link cannot prove that the score itself protects anyone.

> **Key Concept:**
>
> Standard deviation. A standard deviation is **the usual distance of scores from the average**. A one-standard-deviation advantage means scoring about one usual distance above another person. Most scores bunch near the average, and fewer sit far from it.

The studies tested people when young and then counted deaths over the years that followed. Allowing for adult social and economic position weakened it by 34%, and allowing for education weakened it by 54%

(Calvin et al., 2011). **Education carries about half of the link**, and the rest remains after allowing for it.

What weakened the link



A good predictor for a crowd is a weaker one for a person. Across thousands of people, **the link shows up clearly**. For any one person, many other things can push the result up or down, from health to luck to effort. A group link is useful, and it is never a promise about one person on one day.

Work gives the clearest test of what a score predicts. An older review put the validity of general mental ability, the hiring name for g, at .51 for job performance (Schmidt & Hunter, 1998, as reported in Sackett et al., 2022). Validity is **how well a measure predicts later performance** (see 1.3.1).

The same review found that pairing tests helped. General mental ability plus an integrity test reached a "mean validity of .65", and adding a work sample or a structured interview reached ".63" (Schmidt & Hunter, 1998). An integrity test asks about **honesty and keeping rules at work**, and a work sample is a small piece of the real job.

Pairing tests helped

General mental ability alone	Paired with a second method
Validity of .51 for job performance	Plus an integrity test: .65 Plus a work sample or structured interview: .63

> **Key Concept:**
> Range restriction. Studies of workers see only the people who were hired, so **the spread of scores is cut short**. Researchers correct for that, and a later review found that the usual corrections "often result in substantial overcorrection" (Sackett et al., 2022). A firm that hires only strong scorers never sees how weaker scorers would have done. The review called validities "considerably lower than previously thought".

Once the corrections were revised, the review wrote, "This is our estimate of cognitive ability test validity [.31], in contrast with the .51 value presented by Schmidt and Hunter (1998)" (Sackett et al., 2022). A newer study found **"a lower value (.22) for 21st century data"** (Sackett et al., 2024).

The direction holds even where the numbers are argued over, and every review points the same way. **A score does predict job performance**, and it predicts less than the older figures claimed. A figure like .31 is a real link with many exceptions, and in Sackett et al. (2022), structured interviews reached .42.

What a score does and misses

What a score does	What IQ tests leave out
⊕ Predicts job performance	⊖ Rational thinking ⊖ Creativity mostly

Scores move for reasons that have nothing to do with ability, such as **a second try or an extreme first score**. One paper on regression to the mean sets out "what it is and how to deal with it" (A. G. Barnett et al.,

2005). One very good or very bad day is a weak base for any big decision.

> **Science Says:**
>
> IQ tests leave out a lot. They do not measure rational thinking well. A whole book is called **What Intelligence Tests Miss** (Stanovich, 2009). Creativity mostly slips past them, given its small overlap with IQ. Even the experts have **no single agreed definition** of what the tests measure.

Learning styles, another myth that often rides along with IQ talk, **get their own place later in the book**.

What intelligence tests miss



Put all of this together and a fair reading of a score has four parts. You need to know **which test it was**, when it was taken, which norms it used and whether it was a first try. Without those facts, the number tells you very little.

A fair reading of a score



You need to know which test it was



When the test was taken



Which norm group it was compared with



Whether it was a first try

> **Exercise:**
>
> Four questions for any score.
>
> 1. Take any score you know, your own or one you have read about.
> 2. Ask which test produced it, and **when it was taken**.
> 3. Ask which **norm group** it was compared with, and how old those norms were.
> 4. Ask whether it was a first try or a retest. Write down what the score can and cannot tell you.

If a job or a school ever asks you to sit a test, **the score is one piece of the decision**. The evidence says a structured interview, a work sample or a second method adds a good deal. Ask what else will be weighed, and prepare for those parts with the same care.

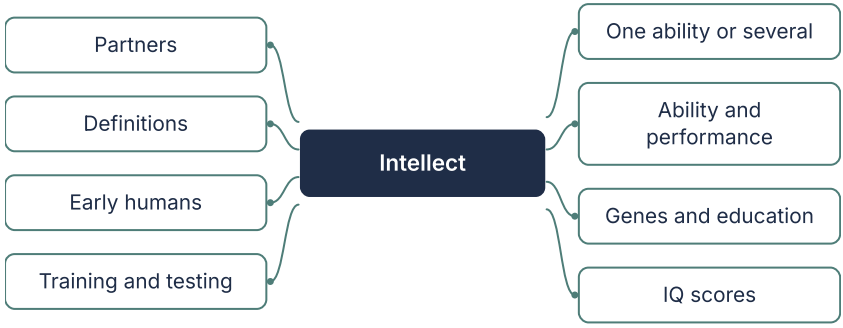
Think of a holiday photo. It shows one moment of a long trip. It is **true to that moment**, and it misses the meals, the walks and the rainy afternoon. An IQ score is the same kind of picture, true to one sitting and silent about the rest.



One holiday photo pinned to a board, with the rest of the trip shown as faint outlines around it.

An IQ score is a snapshot. It catches **some abilities on one day**, compared with one group. Read it with those limits in mind and it becomes a useful tool for planning your own growth. Take a second photo on another day, and the same trip looks a little different from the first one.

Intellect



Key idea:

An IQ score is one snapshot of some abilities on one day, compared with one group.

Quick check:

Why can an old test give a misleading score? Answer: its norms come from an earlier group, and average scores drift over time.



Module

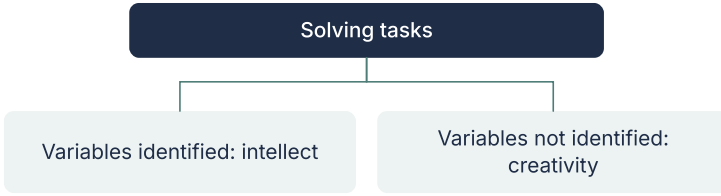
2

How Intellect Works with Attention, Memory and Creativity

INTELLECT NEVER WORKS ALONE. When you check a bill, plan a week or weigh up a choice, **intellect is working with other abilities** at the same moment. This module looks at those partnerships one at a time. It then shows which partner should lead at each step of a real task.

In this book's terms, intellect is **solving tasks where the variables are identified**. Creativity is its partner for the other case, solving tasks where the variables are not identified. Module 1 introduced the partners, and this module shows them at work.

Two kinds of task



The other books use their own words for their own abilities. The Attention book defines attention as "choosing what is important and staying with it". **The Memory book defines memory** as "the thinking ability to take in, keep and bring back information and experiences".

Each book, its own words

Book	Defines its ability as
The Attention book	Choosing what is important and staying with it
The Memory book	The thinking ability to take in, keep and bring back information and experiences

The module has three chapters. **Chapter 2.1 pairs intellect with attention**, and looks at how attention holds the pieces of a problem in

view. Chapter 2.2 pairs intellect with memory, and shows how stored knowledge feeds the task.

Chapter 2.3 pairs intellect with creativity. It looks at **how the two overlap**, how intellect works inside creative thinking, and how to switch between making ideas and judging them. Its last section brings all three partnerships together on one real task.

Intellect and its three partners



Each section ends with exercises at three levels. **Bring one real task of your own** to the module, such as a budget, a plan or a decision at work. Try each section's ideas on it as you go.

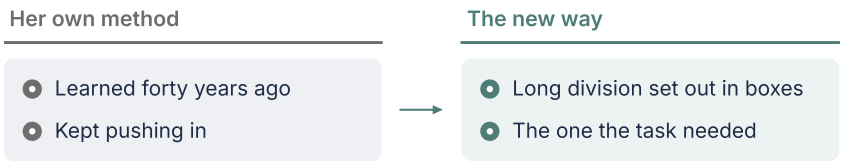
2.1.1 Attention Control: The Common Thread in Reasoning

A MOTHER SAT DOWN TO help her son with his maths homework. The school now teaches long division in a new way, set out in boxes. **Her own method, learned forty years ago, kept pushing in.** Twice she wrote the old layout before she caught herself, and the boy watched her with growing doubt.

Most of us know that feeling. **You learned a way of doing something long ago**, and the newer way feels like wearing your shoes on the wrong feet. The old way was a fine method in its day, and here it was simply the wrong one for the task.

She knew both methods. **Her trouble was keeping the right one in charge** while the old one pulled at her pen. This section looks at that pull, and at the part of attention that holds a task on course when a habit wants to take over.

Two methods, one task



In this book's terms, intellect is solving tasks where the variables are identified. The homework had every variable on the page. **Holding them in the right order, by the right method,** was the part that needed attention.

The Attention book defines attention as "choosing what is important and staying with it". **Reasoning needs both halves of that.** You choose which pieces of the task matter, and you stay with them while the work goes on.

Both halves at work



One researcher put attention at the centre of the link between holding and reasoning. He argued that working memory, in the sense of how much you can hold and use at once, "is an important component of general fluid intelligence" (Engle, 2002). **Fluid intelligence is reasoning with new material.** It is the kind of reasoning a fresh problem asks for.

Fluid intelligence, in plain words

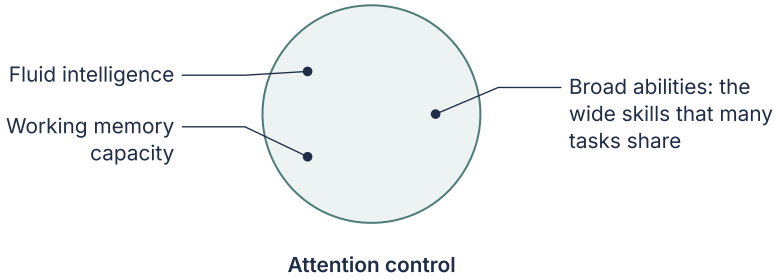
> Definition
>
> **Fluid intelligence**
>
> Reasoning with new material: the kind of reasoning a fresh problem asks for

> Science Says:
>
> The same paper said this holding power "represents a domain-free limitation in ability to control attention" (Engle, 2002). Domain-free means it applies across every kind of task, words, numbers or shapes alike. **On this book's reading, the limit is in the steering.** The space matters less than how well you keep it pointed at the task.

Kane and colleagues hold a similar view of working memory (Kane et al., 2005), which 1.1.1 sets out as executive attention. **This section takes the next step.** It asks what controlling attention does for reasoning, and when that control counts most.

A later review pulled the threads together. It argued that "attention control provides a common thread among broad cognitive abilities, including fluid intelligence, working memory capacity" (Burgoyne & Engle, 2020). **The thread runs through reasoning and holding alike.** Broad abilities are the wide skills that many tasks share.

One common thread





A loom with many coloured threads running through it and one bright red thread crossing all of them.

A common thread is a useful idea for a book about intellect. **If one skill runs through many tasks**, then the habits that support it help with more than one kind of problem. On this book's reading, attention habits are worth building for that reason.

> **Key Concept:**
> Attention control. In this book's terms, attention control is **keeping your reasoning on the goal and method you chose**. It holds firm while other goals, methods or feelings pull at it. It is the steering that turns a task held in mind into a task solved.

> **Science Says:**
> A third team looked at what lies behind the link between holding and reasoning. They reported that "the three factors completely accounted for the relation between WM (both processing and storage) and gF" (Unsworth et al., 2014). **WM is working memory, and gF is fluid intelligence.** One of the three factors they named was attention control.

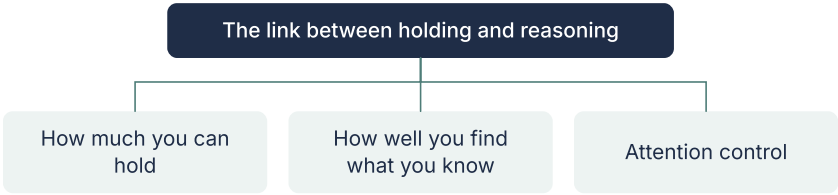
That needs a plain reading. Part of what makes good reasoners good is **how well they keep the task in front of them**. On this book's reading, that is good news. Steering is something you can support with simple habits, even if you cannot change the space itself.

Room and aim

The room you have	Where you point it

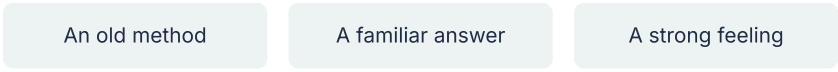
The other two factors were how much you can hold and how well you find what you know. **Each has its own fixes**, and both depend on steering too. A fact you cannot keep your mind on is a fact you will soon lose.

Three factors behind the link



Control counts most when something pulls the wrong way. **An old method, a familiar answer or a strong feeling** can all take over a task. The mother's long division shows the old method at work, arriving first because it was the best-worn path.

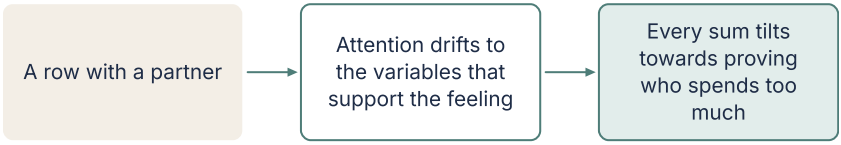
Three pulls on a task



On this book's reading, a pull is easier to resist once you have named it. **Before she started, she could have said aloud, "Boxes this time."** The words would then have been ready when the old layout began to form.

Strong feelings pull too. A row with a partner before you check the household budget can tilt every sum towards **proving who spends too much**. The variables stay the same, and attention keeps drifting to the ones that support the feeling.

How a row tilts the sums



On this book's reading, the fix for a strong feeling is timing. **Leave the budget until the row has cooled**, or ask the other person to read the figures aloud with you. Two sets of eyes keep attention on the numbers that are really there.

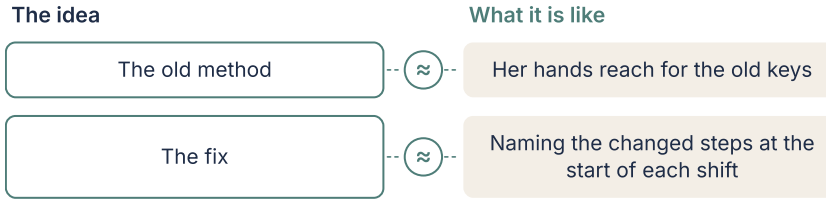
Familiar answers are the quietest pull. **A problem that looks like last month's** invites last month's answer, even when one figure has changed. On this book's reading, the first answer that comes is worth checking against the task in front of you before you trust it.

Each pull and its fix

Pull	On this book's reading
An old method	Name it aloud before you start: "Boxes this time."
A strong feeling	Leave the budget until the row has cooled
A familiar answer	Check the first answer against the task in front of you

A cashier moving to a new till system feels the same pull. **Her hands reach for the old keys** for the first week, and each slip costs a moment of correction. Naming the changed steps at the start of each shift may shorten that week.

A cashier at a new till



You can lighten the load on control. **Remove the pulls you can see before you begin.** Close the tabs you will not need and turn the phone

face down. Put the old notes out of sight if they use the method you are leaving behind.

Write the goal at the top of the page. **“Find the cheapest of the three quotes”** is a short line, and it gives attention something to return to. When you notice you have drifted, read the line and pick up where you left off.

Lighten the load before you begin

- [x] Close the tabs you will not need
- [x] Turn the phone face down
- [x] Put the old notes out of sight
- [x] Write the goal at the top of the page

Work in short stretches when the pull is strong. A tired mind loses its grip on a new method sooner than a fresh one. **Ten focused minutes and a short break** may get you further than an hour of fighting the old habit.

Short stretches or a long fight

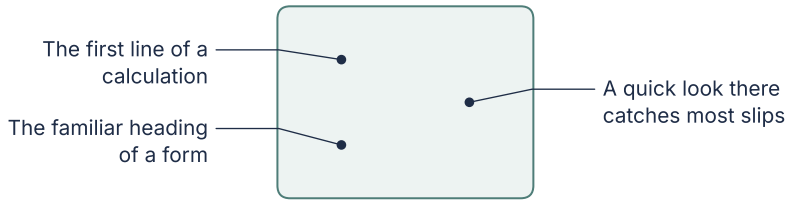
Ten focused minutes and a short break	An hour of fighting the old habit
⊕ A fresh mind keeps its grip on a new method	⊖ A tired mind loses its grip sooner

Speed is a pull of its own. **The wish to be done** can make you skip the step where you check the method. On this book’s reading, slowing down for ten seconds at the start of each step costs little and saves starting again.

Check your work at the points where habits strike. On this book’s reading, these are **the places where a task looks most like an old**

one. The first line of a calculation and the familiar heading of a form are typical. A quick look there catches most slips.

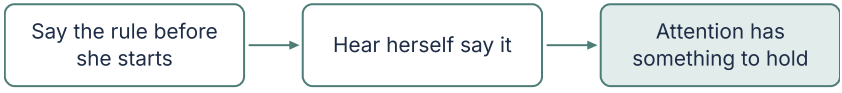
Where habits strike



A task that looks most like an old one

Children feel the same pull and can learn the same habits. **Ask a child to say the rule before she starts**, such as "carry the one" or "check the units". Hearing herself say it gives her attention something to hold when the work gets hard.

A child says the rule



None of this raises fluid intelligence itself. **It helps you use what you have**, by keeping your reasoning on the task you chose. On this book's reading, that is where many everyday mistakes come from, and where small changes pay off.

What the habits change

Fluid intelligence: unchanged	**Everyday mistakes:** fewer

Notice where your own pulls come from. **Some people are pulled most by old methods**, and others by moods or by the wish to finish fast. Knowing your main pull tells you which habit from this section to start with.

The exercises below come from the studies above (Engle, 2002; Burgoyne & Engle, 2020). **No study has tested them as training**, so treat them as practice ideas. The pull list names what drags you off course, and the goal line gives you a way back.

The pull list and the goal line

- The pull list names what drags you off course
- The goal line gives you a way back

Exercise:

Try it. Before your next sum or form, write one line naming the habit most likely to pull you off course.

Exercise:

Keep the task in charge.

1. Starter. Before a task, write the goal in one line at the top of the page.
2. Middle. List the pulls you expect, such as an old method or a strong feeling, and remove the ones you can.
3. Advanced. For a week, **mark each slip you catch** and note what pulled you, then plan for the most common pull.

From pull to plan

Notice	Name	Plan ahead

Key idea:

Reasoning depends on steering, so **name the pull and write the goal down** before a habit can take over.

Quick check:

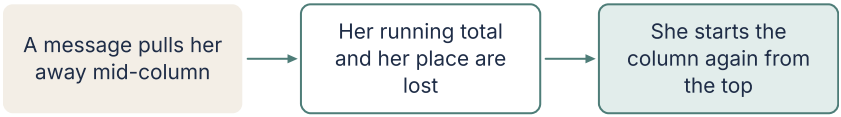
1. What did Engle say the limit on holding comes down to? Answer: "A domain-free limitation in ability to control attention" (Engle, 2002).
2. What does attention control provide, in Burgoyne and Engle's review? Answer: "A common thread among broad cognitive abilities" (Burgoyne & Engle, 2020).
3. When does control count most? Answer: When something pulls the wrong way, such as an old method, a familiar answer or a strong feeling.

2.1.2 Lapses and Distraction in the Middle of a Problem

A WOMAN IS TREASURER OF a small walking club, and every March she checks the year's accounts. She was halfway down a column of figures when her phone buzzed with a message about the spring walk. **When she looked back, she could not tell which row she had reached.** She started the column again from the top.

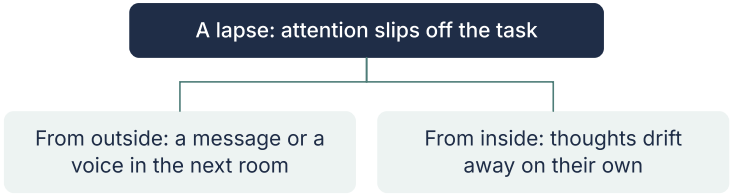
Nothing in the sum was hard. **What cost her was the break in the middle**, at the point where she held a running total and a place in the list. This section looks at what a lapse costs in a task with many steps, and at how to recover without starting over.

What a break in the middle costs



A lapse is a moment when attention slips off the task. **Some lapses come from outside**, such as a message or a voice in the next room. Others come from inside, when your thoughts drift away on their own, which 6.1.1 covers as mind-wandering.

Two sources of lapses



A long task has many variables, and each step depends on the ones before. A lapse in the middle does more damage than a lapse at the start, because more has to be held and found again.

> **Science Says:**
>
> One study looked at lapses alongside reasoning. Its authors wrote that "lapses of attention are strongly related to cognitive abilities" (Unsworth & McMillan, 2014). **The phrase in quotes means thinking skills.** The lapses were "related to working memory capacity and fluid intelligence" (Unsworth & McMillan, 2014), how much people could hold and how well they reasoned.

That needs care. The finding is a link between lapses and reasoning, and **it leaves the cause open**. People who reason well may lapse less, or something else may drive both. On this book's reading, the link is still a good reason to protect long tasks from breaks.

What the lapse study found

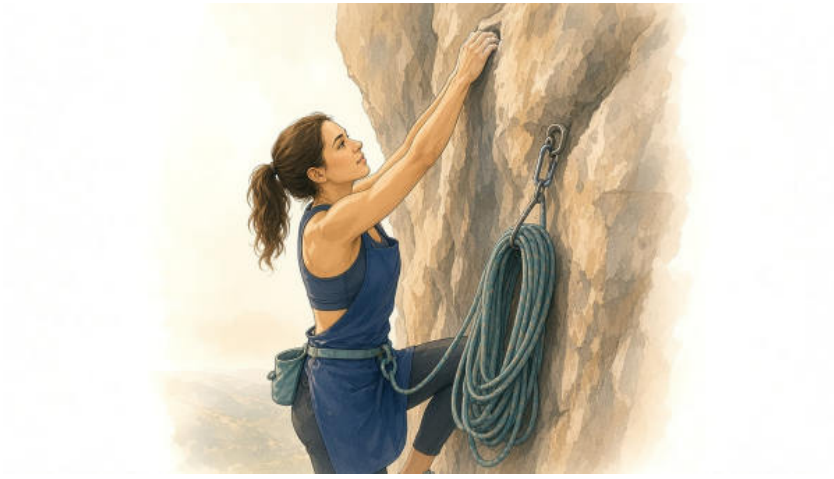
The finding	What stays open
Lapses are "strongly related to cognitive abilities"	The cause
Related to working memory capacity and fluid intelligence	People who reason well may lapse less, or something else may drive both

Whatever the cause, the cost of a lapse in a long task is easy to see. **Every step held only in your head** is at risk while you are away. On this book's reading, that is the part you can change today.

The link fits the picture of attention as steering (Engle, 2002). **A lapse is the steering letting go**, for a second or a minute. In a short task you barely notice. In a long one, the earlier steps fade while you are away, and the next step has nothing firm to stand on.

A lapse in short and long tasks

A short task	A long task
You barely notice	The earlier steps fade while you are away The next step has nothing firm to stand on



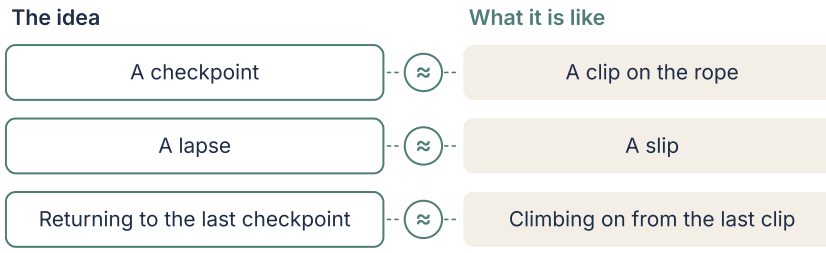
A climber on a rock face reaching for a hold, a coil of rope clipped to a metal ring just below her.

The treasurer's lapse had a clear cost. **She lost her place and her running total at once.** Both lived only in her head, and both were gone when the message pulled her away. The fix is to put them somewhere a lapse cannot reach.

> **Key Concept:**
>
> Checkpoint. In this book's terms, a checkpoint is **a point in a long task where you write down where you are and what you hold**. After a lapse, you return to the last checkpoint and carry on, instead of returning to the start.

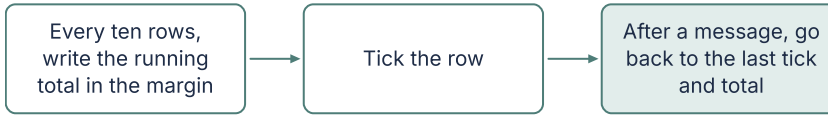
Think of a climber clipping her rope to the rock as she goes. **A slip costs only the distance to the last clip**, and she climbs on. Without the clips, one slip could cost her the whole climb.

Clips on the rock



A checkpoint for the accounts is simple. **Every ten rows, she writes the running total in the margin** and ticks the row. If a message pulls her away, she goes back to the last tick and the last total, and loses ten rows at most.

A checkpoint for the accounts



A checkpoint is lighter than a full record. **You write only enough to find your way back**, and every other step stays in the flow of the work.

On this book's reading, the lighter the habit, the more likely you are to keep it on a busy day.

On this book's reading, checkpoints work because they **move the held pieces onto paper** at regular points. The lapse can still happen. It simply costs less, because the work it would have taken from you is already safe.

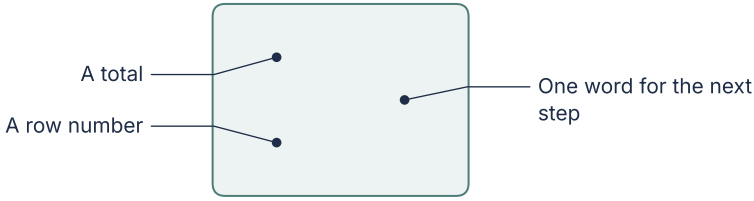
Choose where the checkpoints go. **Natural breaks in the task** are the best places. The end of a page, a change of topic or the end of one calculation all work. A checkpoint in the middle of a step is harder to return to than one at its edge.

Natural breaks for checkpoints

The end of a page	A change of topic	The end of one calculation

Keep each checkpoint short. **A total, a row number and one word for the next step** are enough. A long note takes attention of its own and turns into a second task.

What a short checkpoint holds



A checkpoint

Outside lapses can also be cut at the source. **Put the phone in another room** for the length of the task, or tell the people around you that you need twenty minutes. On this book's reading, each removed interruption is a checkpoint you never need.

Inside lapses are harder to stop. **A worry or a plan for later** can pull you away without any sound at all. Keep a scrap of paper beside you and write the stray thought down in three words. It then waits for you while you finish the task.

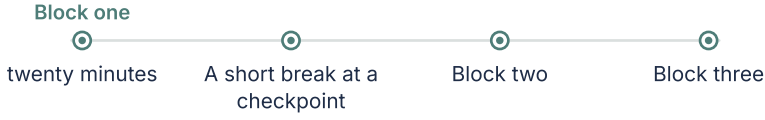
Outside and inside lapses

Outside lapses	Inside lapses
Can be cut at the source	Harder to stop
Put the phone in another room	Write the stray thought down in three words

Notice when your lapses come. On this book's reading, many people drift more **late in a long stretch** or near the end of a tiring day. Put the longest tasks where your attention is usually freshest.

Long tasks can be split. **Three twenty-minute blocks with short breaks** may hold up better than one hour without a pause. Plan each break at a checkpoint, so the pause is chosen and nothing is lost when you stop.

An hour in three blocks



Give each break a clear edge. **Stand up and stretch, then come back to the checkpoint you wrote.** A break with a clear return point feels shorter and costs less.

At work, a shared document can carry checkpoints for a team. **A line at the top saying "checked to row 40"** tells the next person where to start. It also protects you when a meeting cuts across your own work.

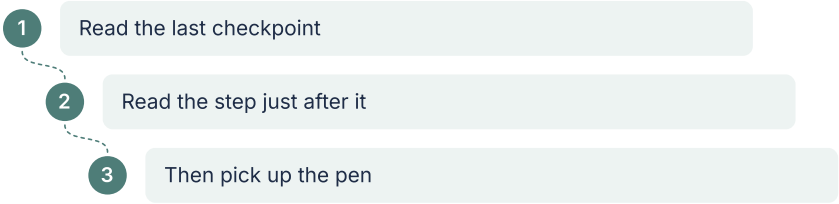
Checkpoints at work

- A line at the top saying "checked to row 40"
- It tells the next person where to start
- It protects you when a meeting cuts across your own work

Interruptions from other people are easier with a set phrase. **"Give me one minute to mark my place"** buys the time to write a checkpoint. Most people are happy to wait, and you return to a task that is still whole.

Recovery after a lapse has its own steps. **First read the last checkpoint, then read the step just after it**, and only then pick up the pen. On this book's reading, that short re-reading rebuilds the held pieces before you lean on them.

Recovery after a lapse



Some tasks have nowhere to write, such as adding up prices in your head as you walk round a shop. **Say the running total quietly** each time it changes. On this book's reading, the spoken total works as a checkpoint for the ear.

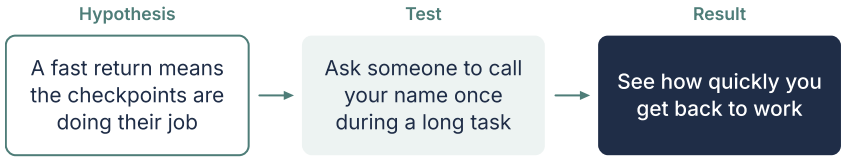
A shop with nowhere to write

No margin to hand	Your voice keeps the place

Be kind to yourself about lapses. **Everyone has them**, and a long task is bound to see a few. The aim is to make each one cheap, and checkpoints do that far better than trying not to drift.

A good test of the habit is a planned interruption. **Ask someone to call your name once** during a long task, then see how quickly you get back to work. On this book's reading, a fast return means the checkpoints are doing their job.

A planned interruption



Children doing long homework can use the same habit. **Ask a child to tick each finished question** and write any carried number in the margin. When her sister calls her away, she comes back to the tick and carries on without fuss.

The same idea helps in reading a long document such as a contract. **Mark each clause you have understood** with a small dot. A lapse

then sends you back one clause, and the dots show you how far you have come.

Ticks, carried numbers and dots

- [x] Tick each finished question
- [x] Write any carried number in the margin
- [x] Mark each clause you have understood with a small dot

Checkpoints also help you see your own pattern. On this book's reading, **a page full of checkpoints shows where you stopped** and how long each stretch lasted. Over a few weeks, that record tells you how long you can work before a break.

The exercises below come from the studies above (Unsworth & McMillan, 2014; Engle, 2002). **No study has tested them as training**, so treat them as practice ideas. The checkpoint habit makes lapses cheap, and the lapse log shows you when they come.

The checkpoint habit and the lapse log

> - The checkpoint habit makes lapses cheap
> - The lapse log shows you when they come

> **Exercise:**
> Try it. On your next long sum or form, write the running total in the margin every ten lines.

Exercise:

Make lapses cheap.

1. Starter. Pick one long task and mark three natural checkpoints before you begin.
2. Middle. At each checkpoint, write the total, the place and one word for the next step.
3. Advanced. For a week, **log each lapse and the time it came**, then move your longest task to your freshest hour.

Cheap lapses

A slip	Back to the last tick

Key idea:

Lapses will happen in long tasks, so **write down where you are at regular checkpoints** and return to the last one.

Quick check:

1. What were lapses of attention related to in one study? Answer: "Working memory capacity and fluid intelligence" (Unsworth & McMillan, 2014).
2. Does that finding show that lapses cause weaker reasoning? Answer: No. It is a link, and the cause is left open.
3. What should a short checkpoint contain? Answer: A total, a place and one word for the next step.

2.1.3 Reading the Problem: Attention at Intake

A LETTER FROM THE ENERGY company arrived on a busy Saturday. A father read it at the counter while the children argued about the television. **He took in that the price was changing and that he could switch.** A month later he found he had missed the date, which sat in the second paragraph.

He had read every line. **His attention had been split while he did it**, and the date never went in. This section looks at the first moment of a problem, when you read it and take in its pieces. That moment needs your full attention.

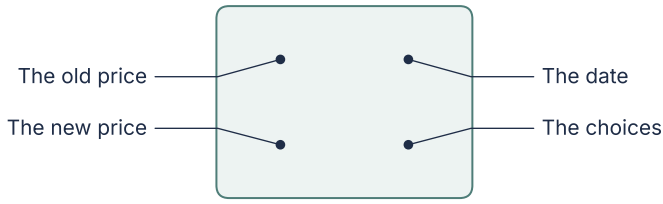
A split reading



The letter held every variable of the task, the old price, the new price, the date and the choices. On this book's reading, a variable you never took in is a variable you cannot reason about, however clear it was on the page.

The Memory book calls this intake side extractivity, and here we look at it from the side of reasoning. **The reading of a problem is a task of its own.** It comes before the solving, and it decides what the solving has to work with.

Every variable in the letter



The letter

> **Science Says:**
>
> One team compared splitting attention while people took material in with splitting it while they brought material back. They found that "At encoding, DA was associated with large reductions in memory performance" (Craik et al., 1996). **DA means divided attention, and encoding is taking information in.** At retrieval, the bringing back, "DA at retrieval resulted in small or no reductions in memory" (Craik et al., 1996).

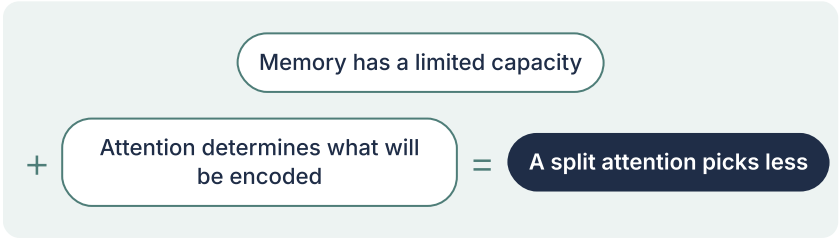
That needs a plain reading. **Splitting attention while you take a problem in** costs a lot of what you later remember about it. Splitting it while you bring the problem back costs little or nothing. The moment of reading is where the damage is done.

Splitting attention, in or out

When attention is split	Cost to memory
At encoding, taking the material in	Large reductions in memory performance
At retrieval, bringing it back	Small or no reductions

A review of attention and memory gave one reason. It said that "memory has a limited capacity, and thus attention determines what will be encoded" (Chun & Turk-Browne, 2007). **Memory cannot save everything at once**, so attention picks what goes in, and a split attention picks less.

Why a split reading picks less





A sieve held over a bowl, with water running through and a few small stones caught in the mesh.

His attention picked the price, because the price was what he cared about. **The date was a small line**, and the arguing children took the attention it needed. On this book's reading, the details that matter most to the solving are often the ones that look least exciting.

Prices and headlines draw the eye, and conditions hide in the small print. **The sentence that starts "You must"** is often the one that sets the deadline. On this book's reading, the dull lines are where a careful reader slows down.

Loud lines and dull lines

	Draws the eye	Hides in the small print
On the page	Prices and headlines	Conditions
A careful reader	Takes them in	Slows down

> 🔑 **Key Concept:**
> Reading for the variables. In this book's terms, this is **a first reading of a problem done only to take in its pieces**, with nothing else competing for attention. Solving waits until the pieces are in.

The lists of what you know, want and lack belong to the next step, and 3.1.1 shows how to write them. **This section is about the reading before that**, the moment that decides which pieces reach the lists at all.

Make the reading quiet. **Take the letter, the brief or the question to a place without noise** for a few minutes. On this book's reading, two calm minutes at the start can save an hour of work on the wrong problem later.

Read it twice. **The first reading gives you the shape**, what the problem is about. The second reading is for the details, such as dates, amounts and conditions. Many small but important pieces only appear on the second pass.

Two readings, two jobs



Read numbers slowly. On this book's reading, **a misread figure is an easy intake slip**, since 15 and 50 look alike at a glance. Say each number under your breath as you underline it.

Eye, then voice



Mark the pieces as you read. **Underline every number, date and name**, and circle every condition, such as "only if" or "before". The marks turn the page into a list of variables you can see at a glance.

Then check the marks against the page. **Count the dates you underlined** and look once more for any you missed. A quick count takes seconds and catches the piece that slipped past on both readings.

Marks on the page

- [x] Underline every number, date and name
- [x] Circle every condition, such as "only if" or "before"
- [x] Say each number under your breath
- [x] Count the dates you underlined

Attention also chooses what you look for. The same review noted that "memory from past experience guides what should be attended" (Chun

& Turk-Browne, 2007). **What you expect to find shapes what you notice.** The father expected a price, so he saw a price.

What you expect, you notice



That guidance helps when the problem is like an old one. It misleads when the problem has changed. On this book's reading, **reading for every variable** guards against seeing only the ones you expected.

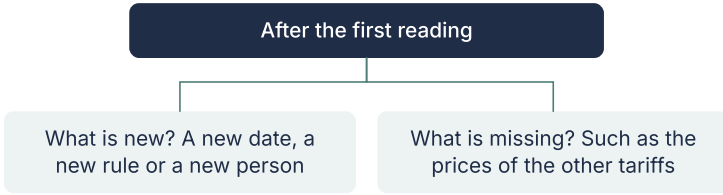
Guidance from past experience

It helps	It misleads
⊕ When the problem is like an old one	⊖ When the problem has changed

Ask what is new. **After the first reading, write one line on what this problem has that the last one did not.** A new date, a new rule or a new person is often the piece your past experience would have hidden.

Ask what is missing too. **Some letters leave out a piece you need**, such as the prices of the other tariffs. Noting the gap at intake tells you what to look up before you start.

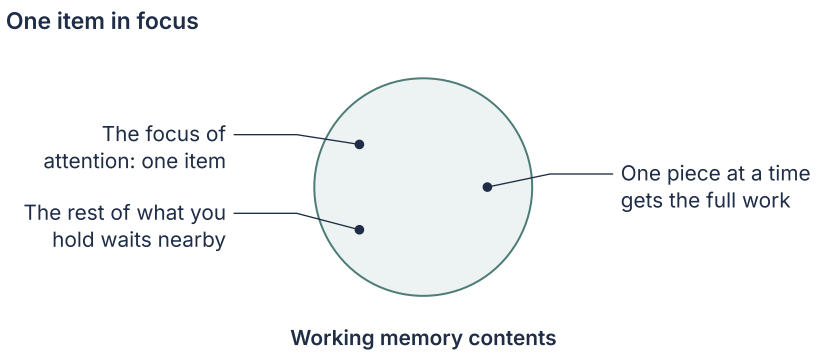
Two questions after the first reading



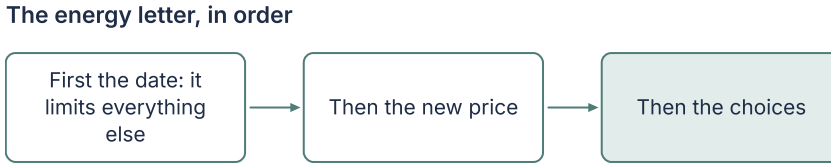
Once the pieces are in, work on them one at a time. **The mind does not hold them all in the same way.** Researchers who study working memory describe a narrower spot inside it, where one piece gets the closest attention.

> **Science Says:**
> One account of working memory puts it this way. “Within working memory contents, a single item is often selected into the focus of attention for processing” (Oberauer, 2019). **The rest of what you hold waits nearby.** The focus of attention is the one item in that space you are working on.

That fits reasoning well. **One piece at a time gets the full work**, while the others wait in view. On this book’s reading, a problem goes more smoothly when you choose which piece is in focus, instead of letting the pieces fight for it.



The energy letter shows the order. **First the date, because it limits everything else.** Then the new price, then the choices. Taking them one by one, in that order, would have told the father he had three weeks to decide.



At work, a brief from a manager deserves the same care. **Read it at your desk before the meeting starts**, mark its variables and note what is new. In the meeting you can then ask about the missing pieces instead of discovering them a week later.

Emails need the same care. **A long email read on a phone between meetings** is intake with split attention. On this book's reading, flag it and read it properly at a desk before you answer its questions.

Intake at work

Read a brief at your desk before the meeting starts	Flag a long email and read it properly at a desk

Children can learn this habit with homework. **Ask a child to read a question twice and underline the numbers** before she picks up her pencil to solve it. The habit costs her a minute and saves many sums done on the wrong figures.

The same steps help with household paperwork at any age. **A folder for letters that need a decision**, read once a week in a quiet hour, keeps intake away from the bustle of the doormat. Nothing with a date gets read on the run.

From doormat to decision

Post arrives	Into the folder	Decided at the weekly sitting

On this book's reading, intake is the step people most often rush. **It feels like nothing is happening** while you read, and the urge to start solving is strong. The two minutes you spend here are part of the solving, and often the most useful part.

If you must read in a noisy place, read for one thing at a time. **Look only for dates on the first pass**, then only for amounts. Narrowing the task gives a split attention less to miss.

Reading for one thing at a time

- Look only for dates on the first pass
- Then only for amounts
- Narrowing the task gives a split attention less to miss

The exercises below come from the studies above (Craik et al., 1996; Chun & Turk-Browne, 2007; Oberauer, 2019). **No study has tested them as training**, so treat them as practice ideas. Quiet reading protects the intake, and the one-at-a-time step uses the focus.

Quiet reading and the focus

Quiet reading protects the intake	The one-at-a-time step uses the focus

Exercise:

Try it. Read your next letter or brief twice in a quiet spot, underlining every date, number and condition.

Exercise:

Read before you solve.

1. Starter. Take one real problem to a quiet place and read it twice before doing anything else.
2. Middle. Mark every variable, then write one line on what is new compared with the last such problem.
3. Advanced. Number the variables in the order they limit the task, and **work on them one at a time** in that order.

Calm intake

Noise outside	Pieces in

Key idea:

Reasoning can only use what reading took in, so give the first reading your full attention and work one piece at a time.

Quick check:

1. Where did divided attention cause large reductions in memory? Answer: At encoding, when people took the material in (Craik et al., 1996).
2. Why does attention decide what is encoded? Answer: Because "memory has a limited capacity" (Chun & Turk-Browne, 2007).
3. What is the focus of attention? Answer: The single item in working memory selected for processing (Oberauer, 2019).

2.2 Intellect and Memory: Knowledge Feeds the Task

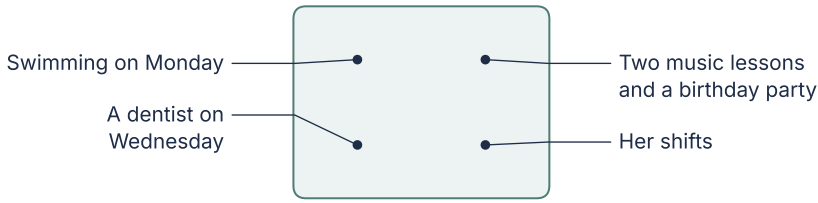
2.2.1 Working Memory and Intelligence: Strongly Linked, Not the Same

On Sunday evening a mother of three plans the week for her children. Swimming on Monday, a dentist on Wednesday, two music lessons and a birthday party all have to fit around her shifts. **By the time she places the party, she has forgotten which day the dentist was.** She sighs and starts again.

Most of us have had an evening like hers. **The pieces are simple one by one**, and it is the number of them that defeats us. On this book's

reading, that is a sign of a holding problem, and holding problems have some of the easiest fixes.

Simple pieces, too many of them



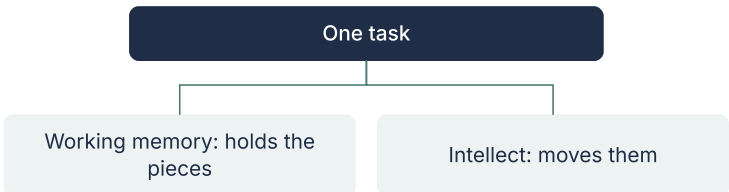
Her week

The planning itself is easy reasoning. **What fails is the holding**, keeping all the pieces in mind while she moves them around. This section looks at how holding and reasoning work together, how they differ, and what that means for the way you tackle a task.

This chapter pairs intellect with memory. The Memory book defines memory as "the thinking ability to take in, keep and bring back information and experiences". **Memory keeps the variables of a task available** while intellect works on them.

The kind of memory at work here is working memory. **It holds the pieces, and intellect moves them.** When the pieces slip, the reasoning has nothing to move.

Memory keeps, intellect works



How closely working memory and intelligence go together is still debated. **The two main figures are in 1.1.1** (Ackerman et al., 2005; Kane et al., 2005), and I do not repeat them here. The point for this section is what the gap between the two means for your own work.

This section takes that as its starting point. **If they were the same, a bigger store would always mean better reasoning.** It does not, and the gap between the two is where most of the useful advice lives.



Two rowers in a narrow boat on a calm river, each pulling a different oar.

Think of two rowers in one boat. **They move together**, and each pulls a different oar. When one stops, the boat turns in circles, however hard the other works.

Two rowers, two jobs

The idea		What it is like
Holding	≈	One rower pulls one oar
Reasoning	≈	The other pulls a different oar
One job stops	≈	The boat turns in circles

> **Key Concept:**
> Holding and reasoning. In this book's terms, these are **two separate jobs inside one task**. So a slip in a crowded plan says little about how well someone reasons. To judge your own reasoning, or anyone else's, look at tasks where the pieces are already on paper.

The mother's plan failed at holding. **Her reasoning was fine**, since she knew a dentist and a music lesson could not share an afternoon. What she lacked was a place to keep every piece in view while she worked out the clashes.

The fix for a holding failure is to hold outside your head. **Write each event on its own sticky note** and lay them out on the calendar. Now every piece stays in view, and her working memory is free for the one real question, which pieces clash.

Hold outside your head

In her head	On the calendar
Every piece held at once	Each event on its own sticky note
She forgets which day the dentist was	Working memory is free for which pieces clash

On this book's reading, paper does more than store. **It lets you see pieces side by side** and move them without losing any. A clash that took effort to spot in your head becomes a matter of looking.

Colour helps too. **One colour per child** lets her see at a glance whose week is crowded. On this book's reading, anything that turns a held fact into a seen fact frees space for the reasoning.

Colours on the calendar

Held in mind	Seen on the wall

Cowan's work on how much working memory holds is told in 3.1.1 (Cowan, 2001). On this book's reading, **plans with many parts** soon outgrow the space. Writing them down is the ordinary way to stay inside it, and nothing to be embarrassed about.

A reasoning failure needs a different fix. **Suppose every piece is on paper** and the plan still does not work. Then the trouble is in the thinking, such as a rule you forgot or a step done in the wrong order. More paper will not solve that.

For reasoning failures, slow down and name the rule. **"No two events in one afternoon"** is a rule she uses without saying it. Written at the top of the page, it turns into a check she can run on each day.

Two failures, two fixes

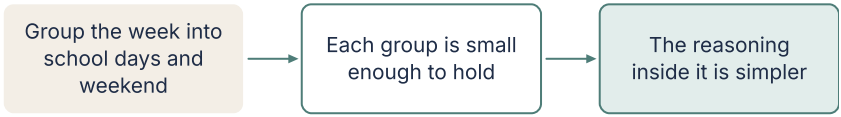
Failure	Fix
Holding: a piece slips	Hold outside your head, on paper
Reasoning: a rule you forgot or a step done in the wrong order	Slow down and name the rule

Some rules hide inside habits. **She knows Tuesdays are hard** because of a late shift, and she never writes it down. Making the hidden rule visible means the plan no longer depends on her remembering it halfway through.

The link between the two jobs runs both ways. On this book's reading, **good reasoning can ease the holding**. If she first groups the week into

school days and weekend, each group is small enough to hold, and the reasoning inside it is simpler.

Reasoning eases holding



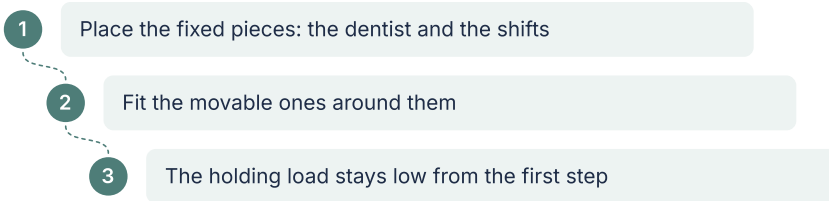
Grouping is one of the strongest moves you have. **Three groups of three pieces** are easier to hold than nine loose ones. On this book's reading, a minute spent grouping before you reason often saves several minutes of starting again.

Three groups or nine loose pieces

Three groups of three	Nine loose ones
⊕ Easier to hold	⊖ Harder to hold
⊕ Each group small enough to hold	⊖ Often means starting again

Order matters as well. **Place the fixed pieces first**, such as the dentist and the shifts, then fit the movable ones around them. On this book's reading, starting with what cannot move keeps the holding load low from the first step.

Fixed pieces first



Money plans follow the same pattern. **A household budget has many fixed pieces**, such as rent, bills and the dates they leave the account. Listing them in date order on one page lets you see which week runs short before it happens.

Health plans can use it too. **A list of medicines with a time beside each one** holds the pieces for you. Your thinking is then free for the questions that matter, such as what to ask at the next appointment.

The same pattern in money and health

Plan	Hold the pieces on
A household budget	Rent and bills listed in date order on one page
Health	A list of medicines with a time beside each one

Paper looks after the holding, and **the reasoning half grows another way**. It needs real tasks to work on, week after week, with the pieces laid out where you can see them.

Practice on real tasks does change something. On this book's reading, **you get faster at the kinds of plan you make often**, because the pieces and rules become familiar. That is a gain in the task itself, and it is the gain most people want.

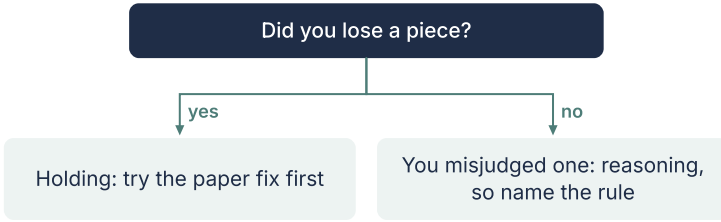
Two kinds of gain

Paper:	Practice:
the holding	the reasoning half

At work, the same split helps you find where a task is going wrong. **Ask whether you lost a piece or misjudged one.** A lost piece points to

holding, and a misjudged piece points to reasoning. The answer tells you which fix to try first.

Lost or misjudged?



Write the answer down when you find it. **A short note such as "lost the date again"** builds a picture of your weak spots over time, and the next fix comes faster.

Meetings are a common holding trap. **Five people each add a condition**, and by the end no one can hold them all. On this book's reading, one person writing each condition on a shared screen keeps the reasoning honest for everyone.

Phone calls are harder, since there is no shared screen. **Keep a pen in hand and note each number or date** as it is said. Read them back before you hang up, so the other person can catch any you misheard.

Holding traps in meetings and calls

- [x] One person writes each condition on a shared screen
- [x] Keep a pen in hand on a call
- [x] Note each number or date as it is said
- [x] Read them back before you hang up

Children learning long sums meet the same split. **A child who loses the carried number** has a holding problem, and a pencil mark fixes it.

A child who carries in the wrong column has a reasoning problem, and needs the rule explained again.

Teachers can use the split when marking. **A margin note saying "lost the carry"** points the child to a holding slip, and "wrong column" points to the rule. The child learns which kind of mistake she makes most.

Two slips in long sums

	Holding slip	Reasoning slip
The child	Loses the carried number	Carries in the wrong column
The fix	A pencil mark	The rule explained again
Margin note	"Lost the carry"	"Wrong column"

You can learn your own pattern in the same way. **Over a month, note which kind of failure** trips you most often. Some people mostly lose pieces and others mostly misjudge them, and the fixes are different.

The paper habits in this section suit any age. They help keep reasoning about plans, money and health on track on days when holding takes more effort.

No study in this section tests these habits directly, and the studies named here are told elsewhere in the book. **Treat the exercises as practice ideas.** The sticky-note layout supports holding, and the rule line supports reasoning.

Sticky notes and the rule line

- The sticky-note layout supports holding
- The rule line supports reasoning

Exercise:

Try it. For tomorrow's plans, write each event on its own scrap and lay them out before deciding anything.

Exercise:

Hold outside, reason inside.

1. Starter. On your next plan, write every piece on its own note before you start to arrange them.
2. Middle. Group the notes into two or three sets, and work on one set at a time.
3. Advanced. When a task goes wrong this week, **decide whether you lost a piece or misjudged one**, and record the fix you used.

Paper and mind

Paper holds	Mind weighs

Key idea:

Holding and reasoning are separate jobs, so **put the pieces on paper and spend your thinking** on what they mean.

Quick check:

1. Why does a bigger store not always mean better reasoning? Answer: Holding and reasoning are separate jobs, and reasoning can still fail with every piece in view.
2. What can be handed to paper, holding or reasoning? Answer: Holding, which frees your thinking for the reasoning.
3. How can good reasoning ease the holding? Answer: Grouping the pieces first makes each group small enough to hold.

2.2.2 Knowledge and Expertise: Why Experts See the Deep Structure

A driver's car had started making a faint knocking sound on hills. She described it to a mechanic, who listened to the engine for less than a minute. **"Your timing chain is wearing," he said, and he was right.** She had heard the same sound for weeks and learned nothing from it.

The driver had the same facts as the mechanic. **The sound, the hills and the timing** were all there for both. What the driver lacked was a case to match them against, so the facts stayed loose and meant nothing.

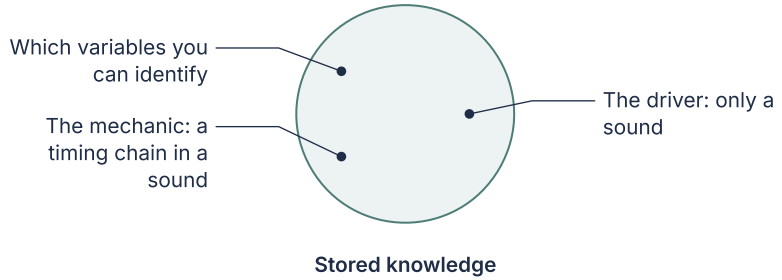
Same facts, different seeing

The driver	The mechanic
Heard the same sound for weeks	Listened for less than a minute
No case to match it against	"Your timing chain is wearing"

The mechanic did not hear better than the driver. **He heard the sound against a store of hundreds of engines**, and the store told him what kind of problem it was. This section looks at how stored knowledge lets people see the type of a problem, and at how to build that kind of store yourself.

This chapter pairs intellect with memory. **Knowledge often decides which variables you can identify at all.** The mechanic saw a timing chain in a sound, and the driver saw only a sound.

Knowledge decides the variables



Experts and beginners look at the same problem in different ways. Chi and colleagues showed this (Chi et al., 1981), and 3.1.2 tells their study.

This section asks what memory adds, and how the knowledge behind expert seeing is built.

Recht and Leslie studied prior knowledge in reading (Recht & Leslie, 1988). **Here I take one lesson from both teams**, that what you already know decides what a new problem looks like to you.

Prior knowledge first

Old knowledge	A new problem, already shaped

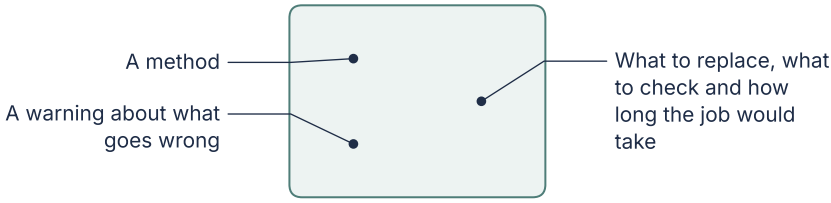
> **Science Says:**
> A classic study of expertise and memory compared chess masters with weaker players. When the pieces were placed at random, "the masters could then do no better in reconstructing them than weaker players" (Chase & Simon, 1973). **Their edge held only for positions that made sense.** Later researchers disputed parts of the authors' explanation.

Chess skill itself is covered in 8.3.1 (Burgoyne et al., 2016). **This section stays with memory**, and with what a store of meaningful cases lets anyone see in their own work.

> **Key Concept:**
> Problem type. In this book's terms, a problem type is **the kind of problem a task belongs to**, recognised by matching it against cases you have stored. Naming the type tells you which method to reach for, before you start working.

A type is more than a label. **It carries a method with it**, and often a warning about what goes wrong. “Worn chain” told the mechanic what to replace, what to check and how long the job would take.

What a type carries



A problem type

On this book’s reading, recognising the type is the quiet first step of expert work. **Once the mechanic knew it was a worn chain**, the rest was routine. The hard part of the problem had been solved by memory before any reasoning began.

That explains why experts can seem fast. **They are often doing less reasoning**, because a stored case has already narrowed the options. A beginner has to reason through every possibility, and that takes longer and goes wrong more often.

Speed is a side effect. On this book’s reading, **the real gain is fewer wrong turns**, since the stored case rules out paths a beginner would try and abandon. Fewer wrong turns also mean less to hold in mind.

Expert and beginner

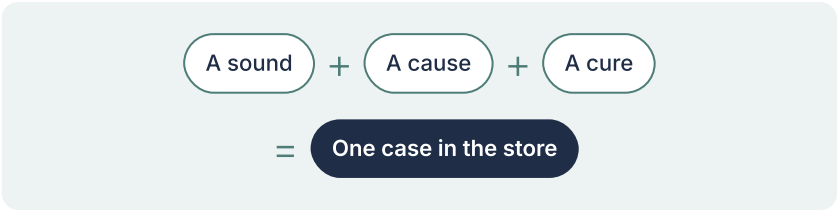
	Expert	Beginner
Reasoning	Less: a stored case has narrowed the options	Reasons through every possibility
Result	Fewer wrong turns	Takes longer and goes wrong more often



A wall of labelled wooden drawers in an old hardware shop, one drawer pulled out to show neat rows of screws.

The store is built from cases. **Each engine the mechanic fixed** added a sound, a cause and a cure to his memory. On this book's reading, the size and order of that store matter more than any special talent for engines.

One stored case



Order is the part people forget. **A pile of cases is hard to search**, however large it is. Cases stored by type, with the sound, the cause and the cure linked together, can be found in seconds when a new car rolls in.

A heap or labelled drawers

Cases stored by type	A pile of cases
⊕ Found in seconds when a new car rolls in	⊖ Hard to search, however large it is

Think of the hardware shop in the picture. **Every screw sits in a labelled drawer**, so the shopkeeper finds the right one in seconds. The same screws in one heap would take an hour to sort.

You can build a store like that on purpose. **After each problem you solve, write three lines.** Note what it looked like, what it really was and what fixed it. The second line names the type, and it is the line that will help you next time.

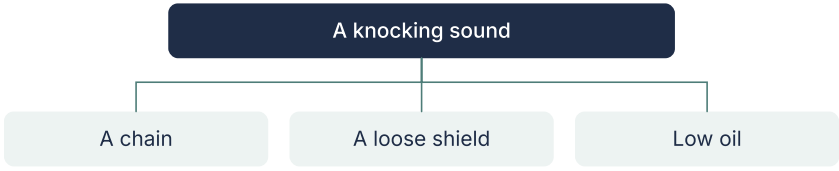
Three lines after each problem



Compare new problems with old ones. **Ask what this one is like**, and look for a case with the same cause, even if it looks different. On this book's reading, practice in naming types grows the habit that makes experts look quick.

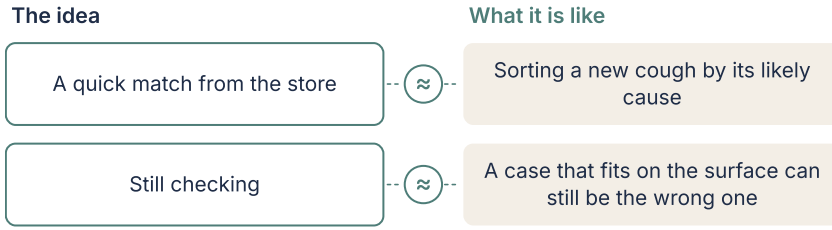
Surface features can mislead. **Two problems that look alike** may have different causes, and two that look different may share one. A knocking sound might be a chain, a loose shield or low oil, and a store organised by cause helps you tell them apart.

One sound, three causes



Doctors work in a similar way. On this book's reading, **a family doctor who has seen many coughs** sorts a new one by its likely cause within moments. She still checks, because a case that fits on the surface can still be the wrong one.

Like a family doctor

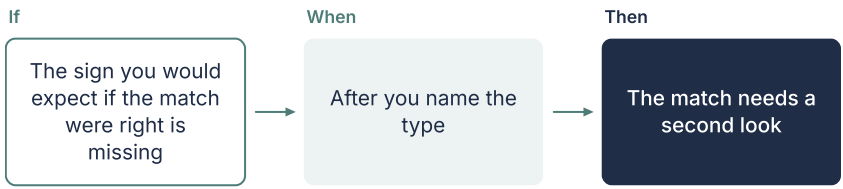


Good doctors also say when a case does not fit. **"This is not the usual pattern"** is a useful sentence for anyone who solves problems. On this book's reading, noticing a misfit is a skill that grows from the same store as the quick match.

Checking matters even for experts. **A quick match can be wrong**, and the more confident you feel, the less you may want to look again. On this book's reading, the safe habit is to name the type, then look for one sign that would prove the match wrong.

A sign like that is easy to choose once you ask for one. **Ask what you would expect to see if the match were right**, then look for it. If it is missing, the match needs a second look.

When the expected sign is missing



Beginners can borrow expert stores. **Ask someone experienced what kind of problem this is**, and how they can tell. Their answer gives you a case and a sign at once, and you can add both to your own notes.

Ask them about their mistakes too. **The case they got wrong once** often teaches the sign they now look for. On this book's reading, an expert's old errors are some of the most useful cases they can pass on.

Borrowing an expert store

- [x] Ask what kind of problem this is
- [x] Ask how they can tell
- [x] Ask about their mistakes
- [x] Add the case and the sign to your notes

At work, a shared case log helps a whole team. **Each person adds a short entry** when a problem is solved, with the type written clearly. A newcomer can then search the log and find in minutes what took others years to learn.

Keep the entries short enough to read. **One line for each column** is plenty. A long story about the problem hides the type, and the type is what the next person needs.

A shared case log

> - Each person adds a short entry when a problem is solved
> - The type written clearly
> - One line for each column

Children build stores in the same way. **Ask a child what kind of sum this is** before she starts it, such as sharing, grouping or taking away. Naming the type first helps her choose the method and see that new questions are often old ones in new clothes.

Parents can do the same with everyday repairs. **When the bathroom tap drips, ask what kind of drip it is**, from the spout, the handle or the pipe below. The type points to the fix, and the child sees naming come before mending.

Naming the type first

Task	Types to ask about
A sum	Sharing, grouping or taking away
A dripping tap	From the spout, the handle or the pipe below

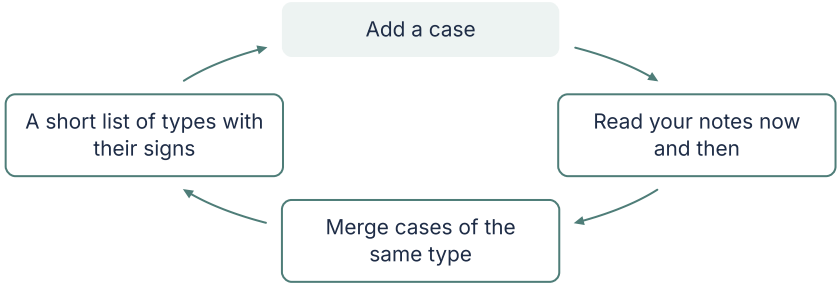
Knowledge grows in one field at a time. **The mechanic's store helps with engines** and says little about tax returns. On this book's reading, that is a reason to build a store in each area where you solve problems often. One kind of skill will not cover them all.

Stores by field

Car repairs	Paperwork	Different stores

The store also needs upkeep. **Read your notes now and then**, and merge cases that turn out to be the same type. Over time the notes become a short list of types with their signs, which is what the expert carries in his head.

Keeping the store



Older learners have an advantage here. On this book's reading, **years of experience mean a large store of cases**, even if it has never been written down. Writing a few of them out can turn that store into something you can search on purpose.

Retirement is a good time for this. **A former nurse or engineer** carries cases that newer people would value. On this book's reading, writing a few down, or talking them through with a younger colleague, passes the store on.

Stores from long experience

Years of experience: a large store of cases	Write a few of them out	Talk them through with a younger colleague

The one new study here is the expertise and memory study above (Chase & Simon, 1973), and the others are told elsewhere in the book. **Treat the exercises as practice ideas.** The case notes build the store, and the type question trains the habit of using it.

Case notes and the type question

- The case notes build the store
- The type question trains the habit of using it

Exercise:

Try it. After your next solved problem, write what it looked like, what it really was and what fixed it.

Exercise:

Build your case store.

1. Starter. Keep three-line notes on every problem you solve for one week.
2. Middle. Sort the notes by type, and give each type one sign that tells it apart.
3. Advanced. Before your next hard problem, **name its type and one sign that would prove you wrong**, then check.

A store that grows

First cases	A searchable store

Key idea:

Experts see the type of a problem from a store of cases, so **build your store by type** and check every quick match.

Quick check:

1. Why could the mechanic tell what the sound meant? Answer: He matched it against a store of cases organised by cause.
2. Why can experts seem fast? Answer: A stored case has already narrowed the options, so they do less reasoning.
3. What should you look for after naming a problem's type? Answer: One sign that would prove the match wrong.

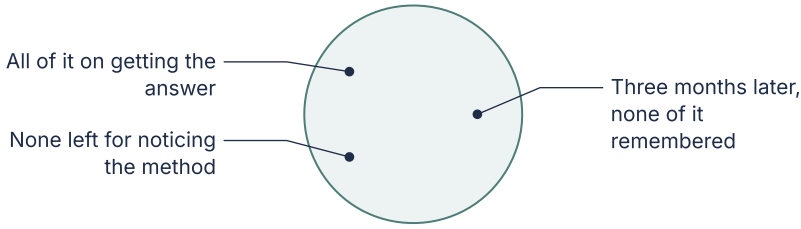
2.2.3 Using What You Remember: Load, Worked Examples and Analogies

A woman runs a small cleaning business, and this year she had to file her own quarterly tax return for the first time. **She spent a whole evening working each box out from scratch**, and got it right. Three months later she sat down for the second one and could not remember how she had done any of it.

She had solved the problem and learned almost nothing from solving it. **All her effort had gone into getting the answer**, and none was left for noticing the method. This section looks at why that happens, and at

how remembered examples and old cases can carry a method to a new task.

Where her effort went



One evening of effort

This chapter pairs intellect with memory. **A method is a stored way of handling a kind of task**, and memory is where you keep it for next time.

A method, in plain words

> Definition
>
> ## A method
>
> A stored way of handling a kind of task, kept in memory for next time

Sweller's work on problem solving and learning (Sweller, 1988) is told in 3.1.1, and **it fits her evening well**. I do not repeat it here. This section looks at what to do about it in everyday work.

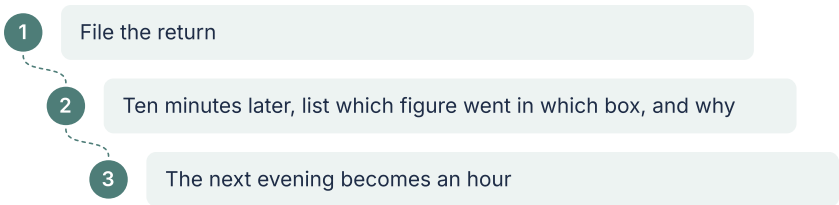
On this book's reading, the plain lesson is to **give the method its own time**. If the solving takes everything, the learning gets nothing, and the next problem starts from scratch.

> **Key Concept:**
> Solve, then study. In this book's terms, this is **the habit of going back over a problem once it is solved**. You write down the method while the work is still fresh. The answer finishes the task, and the study keeps the method for the next one.

Many people skip the study step because the job feels done. **The relief of finishing** pulls you away from the desk. On this book's reading, a note written in that moment is cheap learning, because everything is still in front of you.

The second step is cheap. **Ten minutes after the return was filed**, she could have written a short list of which figure went in which box, and why. That list would have turned her next evening into an hour.

The cheap second step



Write the method in your own words. **"Box 6 is total sales before tax"** is a line you will understand in three months. A copy of the form alone shows what you wrote, and leaves out the reasons.

A copy or a method note

A copy of the form	A method note in your own words
Shows what you wrote	"Box 6 is total sales before tax"
Leaves out the reasons	Understood in three months

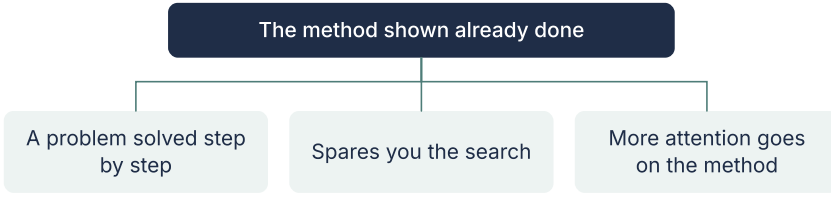
Note the traps as well. **Write down where you went wrong**, such as the box you filled twice. Next time the note warns you before the slip, and a known trap costs nothing.

A good method note

- [x] Written in your own words
- [x] Which figure went in which box, and why
- [x] The traps, such as the box you filled twice

A worked example is the method shown already done, a problem solved step by step. **Studying one before you try** spares you the search, so more of your attention goes on the method. On this book's reading, a worked example is often the fastest way into a new kind of task.

A worked example



Her own first return is now a worked example. **Next quarter she can follow it line by line**, with her notes beside it. The search is gone, and

her attention can go on the two or three figures that are different this time.

Ask for examples at work. **A colleague's finished report**, a past budget or last year's plan can all serve. Read the example for its steps, and note the order in which the parts are done.

Examples at work

A colleague's finished report	A past budget	Last year's plan

Choose examples close to your task. On this book's reading, **an example from the same kind of job** shows the steps most clearly. A distant example may hide the method under details you do not need.

Close or distant examples

From the same kind of job	A distant example
⊕ Shows the steps most clearly	⊖ May hide the method under details you do not need

Keep examples where you can find them. **A folder of solved tasks**, each with its short method note, becomes a library of methods. On this book's reading, that folder is worth more than any single clever solution.

Review the folder before a task you do rarely. **Yearly jobs are the easiest to forget**, such as an insurance renewal or an end-of-year report. Reading last year's method note for five minutes can save an evening.

A library of methods

Solve a task → Add its method note to the folder → Before a rare task, read last year's note for five minutes



A shelf with a row of slim labelled folders, one pulled halfway out.

Old cases can carry a method to a problem that looks quite different. **That is the work of analogy**, using a case you know to solve one you do not. Gick and Holyoak's studies of it are told in 3.1.2 (Gick & Holyoak, 1980; Gick & Holyoak, 1983), and this section adds what memory brings to the move.

The hard part of an analogy is finding the old case. **The useful case is in memory, but nothing on the surface points to it.** On this book's reading, that is why a habit of looking makes such a difference.

The hidden match

Surface: different	**Structure:** the same

The business owner later had a new problem, booking cleaners into houses across town without long drives in between. **It looked nothing like a tax return.** It was more like planning a delivery round, a case she knew from a summer job years before.

Once she saw the match, the method came with it. **Group the houses by area, then order each group by distance.** The old case did the planning, and her reasoning only had to check where the two jobs differed.

A cleaning round as a delivery round

The idea		What it is like
Houses across town	≈	Stops on a delivery round
Group by area, then order each group by distance	≈	The method that came with the match
Checking where the jobs differ	≈	The reasoning left to do

Notice what made the match possible. **She had stored the delivery round as a way of solving**, grouping by area, and a stored method can travel. A case kept only as a memory of a summer job would have stayed in the past.

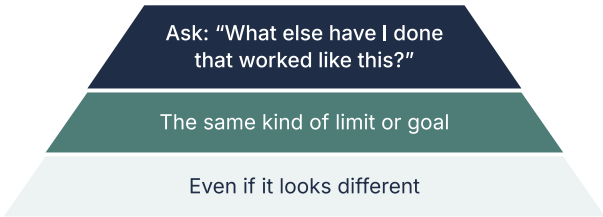
How a case is stored

Stored as	What happens
A way of solving: grouping by area	The method can travel
Only a memory of a summer job	It stays in the past

You can make the search for old cases a habit. **Ask, "What else have I done that worked like this?"** before you start a new problem. Look

for a case with the same structure, the same kind of limit or goal, even if it looks different.

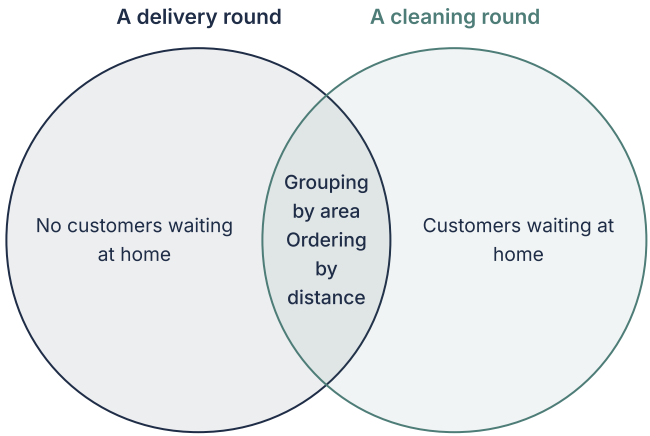
Searching for a case with the same structure



Keep a second solved case beside the first when you can. **Mark the steps the two share**, and give them a short name. On this book's reading, a named method is easier to spot in a third problem.

Check the match before you lean on it. **An analogy can fit on the surface and fail underneath.** A delivery round has no customers waiting at home, and a cleaning round does. The times have to fit the people as well as the map.

Two rounds, one method



Groups can find old cases faster than one person. **Ask each person what the problem reminds them of.** A teacher, a nurse and a builder hold different stores, and one of them may hold the case that unlocks it.

Different stores in a group

A teacher	A nurse	A builder

Write the match down once you find it. **A line saying "cleaning rota works like a delivery round"** goes into the folder with the method. Next time the analogy is already made, and the old case is easy to find.

Children can practise the habit with homework. **Ask a child what a new question is like**, and which past question used the same steps. Finding the match is half the work, and it grows with every question she does.

Teachers can help by setting two worked examples side by side. On this book's reading, **asking pupils what the two share** turns the examples into a method they can carry. The comparison does the teaching that a single example cannot.

Two examples, one method

Example one	Example two	Shared steps named

Older relatives hold large stores of old cases. **A grandparent who once ran a shop** may hold the very method a grandchild's school project needs. On this book's reading, asking across generations is one of the easiest ways to widen your search.

You will not always find a match. **Some problems are new to you**, and the search for an old case comes up empty. Then the search itself has told you something, that this task needs fresh reasoning, and you can plan for a longer job.

A fresh solution is worth a method note of its own. **The first time you solve a new kind of task**, write the note with extra care. It becomes the worked example for the next person, or for you next year.

When no match turns up



The studies behind this section are told elsewhere in the book, so no new study is cited here. **Treat the exercises as practice ideas.** The method note follows the solve-then-study habit, and the case question trains the search for analogies.

Method notes and the case question

- The method note follows the solve-then-study habit
- The case question trains the search for analogies

> **Exercise:**
>
> Try it. After your next solved task, write its method in five short lines, in your own words.

Exercise:

Keep the method.

1. Starter. After each solved task this week, spend ten minutes writing its method.
2. Middle. Before a new task, ask what past task worked the same way, and list where the two differ.
3. Advanced. Find two solved tasks with the same method, and **write the shared steps as one general method** you can use on a third.

A method kept

Solved once	Reused often

Key idea:

Solving uses the space that learning needs, so **study the method after you solve** and keep it for the next task.

Quick check:

1. What is the solve-then-study habit? Answer: Going back over a solved problem to write down its method while the work is fresh.
2. What is the hard part of using an analogy? Answer: Finding the old case, because nothing on the surface points to it.
3. Why give shared steps a short name? Answer: On this book's reading, a named method is easier to spot in a third problem.

2.3.1 How Intellect and Creativity Relate: Overlap, Thresholds and Limits

Two friends opened a small bakery together. Tom can price a loaf to the penny, plan the ovens for a week and spot a wrong invoice at a glance. **Asked to name the shop, he went blank for a fortnight.** Sara had twenty names by lunchtime, and she still cannot make the accounts balance.

You probably know pairs like them. **One friend plans the holiday to the minute**, and another finds the hidden beach nobody else knew about. On this book's reading, both are using intellect and creativity, in different proportions.

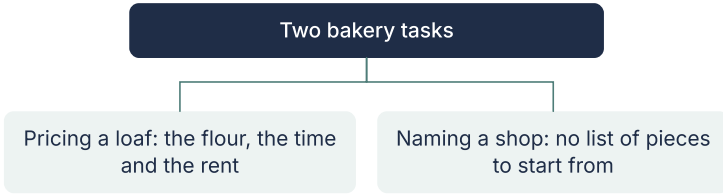
They are both clever, in different ways. **Their bakery works because each covers the other's gap.** This section looks at how intellect and creativity relate. It asks what the overlap between them means for you and the people you work with.

Two friends, two strengths

	Tom	Sara
Does easily	Prices a loaf to the penny and plans the ovens	Twenty names by lunchtime
Struggles with	Naming the shop	Making the accounts balance

In this book's terms, creativity is solving tasks where the variables are not identified. Pricing a loaf has known pieces, the flour, the time and the rent. Naming a shop has no list of pieces to start from.

Known and open pieces



How much the two abilities overlap has been studied for decades. **The size of the overlap is given in 1.1.1**, and I do not repeat it here.

> **Science Says:**
>
> One team looked again at the idea of a cut-off. They wrote that "evidence concerning the threshold hypothesis on the creativity-intelligence relationship is mixed" (Karwowski et al., 2016). **The threshold hypothesis is the idea of a cut-off point**, a level above which more intelligence stops helping creativity.

The threshold idea



Silvia's review of the link (Silvia, 2015) is covered in 3.3.2. **The debate is still open**, and the details matter less here than what follows from them. On this book's reading, the two abilities share some ground, and each keeps ground of its own.

On this book's reading, the shape of the link is what counts for everyday purposes. **Some overlap means some help**, since a good reasoner has tools that ideas work can borrow. Partial overlap means the help has limits, and the rest has to be built on its own.

Some overlap, partial overlap

Some overlap	Partial overlap
⊕ Some help: tools that ideas work can borrow	⊖ The help has limits ⊖ The rest has to be built on its own

> **Key Concept:**
>
> Partial overlap. In this book's terms, partial overlap is **a reason to judge each ability on its own evidence**. A strength in one tells you only a little about the other, so check the other side directly before you decide what someone can do.

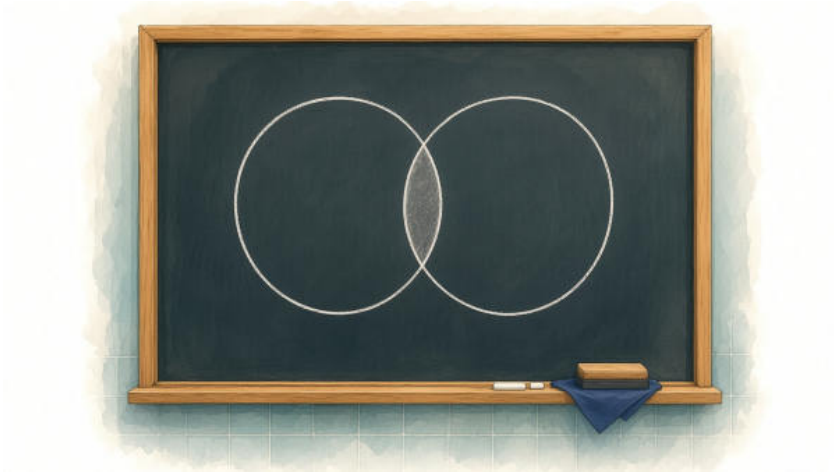
That changes how you read people. **A sharp reasoner is not automatically a strong ideas person**, and the reverse holds too. Tom's skill with numbers said little about his skill with names, and Sara's flow of names said little about her sums.

A strength says little about the other

Tom:	Sara:
numbers, not names	names, not sums

It also changes how you read yourself. **You may be stronger on one side** and assume you are weak on the other. On this book's reading, both sides respond to practice, so a weaker partner is a place to work on, and not a fixed label.

The same goes for the people around you. **A colleague you think of as "only practical"** may surprise you with an idea, if the task gives her room. On this book's reading, the overlap leaves plenty of room for surprises in both directions.



Two overlapping circles drawn in chalk on a blackboard, the shared middle lightly shaded.

The shaded middle is where the two meet. On this book's reading, **it holds skills both partners use**, such as keeping a goal in mind and checking a result. The outer parts hold what each does alone.

Shared ground and own ground

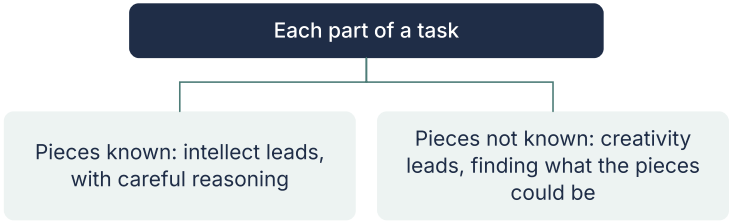
Where	What it holds
The shaded middle	Skills both partners use: keeping a goal in mind, checking a result
The outer parts	What each does alone

The overlap is also a reason to use both. **Most real tasks contain parts of each kind.** Opening the bakery needed a name and a price list, a new idea and a careful sum. Each part called on a different partner, and the shop needed both done well.

Learn to tell the parts apart. **Ask of each part of a task, "Are the pieces known?"** If they are, intellect leads, and the work is careful

reasoning. If they are not, creativity leads, and the work is finding what the pieces could be.

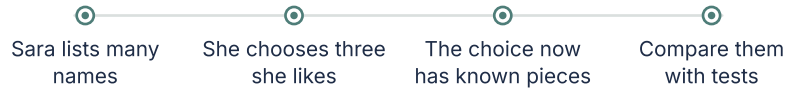
Which partner leads



Parts can change kind as you work. **Once Sara chose three names she liked**, the choice between them had known pieces. Each name had a signage cost, a sound and a rival who might already use it. A creative part had turned into a part for intellect.

That turn is useful to notice. On this book's reading, **the move from open to closed** is the moment to change how you work. Stop adding names and start comparing them, with a short list of tests that each name must pass.

A creative part turns



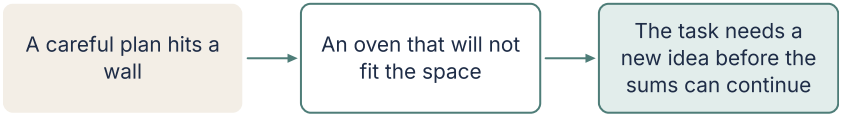
Write the tests down before you look at the names again. **Cost, sound and whether a rival uses it** are three fair tests for a shop name. With the tests fixed, the choice becomes careful reasoning instead of a matter of mood.

Three fair tests for a shop name

- [x] Cost
- [x] Sound
- [x] Whether a rival uses it

The reverse turn happens too. **A careful plan can hit a wall** that reasoning cannot get past, such as an oven that will not fit the space. Then the pieces are no longer known, and the task needs a new idea before the sums can continue.

The reverse turn



Watch for the signs of each turn. **Going round in circles with the same sums** is a sign the pieces are not really known. Endless new ideas with no choice made is a sign that it is time to close the list.

Signs of each turn

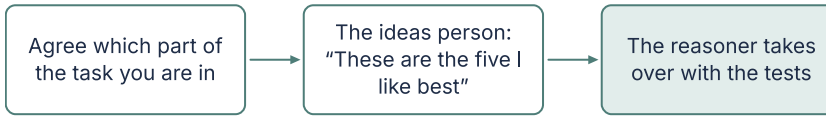
Sign	What it means
Going round in circles with the same sums	The pieces are not really known
Endless new ideas with no choice made	Time to close the list

Teams can use the overlap on purpose. **Pair a strong reasoner with a strong ideas person** on tasks that need both. On this book's reading, each covers the other's gap, as long as both respect the kind of work the other does.

Respect is the hard part. **Reasoners can find early ideas messy**, and ideas people can find careful checking slow. Agreeing in advance which part of a task you are in can stop the two from pulling against each other.

A short handover helps. **The ideas person says, "These are the five I like best,"** and the reasoner takes over with the tests. On this book's reading, a clear handover keeps each kind of work in its own stretch of time.

A clear handover



Children are often labelled early as one kind or the other. **"She is the clever one, he is the creative one"** can stick for years. On this book's reading, since the two overlap only partly, a child can grow both, and a label can stop her trying the other side.

Praise the work, whichever side it is on. **"You found a lot of ideas"** and "you checked every step" both name something a child did. Each kind of praise invites her to keep doing that kind of work.

Praise for the work itself

- "You found a lot of ideas"
- "You checked every step"
- Each names something a child did

Adults change too. **Many people find a new side of themselves** later in life, when a job or a hobby asks for it. On this book's reading, the

partial overlap means there is always room to grow the partner you have used less.

Work often pushes people to one side. **An accountant may spend years on known pieces**, and a designer on open ones. Hobbies can balance the mix, with a craft for the accountant and a budget for the designer.

Hobbies that balance the mix

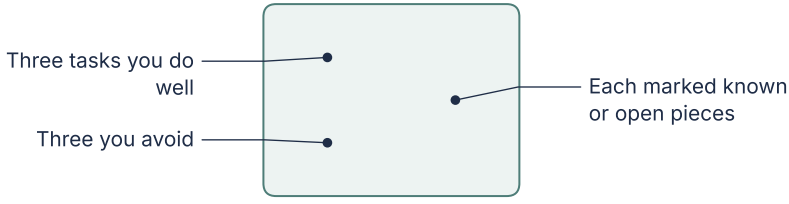
	An accountant	A designer
Years at work on	Known pieces	Open ones
A hobby to balance it	A craft	A budget

Scores have limits of their own. **A reasoning score tells you about known-piece tasks** on the day it was taken. On this book's reading, it says much less about whether someone can name a shop or solve a problem nobody has framed yet.

Keep a fair picture of your own mix. **List three tasks you do well** and mark each as known pieces or open pieces. Then list three you avoid and mark them the same way. The pattern shows which partner you lean on.

Then pick one small task from the side you avoid. **A reasoner might write five names for a family group chat**, and an ideas person might check one bill line by line. On this book's reading, small regular tasks on the weaker side build it without much strain.

Your own mix



Expect the weaker side to feel slow at first. **That feeling is part of the practice**, and it fades as the side grows. On this book's reading, a few minutes a week is enough to notice change over a season.

The weaker side over a season



The exercises below build on this section's argument and on the mixed threshold evidence (Karwowski et al., 2016). **Treat them as practice ideas**, and judge them by how they help with your task. The parts check sorts a task by kind, and the weak-side task builds the partner you use less.

The parts check and the weak-side task

- The parts check sorts a task by kind
- The weak-side task builds the partner you use less

Exercise:

Try it. Take one task you face this week and mark each part as known pieces or open pieces.

Exercise:

Use both partners.

1. Starter. List three tasks you do well and three you avoid, and mark each as known or open pieces.
2. Middle. For one real task, note the moment an open part turns into a known part, and change how you work.
3. Advanced. For a month, **do one small task each week on your weaker side**, and note what changes.

Both sides at work

Reasoning side	Ideas side

Key idea:

Intellect and creativity overlap only partly, so **sort each part of a task by kind** and grow the partner you use less.

Quick check:

1. What does partial overlap mean for judging an ability? Answer: Judge each ability on its own evidence, and check the other side directly.
2. What question tells you which partner should lead a part of a task? Answer: "Are the pieces known?"
3. What should you do when an open part turns into a known part? Answer: Stop adding ideas and start comparing them against tests.

2.3.2 Intelligence Inside Creative Thinking

A young woman wanted a surprise for her parents' fortieth wedding anniversary, with a small budget and a month to plan. Her first ideas were a meal out and a card. **Then she worked through the question in sorted groups.** These were places from their past, people they had lost touch with and things they had meant to do.



The group of old friends gave her the answer, a lunch with the couple who had been their best man and bridesmaid. **The idea was creative, and the search that found it was orderly.** This section looks at how intellect works inside creative thinking, and at how to use it there on purpose.

Nobody had told her what the surprise should contain. Once she chose her groups, each group had pieces she could work through.

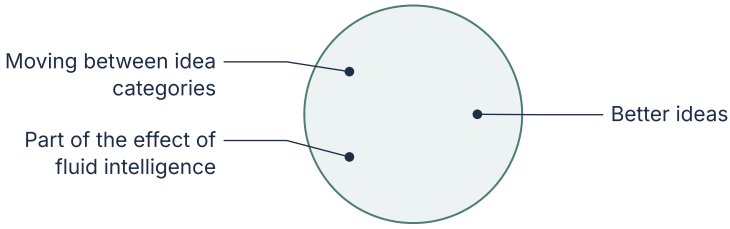
How the two work together in creative tasks is the subject of 3.3.2, which covers the control skills behind them (Benedek et al., 2014). **This section adds studies on strategy and switching**, and on what reasoning does while ideas are being made.

> **Science Says:**
> One study found that "the substantial effect of fluid intelligence (Gf) on creativity was mediated by executive switching" (Nusbaum & Silvia, 2011). **Mediated means the effect ran through it.** Executive switching was "the number of times people switched idea categories during the divergent thinking tasks" (Nusbaum & Silvia, 2011), tasks that ask for many different ideas.

That needs a plain reading. **People who reasoned well tended to move between kinds of idea more often**, and that moving was part

of why their ideas were better. On this book's reading, switching on purpose is one way reasoning helps creativity.

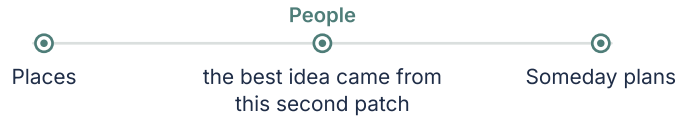
Switching inside creativity



Executive switching

Her groups did that switching for her. **When places ran dry, she moved to people**, and when people ran dry, to someday plans. Each move opened a fresh patch of ideas, and the best one came from the second patch.

When a group ran dry

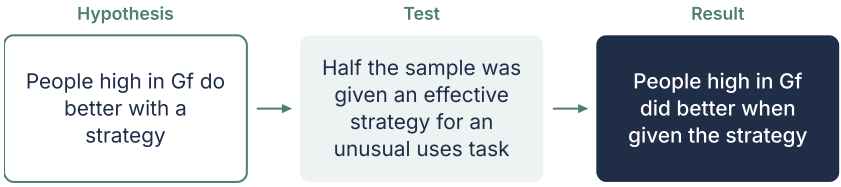




Three garden beds in a row, each with different plants, and a watering can moved halfway between two of them.

The same study tried giving people a method. “Half the sample was given an effective strategy for an unusual uses task”, and “people high in Gf did better when given the strategy” (Nusbaum & Silvia, 2011). **An unusual uses task asks for new uses of an everyday object.**

The strategy study

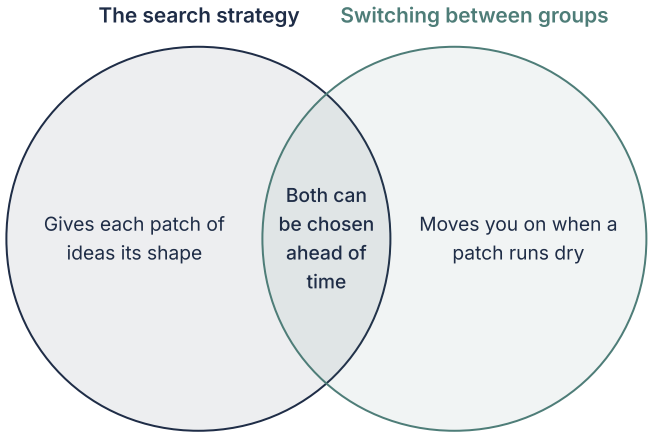


The authors linked that benefit to a “higher ability to maintain access to it and use it despite interference” (Nusbaum & Silvia, 2011). **Interference is anything that pulls you off the strategy**, such as an easy idea from your usual pattern. Holding the method in place is reasoning work.

> **Key Concept:**
> Search strategy. In this book’s terms, a search strategy is **a chosen way of looking for ideas**, such as starting from the people involved. Intellect keeps the strategy in place, and creativity fills it with ideas. A good strategy turns an open search into a set of smaller ones.

On this book’s reading, strategy and switching work as a pair. **A strategy gives each patch of ideas its shape**, and switching moves you on when a patch runs dry. Both can be chosen ahead of time, before the ideas start.

Strategy and switching as a pair



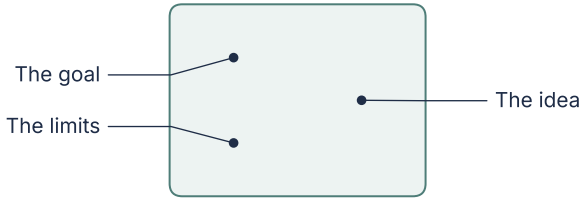
Think of the three garden beds in the picture. **Each bed has its own kind of plant**, and you water one before moving to the next. Switching beds keeps the whole garden alive, and a strategy tells you which bed needs you now.

A second study looked at metaphors, phrases that describe one thing as another, such as “a heart of stone”. It found that “Gf explained approximately 24% of the variance in metaphor quality” (Silvia & Beaty, 2012). **Variance here means the differences between people.** About a quarter of the differences in quality went with reasoning skill.

> **Science Says:**
>
> A third team looked at working memory and creative thinking. They reported that “intelligence significantly influences creative thinking” and that “working memory played a significant role in creative thinking processes” (Lee & Therriault, 2013). **Holding things in mind helps ideas work too.** On this book’s reading, a creative task leans on that support much as a reasoning task does.

Working memory shows up in creative work all the time. **To judge whether an idea fits**, you hold the goal, the limits and the idea together. The young woman held the budget, the month and her parents' tastes in mind as each idea arrived.

Held together while judging an idea



Working memory

On this book's reading, writing the limits down helps here as it does in reasoning. **Three short boxes at the top of the page** hold the limits for you. Later, each idea can be checked against them at a glance, and your working memory stays free for the next idea.

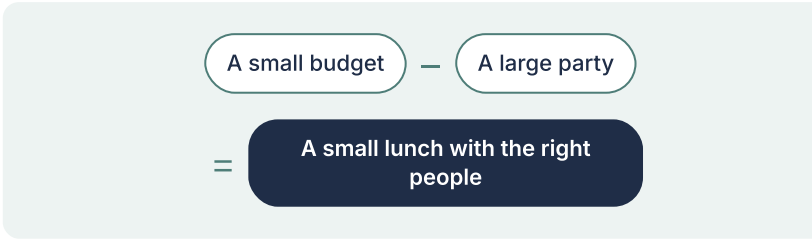
Three boxes at the top of the page

The budget	The month	Her parents' tastes

Leave the checking until the list is done, and **keep every idea in view**, even one that breaks a box. A broken idea can still point toward a better one, once you see which limit it broke.

A limit can also feed an idea. **The small budget ruled out a large party**, which sent her towards a small lunch with the right people. On this book's reading, a clear limit gives the search a direction as well as a boundary.

A limit with a direction



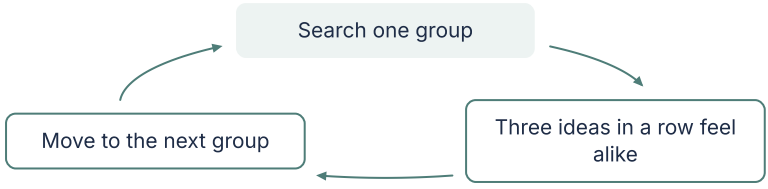
Choose your groups before you start. **For a gift, try people, places and pastimes.** For a new product, try users, uses and materials. On this book's reading, three to five groups is a good number, enough to switch between and few enough to hold.

Groups for the search

Task	Groups to try
A gift	People, places and pastimes
A new product	Users, uses and materials

Set a switch signal too. **When three ideas in a row feel alike**, move to the next group. The signal stops you circling in one patch, and it costs nothing to keep.

Search, signal, switch



After the session, look back over the groups. **The group that gave you the best ideas** is worth remembering for the next task. On this book's reading, a log of which strategies worked becomes a small library of ways to search.

Hold the strategy when easy ideas push in. **A meal out kept returning** to her mind, because it was the usual answer. Writing it once in a separate corner let her set it aside and keep working in her groups.

Holding the strategy

- [x] Write the easy idea once in a separate corner
- [x] Set it aside
- [x] Keep working in your groups

At work, a shared strategy helps a group. **Agree the groups before the meeting**, and spend ten minutes on each in turn. On this book's reading, a shared order stops the loudest idea from taking over, and the group covers more ground.

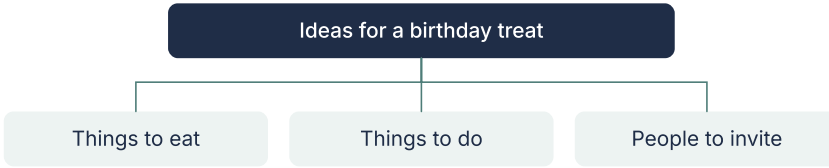
Let each person add a group of their own. **A group nobody else thought of** often brings the freshest ideas, because it opens a patch the others would have missed. On this book's reading, the group's variety becomes part of the strategy.

A shared strategy at work

> - Agree the groups before the meeting
> - Ten minutes on each in turn
> - Each person adds a group of their own

Children enjoy this kind of sorted search. **Ask a child for ideas for a birthday treat** in three groups, things to eat, things to do and people to invite. She sees that ideas come more easily when she knows where to look.

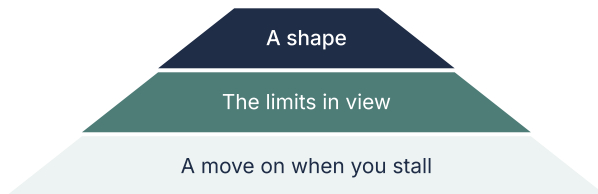
A birthday treat in three groups



These studies measured links, and they do not show that reasoning causes better ideas. **The strategy study is an exception in one way**, since it gave people a method and saw the effect. Even there, it was one kind of task, so I treat the method as a promising habit.

On this book's reading, the lesson is a hopeful one. **Creativity can lean on intellect** without losing its openness. The ideas still come freely, and reasoning gives the search a shape, keeps the limits in view and moves you on when you stall.

What reasoning gives the search



Notice your own pattern of switching. **Some people stay too long in one group**, and others jump before a group is used up. Counting ideas per group after a session shows which you tend to do.

Try the opposite of your usual pattern once. **If you jump early, stay another two minutes**, and if you stay too long, switch sooner. On this book's reading, the comparison tells you more than repeating the same pattern for a month.

Two switching patterns

Stay too long in one group	Jump before a group is used up
⊕ Try: switch sooner	⊖ Try: stay another two minutes

The exercises below come from the studies above (Nusbaum & Silvia, 2011; Lee & Therriault, 2013). **No study has tested them as training**, so treat them as practice ideas. The groups give the search a strategy, and the switch signal moves you on.

Groups and the switch signal

- The groups give the search a strategy
- The switch signal moves you on

> ✎ **Exercise:**
>
> Try it. For your next open problem, write three groups to search in, then spend two minutes on each.

> Exercise:
>
> Give the search a shape.
>
> 1. Starter. Write the limits of a real task in three boxes at the top of a page.
> 2. Middle. Choose three to five groups, and switch when three ideas in a row feel alike.
> 3. Advanced. Hold one strategy for a set time, **note each easy idea that pushes in**, and return to the strategy.

Shape first, ideas after

Edges drawn	Open search

Key idea:

Reasoning gives creative search its shape, so **choose your groups and limits first** and switch when a group runs dry.

Quick check:

1. What did the effect of fluid intelligence on creativity run through, in one study? Answer: Executive switching, the number of times people switched idea categories (Nusbaum & Silvia, 2011).
2. How much of the variance in metaphor quality did Gf explain? Answer: About 24% (Silvia & Beaty, 2012).
3. What role did working memory play in creative thinking, in Lee and Therriault's study? Answer: "A significant role in creative thinking processes" (Lee & Therriault, 2013).

2.3.3 Generate, Then Judge

A LIBRARIAN NEEDED A POSTER to bring teenagers into her library. She wrote one line, crossed it out, wrote another and crossed that out too. **After an hour she had a page of crossings and no poster.** Every idea had been judged the moment it appeared.

The next day she tried it the other way round. **She wrote thirty lines in fifteen minutes without crossing out any**, then went back and chose. The winner was the twenty-sixth. This section looks at how making ideas and judging them fit together, and at where intellect belongs in that cycle.

Two ways to write a poster

Judge each line at once	Make first, then choose
⊕ A page of crossings	⊖ Thirty lines in fifteen minutes
⊕ No poster after an hour	⊖ The winner was the twenty-sixth

Most of us judge too early. On this book's reading, **the inner critic is quick and confident**, and it treats a rough line as a final one. Giving it a later time slot is kinder to the ideas and, in the end, to the work.

Making ideas is open work. Judging them against clear tests is closer to the work of intellect, because the tests give the pieces you check each idea against.

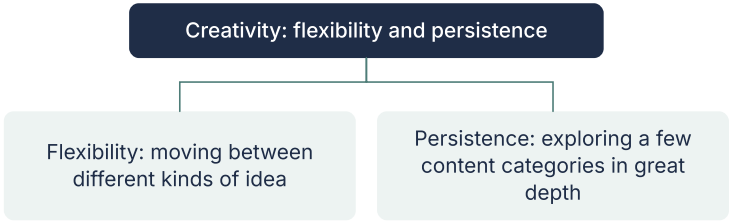
Loose, then checked

Loose first	Checked later

The two halves of creative work, making and choosing, are set out in 3.3.2, and I do not define them again here. **This section adds studies on the order of the two**, and on what reasoning brings to each.

One review described creativity as "a function of cognitive flexibility and cognitive persistence" (Nijstad et al., 2010). **Flexibility is moving between different kinds of idea.** The review found that this moving "directly relates to idea originality", and it pointed to a second route as well.

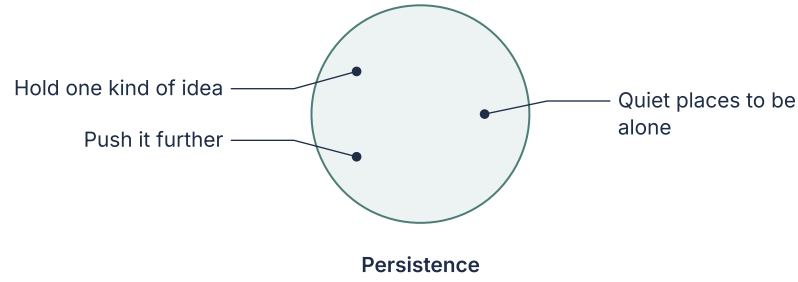
Two routes to originality



> **Key Concept:**
>
> Persistence. In Nijstad and colleagues' term, persistence is the second route, in which "originality can also be achieved by exploring a few content categories in great depth" (Nijstad et al., 2010). **You stay with one kind of idea and dig**, instead of moving across many.

On this book's reading, persistence is where intellect helps most during the making. **Holding one kind of idea and pushing it further** takes the steering that reasoning uses. The librarian's twenty-sixth line came from staying with one theme, quiet places to be alone, and pushing it.

Digging in one theme





A spade standing in a deep hole in a garden, a pile of earth beside it and a small root showing at the bottom.

Think of the spade in the picture. **The first spadefuls are loose soil**, easy and quick. The root you are looking for lies further down, and only steady digging in one spot reaches it.

> **Science Says:**
>
> One study looked at the number of ideas and their newness side by side. It reported that "inhibition may primarily promote the fluency of ideas, whereas intelligence specifically promotes the originality of ideas" (Benedek et al., 2012). **Fluency means how many ideas you produce**, and originality means how unusual they are.

That gives reasoning a clear place. **It seems to help with how new the ideas are**, more than with how many there are. On this book's reading, that fits persistence, since digging deeper in one kind of idea is how many of the newest ideas are found.

What each skill promotes

Skill	Promotes
Inhibition	The fluency of ideas: how many
Intelligence	The originality of ideas: how unusual

Later ideas also tend to be better (Christensen et al., 1957). One study ran a ten-minute idea task and found that "creativity increased sharply with time and flattened slightly by the task's end" (Beaty & Silvia, 2012). **Meanwhile "fluency was highest in the task's first minute and then dropped sharply."** Early ideas came fast, and the better ones came later.

Over a ten-minute idea task



The authors added that "as intelligence increased, the serial order effect diminished" (Beaty & Silvia, 2012). **The serial order effect is that rise in quality over time.** On this book's reading, stronger reasoners may reach good ideas sooner, and everyone does better by not stopping at the first few.

Past the first few

Early ideas:	Better ideas:
fast	later

> Science Says:
>
> A third study changed the instruction. It found that "asking people to be creative yielded better but fewer responses, suggesting a focus on quality over quantity" (Nusbaum et al., 2014). **The words you use to start the task change what comes out.** "As many as possible" and "be creative" lead to different lists.

Instructions work on groups as well. **A manager who asks for "any ideas"** gets a different meeting from one who asks for "two strong ideas". On this book's reading, choosing the words is a small act of planning with a clear effect on the list.

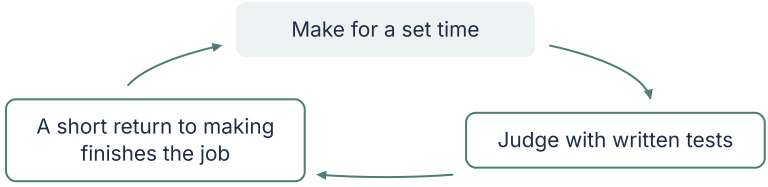
Two instructions, two lists

Instruction	What comes out
"As many as possible"	A wide spread, such as names for a new group
"Be creative"	Better but fewer responses: a few strong ideas

Put these findings together and a working order appears. **Make first, for a set time, and keep going past the easy ideas.** Then judge, with

tests written down before you look. On this book's reading, separating the two stops the judge from cutting off ideas before the better ones arrive.

Make, judge, make again



Set the time before you start. **Fifteen minutes is enough for most small tasks**, and the clock gives you permission to keep going when the ideas slow. The slow patch is often just before the better ideas, so push through it.

Keep the list where you can see it. **Ideas written in one column** let you notice when they start to repeat. On this book's reading, repeats are a sign to switch kinds or to dig deeper into the one you are in.

Keeping the making going

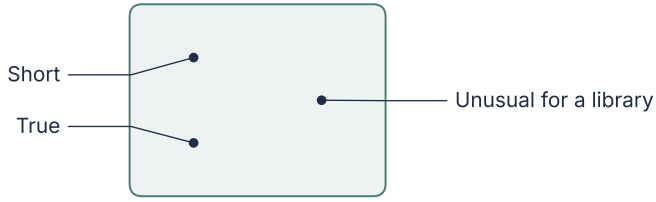
- [x] Set the time before you start
- [x] Push through the slow patch
- [x] Keep the list in one column
- [x] Watch for repeats

Choose your instruction. **Use "as many as possible" when you need a wide spread**, such as names for a new group. Use "be creative" when you need a few strong ideas, such as one poster line. On this book's reading, saying the instruction aloud sets the tone.

Write the tests before you judge. **For the poster, the tests might be short, true and unusual for a library.** Fixed tests turn the judging into reasoning with known pieces. Without them, you tend to pick the idea you happen to like at that moment.

Keep the tests few. **Three tests are easy to hold** and quick to apply. A long list turns judging into a chore and lets weak ideas through on the tests you forget.

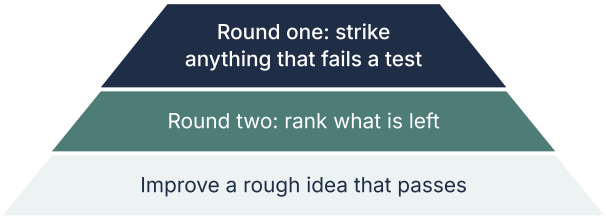
Tests for the poster



The poster line

Judge in rounds. **First strike anything that fails a test**, then rank what is left. On this book's reading, two rounds are kinder to good ideas than a single quick glance. A rough idea that passes the tests can still be improved.

Judging in rounds



Improving is part of judging too. **A line that is nearly right** can be shortened, sharpened or joined with another. On this book's reading, the switch from making to judging can run both ways. A short return to making often finishes the job.

Groups can split the work. **One session for making and a separate one for judging** keeps the two apart. On this book's reading, the person who leads the judging should hold the written tests, so the loudest voice does not decide alone.

Give the makers a break before the judging. **A short walk or a cup of tea** puts a little distance between you and the ideas. On this book's reading, that distance makes it easier to judge the ideas instead of your feelings about them.

Making and judging in groups

- One session for making, a separate one for judging
- The judging lead holds the written tests
- A short walk or a cup of tea before the judging

Watch for the habit of judging early. **If you cross out more than you write**, the judge has taken over the making, and the page fills with crossings. Cover the page and write the next five ideas without looking back, then return to judging later.

When the judge takes over

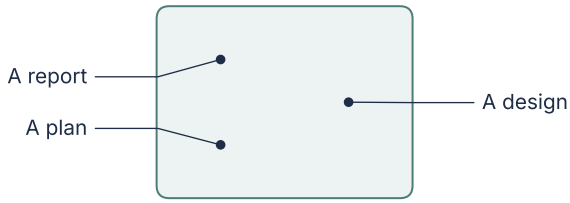
Cover the page	Write the next five ideas	Return to judging later

Children can learn the order with simple tasks. **Ask a child for ten names for a new pet** before choosing one. She learns that the eighth name is often better than the first, and that choosing is easier with a list in front of her.

Teachers can build the order into lessons. **Ten minutes of making and five of judging** give pupils a rhythm they can carry into any subject.

On this book's reading, the cycle repeats in larger tasks. **A report, a plan or a design** each go through rounds of making and judging. Naming which round you are in helps you use the right kind of effort at each point.

Rounds in larger tasks



Making and judging

Keep the rejected ideas for a while. **A line that failed today's tests** may suit next month's poster. A small file of near misses becomes a store to start from next time.

The exercises below come from the studies above (Nijstad et al., 2010; Beaty & Silvia, 2012; Nusbaum et al., 2014). **No study has tested them as training**, so treat them as practice ideas. The timed list follows the later-is-better finding, and the written tests make judging a task for intellect.

The timed list and the written tests

- The timed list follows the later-is-better finding
- The written tests make judging a task for intellect

> Exercise:
>
> Try it. Set a timer for ten minutes and write ideas for one real problem without crossing any out.

> Exercise:
>
> Make, then judge.
>
> 1. Starter. Write ideas for a set time, then mark where the best three appeared in your list.
> 2. Middle. Write three tests before judging, then strike and rank in two rounds.
> 3. Advanced. Pick one kind of idea and **stay inside it for ten minutes**, then compare its ideas with your first list.

Making before judging

Ideas written freely	Judged fairly later

Key idea:

Better ideas tend to come later, so **make for a set time first** and judge afterwards against written tests.

Quick check:

1. What did intelligence specifically promote, in one study? Answer: "The originality of ideas" (Benedek et al., 2012).
2. When was fluency highest in the ten-minute task? Answer: In "the task's first minute" (Beaty & Silvia, 2012).
3. What did asking people to be creative yield? Answer: "Better but fewer responses" (Nusbaum et al., 2014).

2.3.4 When You Need Which: Intellect's Part at Each Step

A woman moved to a smaller flat near her daughter. The move had letters to read and dates to keep, a past move to learn from, a home to make and a budget to respect. **At different points a different ability had to lead**, and when the wrong one led, the work went badly.

On the day she chose curtains by working out costs alone, she bought a set she disliked. **On the day she planned the removal van on a hunch**, it came a day early. This last section walks through one real task

and asks which partner should lead at each step, and where intellect takes over.

Wrong lead, bad result

Step	What led	What happened
Choosing curtains	Working out costs alone	A set she disliked
Planning the removal van	A hunch	It came a day early

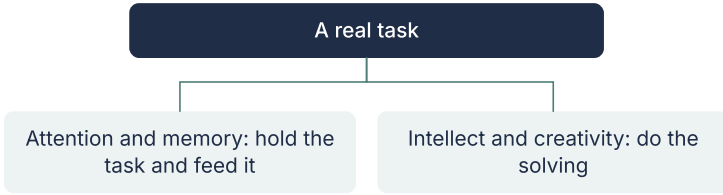
Most people have had a task like that. **The pieces are not hard one by one**, and the trouble lies in using the right kind of effort at the right time. On this book's reading, that is a skill you can practise like any other.



An older woman standing in a half-empty living room surrounded by labelled cardboard boxes, a folder of papers under her arm.

Attention and memory hold the task and feed it, while intellect and creativity do the solving. On this book's reading, a real task passes through all four, and the skill is to let each lead in its turn.

Holding and solving

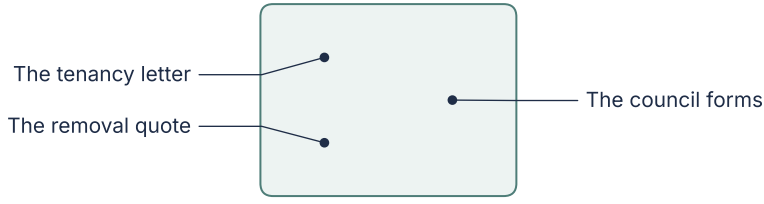


Think of removal men passing boxes down a narrow stair. **Each one carries a box for a few steps**, then hands it on. On this book's reading, a box is most at risk at the handover. A task is too, when the lead passes from one partner to the next.

> **Science Says:**
>
> Benedek and colleagues' study, told in 3.3.2, also looked at reasoning. It found that "fluid intelligence was strongly predicted by updating" (Benedek et al., 2014). **Reasoning leaned on keeping what you hold up to date.** On this book's reading, that is the skill a moving plan calls for, as dates and costs shift.

Step one is taking in, and **attention leads.** The tenancy letter, the removal quote and the council forms all have dates and conditions. Splitting attention while you read costs more than splitting it later (Craik et al., 1996). The woman did best when she read them at a quiet table in the morning.

Step one: taking in



Attention leads

Step two is holding. **Memory leads, with paper as its helper.** The dates, the costs and the list of what goes where are too many to keep in mind. A single sheet with every date and amount let her see the whole move at once.

Step three is recalling. **Memory leads again**, this time as a store of past cases. Her last move, twenty years earlier, taught her that boxes should be labelled by room and that the kettle should travel in the car. Old cases saved her from old mistakes.

Recalling also includes other people's cases. **A friend of hers who had moved recently** told her which removal firms turned up on time. On this book's reading, borrowed cases are as useful as your own, and they cost only a phone call.

Old cases and borrowed cases

- Boxes labelled by room
- The kettle travels in the car
- Which removal firms turned up on time

Step four is making the flat feel like home. **Creativity leads here**, because nobody can list the pieces of "home" in advance. She tried ideas freely, a reading corner by the window, her late husband's clock on the shelf, plants on the balcony.

Ideas for home

A reading corner by the window	Her late husband's clock on the shelf	Plants on the balcony

Making ideas needs room. **She gave herself an afternoon in the empty flat** with a notebook and no budget sheet in sight. The budget came back later, at the judging step, where it belonged.

Step five is judging. **Intellect leads once the variables are identified.** With a list of ideas in front of her, the pieces are known, among them cost, space, safety and what each idea meant to her. Now careful reasoning can weigh them.

Pieces for judging

- [x] Cost
- [x] Space
- [x] Safety
- [x] What each idea meant to her

> **Key Concept:**
> Which partner leads. In this book's terms, this is **the habit of naming, at each step of a task, the ability that should be in front**. The others still work, in support. On this book's reading, many mistakes in a long task come from the wrong partner leading at the wrong step.

Look back at the curtains. **She let intellect lead a step that belonged to creativity**, choosing on cost before she knew what she wanted the room to feel like. The van went wrong the other way, with a hunch leading a step that had a date and a contract.

Supporting partners still work at every step. **While intellect judged, memory held the measurements** and attention kept her on the list. On this book's reading, the lead partner sets the course, and the others keep working alongside.

Five steps, five leads

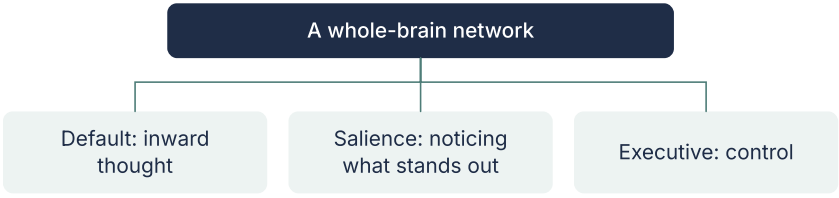
Step	Lead partner
Taking in	Attention
Holding	Memory, with paper as its helper
Recalling	Memory, as a store of past cases
Making	Creativity
Judging	Intellect, once the variables are identified

On this book's reading, each step also needs attention control to stay on track. **Keeping the chosen method in charge** when a habit pulls is the steering that reasoning depends on (Engle, 2002). On a busy moving day, the pulls are everywhere.

A brain-scan study looked at creative ability across the whole brain. It reported "a whole-brain network associated with high-creative ability comprised of cortical hubs within default, salience, and executive systems" (Beaty et al., 2018). **Networks are groups of brain areas that work together.**

Cortical hubs are busy meeting points in the brain's outer layer. **The three systems are networks** linked, in general use, with inward thought, with noticing what stands out and with control.

Three brain systems



> **Science Says:**
>
> The same team suggested that "highly creative people are characterized by the ability to simultaneously engage these large-scale brain networks" (Beaty et al., 2018). **That is a finding about the brain**, and it does not tell you how to plan a move. On this book's reading, it fits the idea that strong work draws on several systems at once.

You can run the same five steps on any task. **Taking in, holding, recalling, making and judging** each have a partner that should lead. Write the five steps down the side of a page, and name the lead partner beside each one before you start.

The steps are not always in that order. **Judging may send you back to making**, as when her favourite idea would not fit through the door. Recalling may send you back to taking in, when an old case shows a form you forgot to read. Name the step you have moved to, and change the lead.

Moving back a step

From	Back to	When
Judging	Making	Her favourite idea would not fit through the door
Recalling	Taking in	An old case shows a form you forgot to read

A stuck feeling is often a sign of the wrong lead. **If you keep doing sums and nothing settles**, the pieces may not really be known, and creativity should lead for a while. If ideas keep coming and nothing gets chosen, it is time for intellect.

Signs of the wrong lead

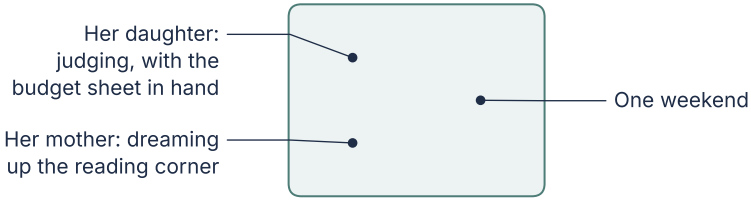
Sums that never settle	Ideas that never get chosen
⊕ Creativity should lead for a while	⊖ Time for intellect

Time pressure can push the wrong partner forward. **With the van booked for Friday**, it is tempting to skip the making step and buy the first curtains you see. A short, timed making step costs little and saves a choice you will live with for years.

At work, the same map helps a project team. **Give each step an owner** whose strength suits its lead partner. On this book's reading, a careful reasoner judging and a free thinker making will each do their step better than one person forcing both.

Family tasks benefit too. **When her daughter took over the judging**, with the budget sheet in hand, her mother was free to dream up the reading corner. Two people, each leading a different step, got the room right in one weekend.

Leads shared in a family



Getting the room right

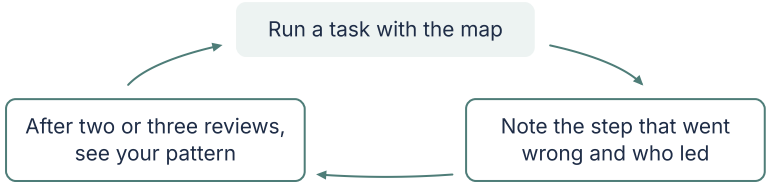
Children can learn the map with small projects. **Ask a child planning a school display** to say which step she is on, reading the brief, gathering facts, making ideas or choosing the best. She learns that each step asks for a different kind of effort.

A school display, step by step

Reading the brief	Gathering facts	Making ideas	Choosing the best

Review the map after the task. **Note the step where things went wrong** and which partner was leading. On this book's reading, two or three reviews show your own pattern, the step where you most often put the wrong partner in front.

Review the map



Most of this section is a way of working that this book puts forward. **The tested findings are the ones cited above**, on updating, intake, steering and brain networks. No study has tested the five-step map as training, so treat the exercises as practice ideas.

> ✎ **Exercise:**
>
> Try it. For one task this week, write the five steps and name the lead partner beside each before starting.

> ✎ **Exercise:**
>
> Five steps, one task.
>
> 1. Starter. Pick one real task and write the five steps down the side of a page.
> 2. Middle. Name the lead partner for each step, and note when you move back a step.
> 3. Advanced. After three tasks, **mark the step where the wrong partner led** most often, and plan a fix.

Map, lead, review

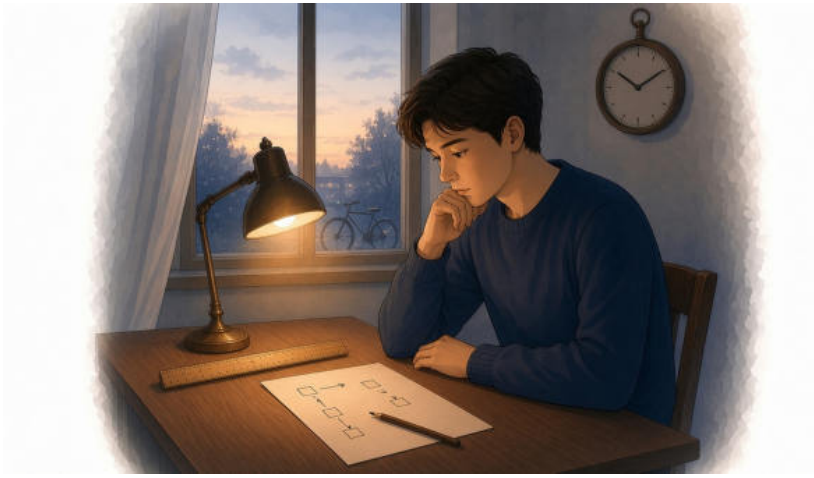
Leads chosen up front	Pattern seen afterwards

Key idea:

Each step of a task has a partner that should lead, and **intellect leads once the variables are identified.**

Quick check:

1. What strongly predicted fluid intelligence in Benedek and colleagues' study? Answer: Updating (Benedek et al., 2014).
2. Which partner leads the making step? Answer: Creativity, because the pieces of the task are not yet known.
3. When does intellect take the lead? Answer: Once the variables are identified, as at the judging step.



Module

3

Developing the Core Skills of Intellect

3.1 Understanding the Problem

3.1.1 Identifying What Is Known, Unknown and Missing, and Keeping Track of It

A FRIEND TEXTS YOU AT breakfast with a question. Her train leaves at 9.40, the walk to the station takes 25 minutes, and she still has to buy a ticket. She wants to know when to leave the house. Her question looks simple, and **it hides a missing piece**.

Two pieces are known, the train time and the walk. One piece is wanted, the time to leave. One piece is **missing altogether**, because nobody has said how long the ticket queue will take.

Known, wanted and missing



Known: the train time and the walk



Wanted: the time to leave



Missing: the ticket queue

In this book's language, the queue is **a piece that has not been named yet** (see 1.1.2). Until somebody names it, the task is not quite ready for intellect. Simon called problems with unclear pieces ill-structured, and he saw the border between the two kinds as blurred (Simon, 1973).

Most real tasks arrive like your friend's text. **Some pieces come labelled**, some hide inside the wording, and some are not there at all. The first job is to find out which is which, before any sum is done.



A station clock above a short queue at a ticket machine, with a traveller glancing up at the time.

> **Science Says:**
>
> Pólya split the work of solving into four phases. First, “we have to understand the problem; we have to see clearly what is required”. Then come making a plan, carrying it out and looking back at the finished solution (Pólya, 1945/1957). **His first questions ask for the unknown and the data**, the wanted and known lists under older names.

Sorting is only half the work. Once the pieces are found, you have to **hold on to them** while you solve, and that is where the trouble starts. Your head keeps track far less well than it feels.

Keeping track leans on working memory, **the mind’s worktop** (see 1.1.1). The worktop holds pieces while you use them. The surprise is how few it holds at once.

> **Science Says:**
>
> In 1956 Miller wrote a paper titled The magical number seven, plus or minus two (Miller, 1956). Many people still treat seven as a hard limit. Cowan looked at the evidence again and wrote that Miller's seven was used "more as a rough estimate and a rhetorical device than as a real capacity limit". Under the conditions he describes, the limit is **"only three to five chunks"** (Cowan, 2001).

A rhetorical device is **a way of making a point stick**, and the number seven did stick. A chunk is a group of items that the mind treats as one thing. Three to five chunks is not many, and a busy morning fills them fast.

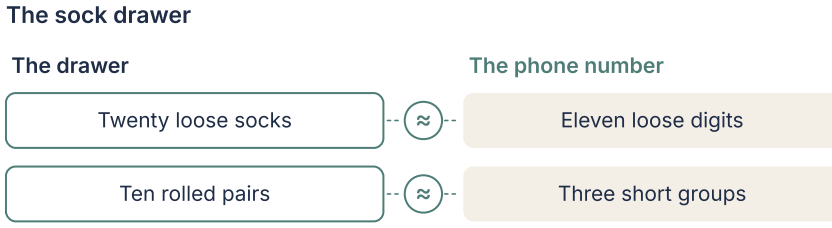
Chunks are how people cope with so few slots. Take a phone number. Eleven loose digits are hard to hold, and **three short groups are easy**, because each group becomes one chunk.

Eleven digits, three groups



Miller saw this trick in 1956. By organising what comes in "into a sequence or chunks, we manage to break (or at least stretch) this informational bottleneck" (Miller, 1956). A bottleneck is **the narrow neck of a bottle**, where everything has to squeeze through.

A sock drawer works the same way. Twenty loose socks fill it in a jumble, and ten rolled pairs fit with room to spare. **The drawer has not grown**, and each thing in it now carries more.



Baddeley added a new part to his model of working memory and called it the episodic buffer. He described it as **"a limited capacity system that provides temporary storage of information held in a multimodal code"** (Baddeley, 2000). In plain words, it is a small, short-lived store that can hold sounds, pictures and meanings together in one scene.

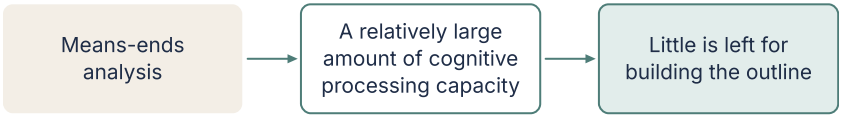
A model is **a proposed picture of how something works**, and his paper's title ends with a question mark. Treat the buffer as an idea under test. The plain lesson holds either way, because your head keeps a few pieces for a short time, and then they slip.

> 🔑 **Key Concept:**
>
> Known, wanted and missing. Every task has **pieces you know, a piece you want and pieces you lack**. Write the three lists before you start. A missing piece can be found, asked about or guessed, and a guess should be marked as a guess.

Searching for an answer uses the same small store. Sweller studied means-ends analysis, a way of solving where you keep comparing where you are with where you want to be. He found that it **"requires a relatively large amount of cognitive processing capacity"**, which is then not free for learning the shape of the problem (Sweller, 1988).

Sweller's word for that shape is a schema, **a stored outline for a kind of problem**, like the outline you carry for any trip by train. While all your effort goes on the search, little is left for building the outline. You may solve today's problem and learn less for the next one.

Searching uses the store



The rule that follows is simple. When a search goes round in circles, **stop and write down where you are**, what you have tried and what is still open. The page takes some load off the store, and part of your effort comes back for seeing the shape of the problem.

The way out is to **move some pieces out of your head** and onto paper. Larkin and Simon asked in a paper's title why a diagram is (sometimes) worth ten thousand words (Larkin & Simon, 1987). Their answer was that a picture can show at a glance what a row of sentences only hints at.

> **Science Says:**
> Diagrams "typically display information that is only implicit in sentential representations and that therefore has to be computed, sometimes at great cost" (Larkin & Simon, 1987). Implicit means **hidden inside**, and sentential representations are plain sentences. The authors kept the word "sometimes" in their title, so a diagram is no magic fix.

Kirsh went further, in an essay of ideas. He argued that saving memory "is only part of the story" (Kirsh, 2010). Marks on paper **"create**

persistent referents”, things that stay put so you can point at them and come back. They “facilitate re-representation”, which means they make it easier to see the same task in a new way.

A waiter’s order pad shows both points. The pad stops the order slipping from memory, and it **stays in plain view where anyone can check it**. When a diner changes their mind, the waiter crosses out one line and writes another, and the whole order reads differently at a glance.

A waiter’s order pad



Zhang and Norman showed that **part of a task can live outside the head**. In their experiments, the way a task was held was “a set of internal and external representations, which together represent the abstract structure of the task” (Zhang & Norman, 1994). Some of the task’s structure sat in the world, where the solver could see it.

A second example shows how all of this fits a real task. Say four friends rent a holiday cottage for a week, and the total bill is known. Each person’s share is wanted. **Who stayed which nights is missing**, and until someone writes it down, the sum cannot start.

Once the nights are on paper, chunks appear by themselves. **Two friends stayed all week**, and two left on Wednesday. Four people become two groups, the sums shrink to two, and your worktop has room again.

Four people become two groups



Two friends stayed all week



Two left on Wednesday



The sums shrink to two

The tick grid is a small diagram, and it does what Larkin and Simon described. **The groups jump out of the page**, where a list of sentences would make you work them out. Nobody has to hold four people and seven nights in mind at once.

Known pieces deserve a second look. The 25-minute walk in the breakfast text might be a guess from last summer. **A guess that looks like a fact** is the most dangerous piece on any list, because nobody bothers to check it.

Missing pieces come in different kinds, and each needs a different move. Some are missing because nobody told you, and a question fixes them. Some are missing because **nobody knows yet**, and you have to plan for both outcomes. Some are missing because you have to choose them, and choosing is creative work.

Kinds of missing piece



> **Exercise:**
>
> Three lists.
>
> 1. Pick one task waiting for you this week, such as a booking, a bill or a repair.
> 2. On a sheet of paper, write three headings, known, wanted and missing.
> 3. Fill each list, and put a question mark beside every guess.
> 4. Each time you learn something new, **move it from missing to known**. Stop when the missing list is empty or every gap has a plan.

Updating the page is the other half of keeping track. When a missing piece turns up, cross it out and add it to the known list. When a new question appears, **add it straight away**, before it slips. A list that never changes was written once and then forgotten.

Longer tasks need the page even more. A house move or a job application runs for weeks, and **what you knew on Monday can be gone by Friday** unless it is written down. Keep one page per task, and read it before each new session.

Updating the page



Back at breakfast, your friend's task gets easier the moment it is written down. Train at 9.40, walk 25 minutes, queue unknown. **The missing piece now has a name**, and she can check the queue on the station website, allow extra time, or buy the ticket on her phone.

Key idea:

Write down what you know, what you want and what is missing, and let the page keep track while your mind does the solving.

Quick check:

How many chunks does Cowan say short-term memory holds? Answer: about three to five, under the conditions he describes, and not seven.

3.1.2 Recognising Patterns, Rules and Analogies

You move to a new street. For three weeks the recycling lorry comes on a Thursday, and in the fourth week it comes on a Friday. Either there is a rule you have missed, or something has changed. **Spotting a pattern is easy**, and knowing what it means is harder.

Your neighbour, say, knows the answer. A bank holiday that week pushed every collection back by one day. **Once you know the rule**, the odd Friday stops being odd and becomes something you could have predicted.

Patterns, rules and analogies are three steps of one skill. **A pattern is what repeats**, a rule is the reason it repeats, and an analogy carries a

rule from one place to another. Intellect uses all three whenever the pieces of a task are named and the job is to see how they fit together.

One skill, three steps



Intelligence tests lean heavily on the first two steps, and everyday problems use all three. Matrix tests, the grids of shapes with one piece missing, depend on **finding the rule that links the shapes** (see 1.2.2). The same analysis found that people differ in how well they manage many goals at once while they work (Carpenter et al., 1990).

> **Key Concept:**
> Pattern, rule and analogy. A pattern is **something that repeats**. A rule says why it repeats, so you can predict the next case. An analogy takes a rule found in one place and tries it in another, where the things look different and the links between them match.

Seeing the rule depends on **looking past the surface**. Chi and two colleagues asked experts and beginners to sort physics problems. The experts "initially abstract physics principles", while novices "base their representation and approaches on the problem's literal features" (Chi et al., 1981).

Literal features are what you can see on the page, such as a slope, a spring or a pulley. **Two problems about slopes** may need different

laws, and a slope problem and a spring problem may need the same one. Beginners group by the drawing, and experts group by the law.

How experts and beginners sort



Faced with a new problem, **the expert's first move is to name the principle**, and the beginner's is to look for a problem with the same picture. A problem chosen by its picture may need a different law. Then every step that follows starts from the wrong place, however carefully it is done.

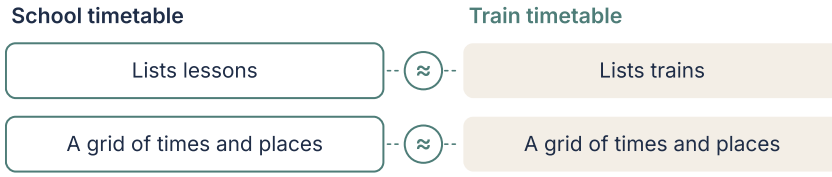
Gentner built a theory of how analogies work and called it structure-mapping. In her account, an analogy carries over **the relations between things** and leaves the looks of the things behind (Gentner, 1983). What crosses from the first case to the second is the way the parts connect.

> **Key Concept:**
> Surface and structure. The surface of a problem is **what it looks like**, such as the objects, the names and the setting. The structure is how its parts depend on each other. Expert sorting and good analogies both work on the structure.

A school timetable and a train timetable show the idea. One lists lessons and the other lists trains, and they look nothing alike. **Both are grids**

of times and places, and once you can read one, you can read the other, because the rows and columns relate in the same way.

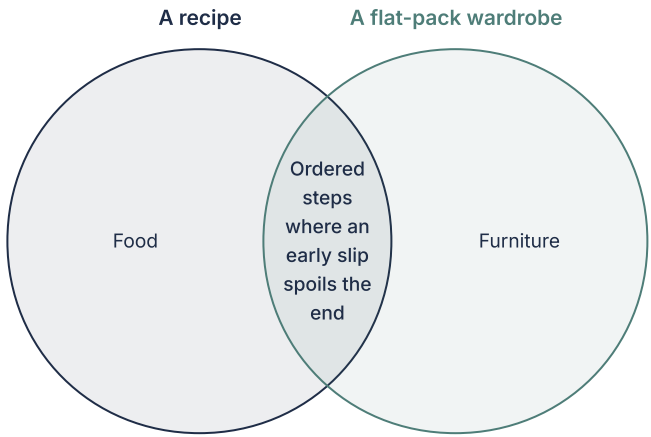
Two timetables



Richland and Simms describe analogy as "the ability to understand phenomena as systems of structured relationships that can be aligned, compared, and mapped together" (Richland & Simms, 2015). They go on to propose that **reasoning about relations** is what the harder kinds of school work are built on. It is a proposal, and they present it as one.

A recipe and a flat-pack wardrobe make the point. One is food and one is furniture, and both are ordered steps where an early slip spoils the end. **Spotting that shared structure** lets the care you learnt in the kitchen carry over to the bedroom floor.

A recipe and a wardrobe



If relations are the key, the next question is how to make them stand out. **Comparing two cases side by side** is one answer. Gentner and two colleagues trained beginners in negotiation and found "a marked advantage for comparing two cases over studying the 2 cases separately" (Gentner et al., 2003).

> Science Says:
>
> In the same work, more support for comparing **"increased the rate of transfer"** to a new case (Gentner et al., 2003). A later review pulled together "57 experiments with 336 tests". Comparison "commonly led to greater learning outcomes", with an effect size of d = .50 (Alfieri et al., 2013).

The comparison has to be made on purpose. In the negotiation work, studying the same two cases one at a time did less than comparing them. **Seeing both cases is one thing, and lining them up is another.** Two cases on one sheet, read together, give the rule a chance to show itself.

Comparing works like holding two photos of the same street, one taken in summer and one in winter. **The leaves and the snow differ**, so your eye skips past them. The road, the houses and the lamp posts stand out as what stays the same.

Two photos of one street



The leaves and the snow differ



The road, the houses and the lamp posts



What stays the same

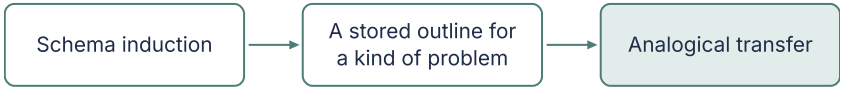
Gick and Holyoak gave people a story, then a medical problem, Duncker's "radiation problem". Given a hint to use the story, **11 of 12 people (92%) found the full solution**, against 3 of 15 (20%) with no hint. Only "1 of the 15 subjects spontaneously noticed the critical analogy" (Gick & Holyoak, 1980). The groups were small.

The radiation problem



A later paper by the same pair links two ideas in its title, "Schema induction and analogical transfer" (Gick & Holyoak, 1983). **Schema induction** means building a schema, the stored outline for a kind of problem (see 3.1.1), out of examples. Analogical transfer means carrying what one problem taught you over to another problem of the same kind.

Schema induction



Pattern seeing can be practised, at least inside one subject. Kellman and colleagues built short practice lessons for school maths. They found that **"practice in matching function information across multiple representations improved students' abilities to generate correct graphs and equations from word problems"** (Kellman et al., 2010).

Take a taxi that charges, say, £3 to start and £2 a mile. As an equation that is fare = 3 + 2 × miles, and as a graph it is a straight line climbing 2

for every mile. **One rule wears three outfits**, and the students practised seeing it under all three. The gain they measured was in maths.

One rule wears three outfits



£3 to start and £2 a mile



fare = 3 + 2 × miles



A straight line climbing 2 for every mile

The same skill has a down side. **We see patterns that are not there**, like a face in a cloud or in the front of a car. The habit that finds real rules can find false ones. Three heads in a row from a coin can feel like a streak, though each toss starts fresh.



Clouds drifting over a field, one of them a little like a face, with a child pointing up at it.

> **Science Says:**
>
> Whitson and Galinsky named this illusory pattern perception, **"the identification of a coherent and meaningful interrelationship among a set of random or unrelated stimuli"** (Whitson & Galinsky, 2008). Stimuli are the things a person sees, hears or reads. A coherent interrelationship is a link that seems to make sense.

Your electricity bill, say, jumps every January. A guess at the rule is that the heating runs longer in the cold. **A good rule makes a prediction**, here that the bill should fall again by spring. If it holds, the rule may travel by analogy to the water bill in a dry summer, when the garden hose runs longer.

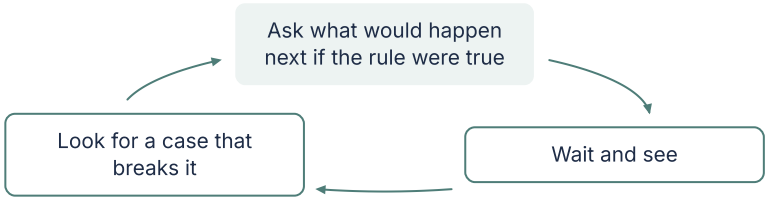
The rule for intellect is to **test a pattern before you trust it**. Ask what would happen next if the rule were true, then wait and see, or look for a case that breaks it. A single odd case is a reason to ask questions, and it is not yet a new rule.

> **Exercise:**
>
> Two cases, one rule.
>
> 1. Find two problems you have solved that looked different, such as a wobbly table and a door that sticks.
> 2. Write each one down in two lines.
> 3. Underneath, write what the two share **under the surface**, such as "something is uneven, so find the low point".
> 4. Look for a third case where the same rule would help, and try it.

Comparing on purpose turns lucky noticing into a habit you can use on any week of the year. **Two cases teach more than one**, because the

shared rule shows up only when the surfaces sit side by side. A written rule can then travel to the next task.

Test a pattern before you trust it



An analogy can lead you astray when the looks match and the relations do not. **Check the links before you carry a rule across.** A whale looks like a fish, and the rules for fish will not tell you how a whale breathes.

Back on your new street, the odd Friday now has a reason. You can predict the next bank holiday week, and **the pattern has become a rule**. The same rule may carry over to the post and the milk round. Write the rule on the calendar, and next year the lorry will not catch you out.

Key idea:

Look for the relations under the surface, and compare two cases to find the rule they share.

Quick check:

When two problems look different and need the same law, who is more likely to put them in one group, an expert or a beginner? Answer: an expert, because experts sort by principle and beginners by surface features.

3.2.1 Words, Concepts and Clear Explanations

You ride a bike with gears every week. Explaining, step by step, how a lower gear makes a hill easier to climb sounds like a small job. Riding them every week makes the answer feel close, right up to the moment you start. **The feeling of knowing arrives long before the knowing itself.**

Try it now, on paper. You might say the chain moves to a bigger cog at the back, and then you stall. The next steps, why a bigger cog makes pedalling lighter and what you give up for it, are harder to say. **The gaps show up only when you try to fill them.**



A bicycle leaning on a garden wall, its chain and back gears drawn large, with its owner crouched beside it, looking closely.

Rozenblit and Keil gave this gap a name, the illusion of explanatory depth. People "feel they understand complex phenomena with far

greater precision, coherence, and depth than they really do" (Rozenblit & Keil, 2002). **The illusion is far stronger for explanations** than for "facts, procedures or narratives", they found.

Narratives are stories, and procedures are the steps of a routine, such as making tea. **You can follow a routine without knowing why each step works**, and the routine never tests the why. A how question does.

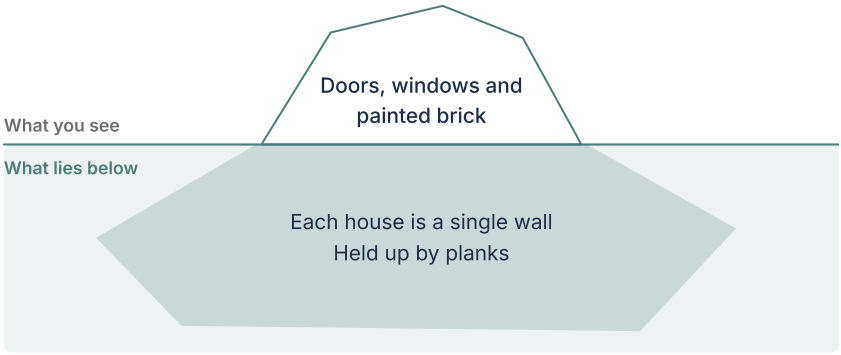
> 🗝 **Key Concept:**
>
> Illusion of explanatory depth. The **sense that you understand how something works**, which falls apart when you try to explain it step by step. It is strongest for how and why questions, and weaker for plain facts, such as a capital city, or for stories.

Facts feel different. You either know the capital of a country or you do not, and you can tell which. **A how question hides its gaps**, because a rough picture of the parts feels like a full picture of how they work together.



A film-set street works in a similar way. From the camera, the houses have doors, windows and painted brick. Walk round the side and **each house is a single wall held up by planks**. Explaining step by step is the walk round the side.

The film-set street



The good news is that **the walk round the side is enough to shrink the illusion**. Fernbach and colleagues asked people about public policies and had some of them explain, step by step, how each policy would work. Explaining "undermined the illusion of explanatory depth" (Fernbach et al., 2013).

The effects "did not occur when people were instead asked to enumerate reasons" (Fernbach et al., 2013). To enumerate is to list. **Listing reasons did not shrink the illusion**, because a list never forces you to show how the parts connect. Five reasons can sit beside a hollow picture of how the plan works.

Listing or explaining

Listing reasons	Explaining step by step
Did not shrink the illusion	Undermined the illusion of explanatory depth

The finding is about explaining, and it says nothing about which views are right. **Any view you hold firmly** is worth the same test, whether it

is about a school timetable, a bus route or a household rule. Explain how the plan would work, step by step, and see where you stall.

Words and ideas lean on each other. A concept is the idea behind a word, such as bird or gear. Murphy and Medin argued that "concepts are coherent to the extent that they fit people's background knowledge or naive theories about the world" (Murphy & Medin, 1985). **A concept is held in place by what you already believe.**

Take the word gear. **It means little on its own**, and it makes sense through what you know about wheels, chains and effort. Your store of words and facts is crystallised knowledge (see 1.1.1), and each new word hooks onto it. A naive theory is a home-made idea of how things work, often half right.

The word gear

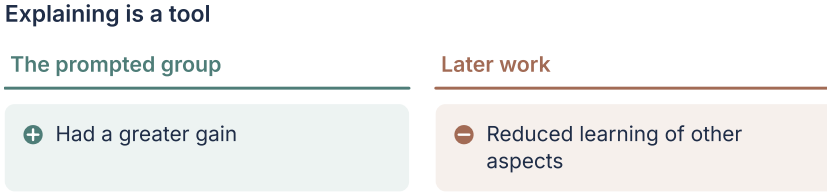


Explaining does more than test what you know. Lombrozo wrote that "explanations accommodate novel information in the context of prior beliefs" (Lombrozo, 2006). **A good explanation fits the new fact into what you already hold**, so it has somewhere to live. Her paper goes on to say that this helps people generalise, or carry what they learnt to new cases.

> **Science Says:**
>
> Chi and colleagues prompted 14 pupils in the eighth grade to explain a text to themselves as they read it, and 10 others were not prompted. **"The prompted group had a greater gain"** (Chi et al., 1994). In their words, "Generating explanations to oneself (self-explaining) facilitates that integration process". Integration means joining new pieces to old ones.

With 24 pupils in all, the study was small, and later work found limits. Prompting "improved some aspects of learning, but reduced learning of other aspects" (Rittle-Johnson & Loehr, 2017). **Explaining is a tool, and like any tool it fits some jobs better than others.** A screwdriver is a fine tool and a poor hammer.

The same paper warns that "explaining one's own solution methods or choices may reduce learning under certain conditions" (Rittle-Johnson & Loehr, 2017). **Explain how a thing works** when you want to find the gaps in your picture of it. Treat a long account of your own choices with more caution.



A large review by Dunlosky and colleagues rated ten study techniques for how useful they are. They wrote, "We rate self explanation as having moderate utility" (Dunlosky et al., 2013). **Moderate is a middle mark**, below practice testing and distributed practice, which were rated

high. Practice testing means quizzing yourself, and distributed practice means spreading study out over time.



Explaining to others brings its own trap. Once you know something, **it is hard to picture not knowing it**. Camerer and colleagues called this the curse of knowledge, and found that "Better-informed agents are unable to ignore private information even when it is in their interest to do so" (Camerer et al., 1989).

Their title places the work in economic settings, and economists call the people making decisions agents. In everyday terms, **the person giving directions forgets that you have never seen the church on the corner**, and the directions skip it. Directions that feel complete to the giver can leave the listener lost at the first turn.

> Science Says:
>
> Hinds asked people with different levels of skill to predict how long beginners would take on a task. She found that **"those with more expertise were worse predictors of novice performance times and were resistant to debiasing techniques"** (Hinds, 1999). Debiasing techniques are steps meant to correct a bias.

Try explaining how a letter gets from a post box to a door at the other end of the country. **The steps you skip are the ones you know best**,

such as the postcode that tells the sorting office where to send it. A newcomer needs that step said out loud.

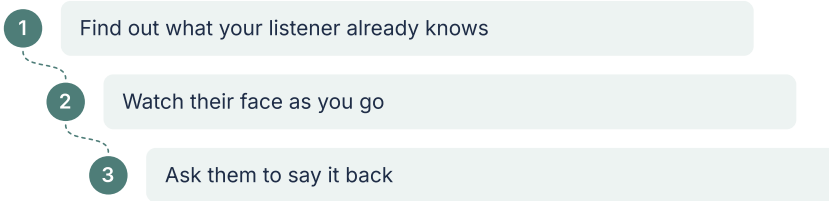
The curse of knowledge



Once you have spotted a dog hidden in a spotty black and white photo, you cannot unsee it. **The knowledge sits over your eyes**, and you can no longer look at the photo the way a newcomer does. The person you explain to is still looking at plain spots. Describe the spots first, then the dog.

The fix is to ask before you guess. Before you explain, **find out what your listener already knows**, and watch their face as you go. A blank look at step three tells you which step to slow down. At the end, ask them to say it back in their own words.

Ask before you guess



Plain words help your listener and your standing with them. Oppenheimer found "a negative relationship between complexity and judged intelligence" (Oppenheimer, 2006). **Writers who used needless long words were judged less intelligent.** The effect was

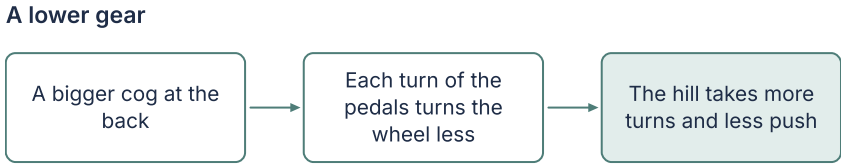
"mediated by processing fluency", which means it worked through how easily the text read.

His paper's title reads "Consequences of erudite vernacular utilized irrespective of necessity" (Oppenheimer, 2006). In plain words, that means using long words when you do not need them, and the title shows how tiring they are to read. **Say it in the plainest words that still say it right.**

Sometimes a drawing beats any sentence. A diagram can make plain what a page of sentences hides (see 3.1.1). **Draw the chain and the two cogs**, and the trade between pedal turns and effort shows on the page. A sketch on the back of an envelope often explains a machine faster than a paragraph.

> Exercise:
>
> Explain it to a ten-year-old.
>
> 1. Pick something you use daily, such as a zip or a kettle.
> 2. Rate how well you understand it, from 1 to 7.
> 3. Write, step by step, how it works, in words a ten-year-old knows.
> 4. Mark each step where you got stuck.
> 5. Rate yourself again, then look up the stuck steps. I borrowed these steps from the method of Rozenblit and Keil (2002).

If your second rating is lower, the exercise worked. **A lower score is a map of what to learn next.** Keep the page, and compare it with your next try. Fill one gap at a time, and explain the thing again a few days later to see whether the steps hold.



Back on the bike, the full answer fits in two lines. A lower gear puts a bigger cog at the back, so each turn of the pedals turns the wheel less. **You trade distance for ease**, and the hill takes more turns and less push. Your first try showed where the gaps were, and plain words filled them.

Key idea:

Explaining step by step shows you what you really understand, and plain words carry it to others.

Quick check:

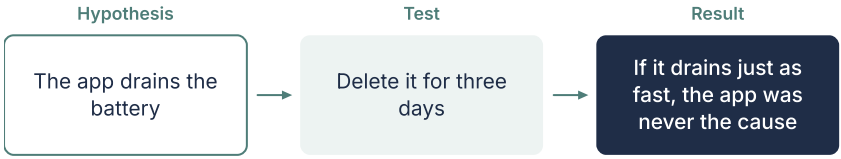
Which shrank the illusion of explanatory depth in the work by Fernbach and colleagues, listing reasons or explaining step by step? Answer: explaining step by step.

3.2.2 Reasoning, Testing and Comparing Explanations

Your phone battery now runs flat by lunchtime, and you blame the new app from last week. The hard part is finding out whether you are wrong. The usual move is to watch the battery on days you use the app, and nod each time it drops. **A test that can only say yes is no test at all.**

The fairer test asks what would happen if the app were innocent. Delete it for three days and see whether the battery still runs flat. **If it drains just as fast, the app was never the cause**, and something else needs a look. The case that could prove you wrong is the one worth checking.

A fair test





A new umbrella held open under a garden hose on a sunny afternoon.

A new umbrella shows the idea. Carry it only on dry days and it never lets you down, and you learn nothing about it. **The honest test is the garden hose**, aimed straight at it on a sunny afternoon, where a leak has every chance to show itself.

The same move works on any everyday guess. Say you believe a plant wilts because it is thirsty. **Water it more for a week and watch.** If it wilts anyway, the guess was wrong, and you have saved yourself months

of the wrong care. One week of honest testing beats a season of hopeful watching.

> **Key Concept:**
>
> Hypothesis and test. A hypothesis is **a guess about what causes what**, such as "the app drains the battery". A test is a check whose result could go either way. A good test is one the guess could fail, and a guess that survives such tests earns more trust.

Wason studied how people test their guesses. He gave them a task where they had to find a rule the experimenter had in mind by trying out examples. **"Six out of 29 subjects reached the correct conclusion without previous incorrect ones"** (Wason, 1960). Those who kept making errors "were unable, or unwilling to test their hypotheses".

Wason's rule task

W1

Wason, 1960

- Six out of 29 subjects reached the correct conclusion
- Others were unable, or unwilling to test their hypotheses

A simple reading of results like these says people seek only evidence that agrees with them. Klayman and Ha took a closer look. They argued that such results "are better understood in terms of a general positive test strategy" (Klayman & Ha, 1987). **A positive test checks a case you expect to fit the rule.**

> **Science Says:**
> Klayman and Ha found that a positive test strategy **"can be a very good heuristic"** (Klayman & Ha, 1987). Whether it helps depends on the task. Nickerson's review defines confirmation bias as "the seeking or interpreting of evidence in ways that are partial to existing beliefs, expectations, or a hypothesis in hand" (Nickerson, 1998).

Partial here means leaning to one side. **Checking the cases you expect is a sensible first move**, and the danger comes when it is the only move. For the battery, using the app and watching the drop is a positive test. Deleting the app is the test that could break the guess.

Two tests for the battery

A positive test	The fairer test
Using the app and watching the drop	→ Deleting the app

Rules of the form "if P, then Q" are harder than they look. Wason found that people struggle with "the contra-positive inference", "that not-P follows from not-Q" (Wason, 1968). **Take the rule "if it rained, the pavement is wet".** If the pavement is dry, it did not rain, and that step from dry to no rain is the contrapositive.

If it rained

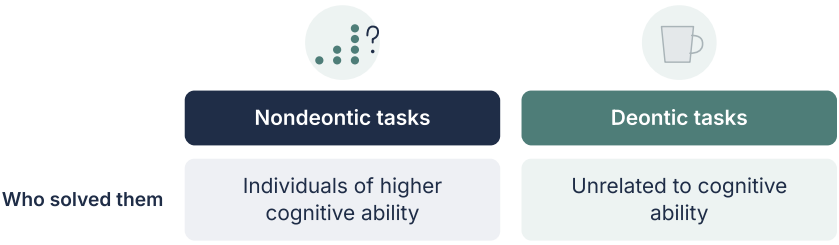
If	Then
It rained	→ The pavement is wet

To check a rule, **look at the cases where Q is false**. A dry pavement on a day you know it rained would break the rule. No number of wet pavements could prove it, because wet pavements fit plenty of other causes, such as a burst pipe or a street cleaner.

The form of a task changes how hard it feels. Stanovich and West found that "Nondeontic tasks were solved disproportionately by individuals of higher cognitive ability" (Stanovich & West, 1998). **Deontic means about what people may or must do**, such as who is allowed to buy a drink.

Versions built on such rules, like "the Drinking-age Problem", "were unrelated to cognitive ability" (Stanovich & West, 1998). **Wrap the logic in a familiar rule about permission**, and ability stops predicting who gets it right. The abstract version, with letters and numbers, is where ability shows.

Same logic, two forms



Beliefs tug at how we read evidence. Lord, Ross and Lepper gave people on two sides of a debated social question the same mixed set of studies. People "accept 'confirming' evidence at face value while subjecting 'disconfirming' evidence to critical evaluation" (Lord et al., 1979). **The same evidence can push two sides further apart.**

J. S. B. T. Evans and colleagues named a related clash in their title, "On the conflict between logic and belief in syllogistic reasoning" (J. S. B. T. Evans et al., 1983). A syllogism is a two-step argument, such as all robins are birds, this is a robin, so it is a bird. **Logic and belief can point in different directions.**

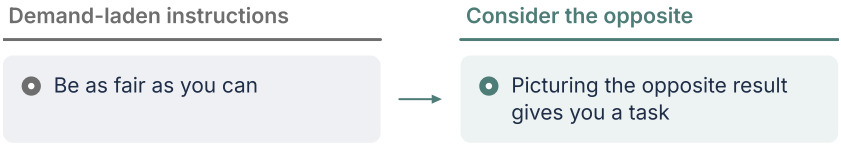
A syllogism



The fix is something other than trying harder to be fair. Lord, Lepper and Preston found that "the induction of a consider-the-opposite strategy had greater corrective effect than more demand-laden alternative instructions to be as fair and unbiased as possible" (Lord et al., 1984). **Ask what you would conclude if the evidence pointed the other way.**

Demand-laden instructions press hard on people to behave well, such as "be as fair as you can". **A promise to be fair gives you nothing to do.** Picturing the opposite result gives you a task, and doing the task is what the study found helped more.

Be fair or picture the opposite



Confidence follows the same pattern. Koriat and colleagues found that "Only the listing of contradicting reasons improved the appropriateness

of confidence" (Koriat et al., 1980). **Write down one reason you might be wrong**, and your sense of how sure to be moves closer to how often you are right.

Mercier and Sperber offered one account of why we go easy on our own ideas. They proposed that "the function of reasoning is argumentative" (Mercier & Sperber, 2011). On their view, people reason to make arguments and to judge the arguments of others. **It is a hypothesis, and a debated one.**

Seen this way, reasoning works best in company. **A friend who disagrees with you** does the checking that you tend to skip on your own ideas, and you do the same for theirs. Ask one such friend to read your plan before you act on it.

> Science Says:
>
> Trouche and colleagues showed people their own earlier arguments, presented as someone else's. They found that **"more than half (56% and 58%) rejected the arguments that were in fact their own"** (Trouche et al., 2016). The title of their paper calls this the selective laziness of reasoning.

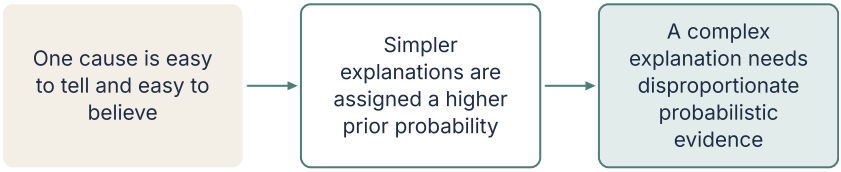
Selective means it picks its targets. **We check other people's arguments harder than our own.** The cure is to turn your own argument into a stranger's, and swap seats with your critic for ten minutes. Write it down, leave it a day, and read it as if someone you disagree with had written it.

Simple stories have a pull of their own, because one cause is easy to tell and easy to believe. Lombrozo found that "simpler explanations are assigned a higher prior probability" (Lombrozo, 2007). A prior

probability is how likely something seems before the new evidence arrives. **Simple explanations start the race ahead.**

As a result, "disproportionate probabilistic evidence is required before a complex explanation will be favored" (Lombrozo, 2007). "The new app did it" is one cause and easy to say. **A mix of causes is harder to hold in mind**, such as an old battery, a cold week and a brighter screen, and it may still be the truth.

Simple stories have a pull



Short cuts like these are heuristics (see 1.3.1). Tversky and Kahneman wrote that heuristics "are highly economical and usually effective, but they lead to systematic and predictable errors" (Tversky & Kahneman, 1974). **A short cut saves time most days and trips you in the same place each time.** Learn where yours trip you, and slow down at those spots.

> **Exercise:**
>
> Argue the other side.
>
> 1. Pick a small view you hold, such as the best route to work or why a plant is wilting.
> 2. Write the strongest case for the opposite view, in three sentences.
> 3. List one fact that would change your mind.
> 4. Check that fact, if you can.

Arguing the other side feels awkward at first, because it means building a case you do not believe. **You may keep your view, and now you know what it rests on.** If the fact you listed turns out against you, you have learnt something before it cost you.

Back to the phone. Say you delete the app and the battery still runs flat by lunch. **Your first guess failed a fair test**, which is good news, because now you can look at the battery's age or the screen settings. A guess that could not fail would have kept you stuck.

Key idea:

Look for the case that could prove you wrong, and judge your own argument as hard as a stranger's.

Quick check:

In the work by Koriat and colleagues, what improved how well people's confidence matched their answers? Answer: listing reasons against their answer.

3.2.3 Numbers, Chances, Shapes and Space

A CAR ALARM GOES OFF in your street at night. I want to know how likely it is that a car is being stolen. The sound is loud and urgent, and the picture of a thief at the door comes to mind at once. **The alarm tells you less than it seems to**, and a little counting shows why.

Say that over a year, a thief comes to your street on one night. On that night the alarm sounds. On 50 other nights it sounds for a cat, a gust of

wind or an owner who pressed the wrong button. **Out of 51 alarms, one meant a theft.** On any given night, the chance is about 1 in 51.



Numbers like these sit under a great many choices, from bills to health checks. Reyna and colleagues reviewed the work and wrote that "Low numeracy distorts perceptions of risks and benefits of screening" (Reyna et al., 2009). **Numeracy is the skill of using numbers in daily life**, and screening means health checks for people with no signs of illness.



> **Science Says:**
>
> Lipkus and colleagues gave a short numeracy test to 463 people aged 40 and older, most of them highly educated. Only **"18% and 32% of participants correctly answered all of the general and expanded numeracy scale items, respectively"** (Lipkus et al., 2001). The two figures are for the short and the longer version of the test.

Skill with numbers seems to guard against some tricks of wording. Peters and colleagues found that highly numerate people were **"less**

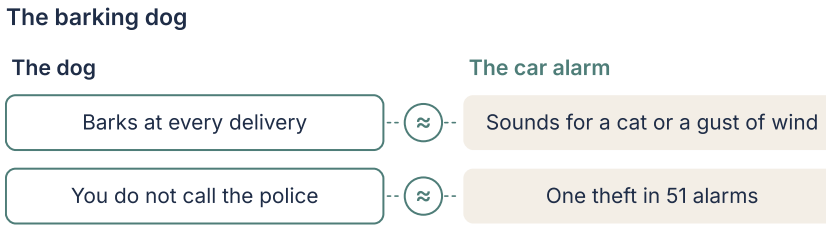
susceptible to framing effects" (Peters et al., 2006). Framing means describing the same fact in two ways, such as "90 per cent fat free" and "10 per cent fat". The study was correlational.

Back to the car alarm. The number that settles the question is how often thefts happen at all. **The base rate is how common something is** before you get any new clue. Kahneman and Tversky found that predictions "are insensitive to the reliability of the evidence or to the prior probability of the outcome" (Kahneman & Tversky, 1973).

> 🗝 **Key Concept:**
>
> Base rate. The base rate is **how often something happens in general**, before the clue in front of you. A rare event stays fairly rare even after a clue, unless the clue is very good. Start from the base rate, then adjust for the clue.

Insensitive here means the predictions barely changed when the base rate changed. **People followed the vivid clue and forgot the count.** Heuristics, the mental short cuts (see 1.3.1), help explain why, because a clue that looks like the outcome feels like strong evidence.

A dog that barks at every delivery shows the trap. When it barks, you do not call the police, because you know how often it barks for nothing. **You have learnt the base rate of the dog.** Car alarms and smoke alarms work the same way, and most of us have never counted them.



Counts are easier than percentages. Gigerenzer and Hoffrage gave people chance problems written as natural frequencies, which means counts of people or cases, such as “10 out of 1,000”. With these formats, answers matched the correct method in **“up to 50 % of all inferences by Bayesian algorithms”** (Gigerenzer & Hoffrage, 1995).

A Bayesian algorithm is the exact sum for updating a chance when a new clue arrives. **Counts let people do that sum without being taught it.** The title of their paper promises to improve such reasoning “without instruction”, and counts are how.

> **Science Says:**
>
> A later short paper in Science found that “Most people, experts included, have difficulties” with statistical information. These difficulties **“can be considerably reduced by communicating the information in terms of natural frequencies”** (Hoffrage et al., 2000).

Try the alarm both ways. As a percentage, the alarm means a theft on about 2 per cent of the nights it sounds. As a count, it is one theft in 51 alarms. **The count shows you the 50 false alarms**, and the percentage hides them inside a small number.

Percentage or count

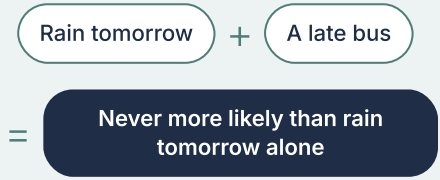


Imagine a room of 100 people. A percentage asks you to juggle fractions in your head, and a count asks you to look round the room. **Ten people standing up out of a hundred is easier to see** than 10 per cent of anything. Turn chances into people, and the sum often does itself.

Counts help with small choices. Say the forecast gives a 25 per cent chance of rain, and imagine 100 days like tomorrow, with rain on 25 of them. **Seen as days, the chance is easy to plan around.** Most of those days stay dry, and a small umbrella in the bag covers the rest.

Another rule of chance is easy to break. Tversky and Kahneman wrote that "P (A&B) cannot exceed the probabilities of its constituents" (Tversky & Kahneman, 1983). **Two things both happening can never be more likely than one of them happening.** Their judgments, they found, "are often mediated by intuitive heuristics that are not bound by the conjunction rule".

Rain and a late bus



> 🗝 **Key Concept:**
>
> The conjunction rule. A conjunction is **two things joined by "and"**. The chance of rain tomorrow and a late bus can never be higher than the chance of rain tomorrow alone, because every day with both is a day with rain. Extra detail can make a story feel more likely while it makes it less likely.

Numbers take up space in the mind. Siegler and Booth asked young children to mark numbers on a line. Their estimates **"progressed from consistently logarithmic to a mixture of logarithmic and linear to a primarily linear pattern"** (Siegler & Booth, 2004). Better number-line estimates went with better maths results.

A logarithmic line gives small numbers lots of room and squashes the big ones together at the far end. **A linear line spaces every number evenly**, the way a ruler does. Young children start with the squashed line, and the even ruler takes over as they grow.

Two number lines

A logarithmic line	A linear line
Gives small numbers lots of room	Spaces every number evenly
Squashes the big ones together	The way a ruler does

Shepard and Metzler showed people pairs of drawings of solid shapes and asked whether the two were the same shape turned round. The time to answer was **"a linearly increasing function of the angular difference"** (Shepard & Metzler, 1971). The further one shape had to turn to match the other, the longer people took.

Turning a shape

The further one shape had to turn → The longer people took

Moving a sofa up a narrow staircase feels like that. **You turn it a bit at a time in your mind**, then on the stairs, and a big turn takes longer to

plan than a small one. People seem to rotate the picture in their heads at a set pace.

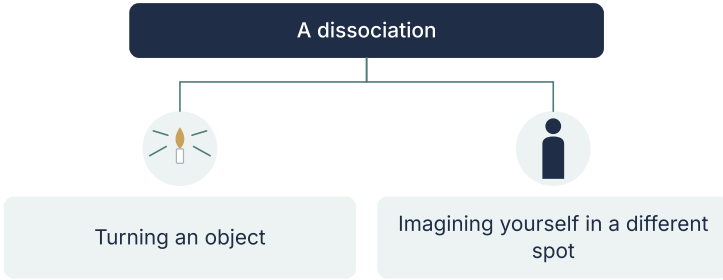


Two people carrying a sofa up a narrow staircase, tilting it to get round the bend.

Reading a map while walking south asks for a turn of a different kind. **You picture the street from where you stand**, while the map shows it from above with north at the top.

Turning an object is one skill, and imagining yourself in a different spot is another. The title of a paper by Hegarty and Waller names “A dissociation between mental rotation and perspective-taking spatial abilities” (Hegarty & Waller, 2004). **A dissociation means the two can come apart**, so a person may be strong at one and weaker at the other.

Two spatial skills



> **Science Says:**
>
> Uttal and colleagues pooled 217 research studies of spatial training. The average effect size for training relative to control groups was **0.47** (Uttal et al., 2013). Their title calls spatial skills malleable, which means they can be shaped. The gains showed up mainly on spatial tasks like the ones practised.

The word mainly carries weight. **Practice at a spatial task made people better at that kind of task**, and the review gives no promise of wider gains.

Spatial training



Spatial skill grows with practice. **Practise the kind of task you want to get better at**, such as reading maps, packing a car boot or following flat-pack drawings. Worry about maths can pull scores below what a

person can do (see 1.1.1), so give yourself a calm moment before you start on a chance question.

> Exercise:
>
> Turn percentages into people.
>
> 1. Find a chance written as a percentage, in a news story or on a label.
> 2. Rewrite it as a count out of 100 or 1,000 people.
> 3. Ask what the base rate is before the new clue.
> 4. Say the result out loud as people, such as "3 in every 100".

Counts give your mind something to look at. **A number you can picture is a number you can check.** If the count looks odd, find the base rate behind it before you worry.

Back in your street, the alarm is still loud, and you now know what it means. Say one alarm in 51 is a theft. **The chance is small, and it is worth a look out of the window**, and nowhere near the certainty the noise suggests. The counting took a minute and changed the whole picture.

Key idea:

Turn chances into counts of people, start from the base rate, and give shapes time to turn in your head.

Quick check:

Which is more likely, rain tomorrow, or rain tomorrow and a late bus?
Answer: rain tomorrow, because a pair can never be more likely than one part of it.

3.3 Directing Your Own Intellectual Work

3.3.1 Choosing a Strategy and Checking Your Answer

You add up a restaurant bill for four friends, and the total feels right. You could check it. Most evenings the feeling wins, the card goes down and the night moves on. **An answer that feels right is the one we are least likely to check**, and that makes it the one worth checking.

Say the bill has eight dishes and three drinks, and your total is £86. A quick second pass, rounding each item to the nearest five pounds, gives about £95. **The gap tells you something went wrong**, and a slower count finds a dish you skipped. Two methods that disagree are a signal to look again.

Two passes on the bill

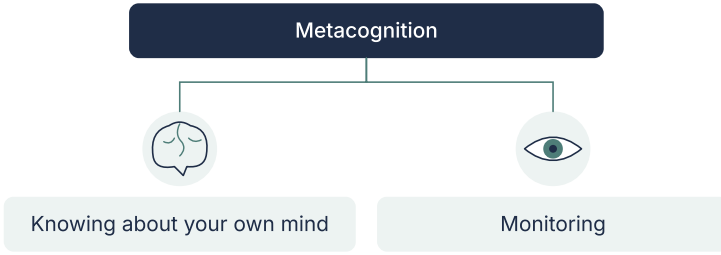


Checking an answer means stepping back and watching your own work. Flavell put a name to this in the title of a 1979 paper, "Metacognition and cognitive monitoring" (Flavell, 1979). **Metacognition is knowing about your own knowing**, and monitoring is keeping an eye on how a task is going while you do it.

The two parts are worth keeping apart. **Knowing about your own mind** includes things like knowing that you rush sums when tired.

Monitoring is the live part, the moment you notice mid-task that a number looks odd. A good check needs both of them working together.

Metacognition



> **Key Concept:**
> Metacognition. Metacognition is **your view of your own mind at work**. It covers what you know about how you learn and solve problems, and the checks you run while you are working. Choosing a strategy and checking an answer are both metacognition.

A carpenter who measures twice before cutting shows the habit. The first measure gives a number. **The second measure checks the first**, and a cut plank cannot be uncut. A minute spent on the check saves a plank, an afternoon and a trip to the shop.

Checking costs a little time, and skipping it can cost a lot. **The size of the check should match the size of the mistake it could catch.** A shopping total deserves a glance, and a tax form deserves a full second pass, line by line.

The size of the check



A shopping total deserves a glance



A tax form deserves a full second pass



The size of the mistake it could catch

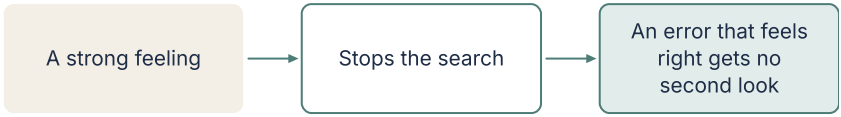


A carpenter measuring a plank a second time before cutting, a pencil tucked behind one ear.

Some answers get checked and others do not. Thompson and colleagues found that first answers come with "a metacognitive experience, called the Feeling of Rightness (FOR), which can signal when additional analysis is needed" (Thompson et al., 2011). **A strong feeling of rightness lets the answer through**, and a weak one sends you back for a second look.

Signal is the key word. **The feeling is a signal, and signals can be wrong.** A strong feeling stops the search, so an error that feels right gets no second look at all. The checks in the rest of this section are ways round that gap.

The feeling of rightness



> **Science Says:**
> The Cognitive Reflection Test (see 1.3.1) was built around this moment. Frederick describes it as a **"three-item"** test of "the ability or disposition to reflect on a question and resist reporting the first response that comes to mind" (Frederick, 2005). Disposition means a habit or leaning. The test catches answers that feel right and are wrong.

The feeling of rightness works like the warning light on a car dashboard. When it stays dark, you drive on. **A dark light is good news only if the bulb works**, and with quick answers it often stays dark when it should be lit. The fix is a habit of checking that does not wait for the light.

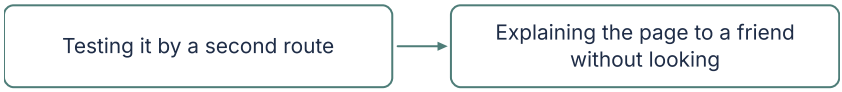
The warning light



Our view of our own learning can be off in a similar way. Bjork and colleagues wrote that "people often have a faulty mental model of how they learn and remember" (Bjork et al., 2013). **A mental model is your private picture of how something works.**

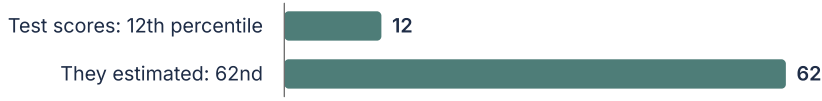
If that picture is wrong, **you may pick a study method that feels good and works badly**. Checking your learning, like checking a bill, means testing it by a second route, such as explaining the page to a friend without looking.

Checking your learning



Kruger and Dunning asked people to rate their own test scores. For the weakest group, they wrote, **"Although their test scores put them in the 12th percentile, they estimated themselves to be in the 62nd"** (Kruger & Dunning, 1999). A percentile is your place in a line of 100 people, from lowest to highest.

Kruger and Dunning



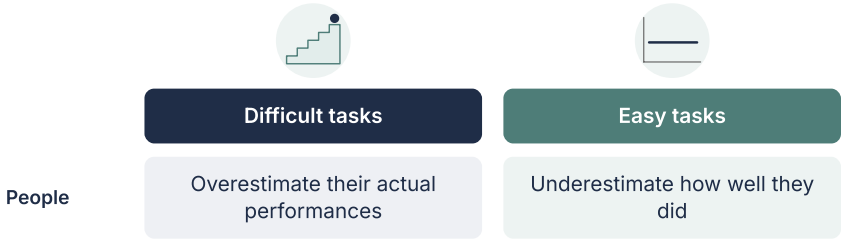
> **Science Says:**
>
> The popular telling of this result is that the less you know, the more confident you feel. A later paper's title disagrees, "The Dunning-Kruger effect is (mostly) a statistical artefact" (Gignac & Zajenkowski, 2020). **A statistical artefact is a pattern made by the way the numbers are handled**, more than by the people being studied.

The safe reading is narrow. **In that study, the lowest scorers rated themselves well above where they scored.** How much of the wider

story holds up is a question the critics have raised, and the title says most of it does not. Your own confidence is worth checking either way.

Task difficulty shifts confidence in both directions. Moore and Healy found that "On difficult tasks, people overestimate their actual performances" (Moore & Healy, 2008). **On easy tasks, the pattern flips**, and people underestimate how well they did. Hard work breeds false hope, and easy work hides real skill, so judge yourself on a mix of hard and easy tasks.

Hard and easy tasks



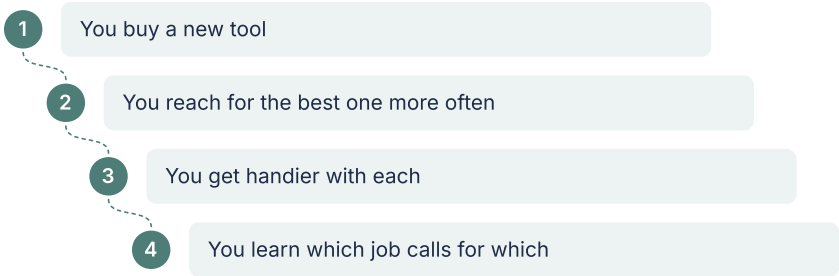
Checking is one half of the job, and choosing a method is the other. Lemaire and Siegler studied how children's strategies change as they learn multiplication. They described **"four aspects of strategic change"** in their title, and the abstract lists them (Lemaire & Siegler, 1995).

For the restaurant bill, the strategies might be adding each line, rounding to fives, or splitting by person. **Each has a job it does best.** Rounding is fast and rough, adding line by line is slow and exact, and splitting by person answers a different question.

> **Key Concept:**
> Four kinds of strategy change. Lemaire and Siegler list "introduction of new strategies, increasing use of the most efficient existing strategies, more efficient execution of each strategy, and more adaptive choices among strategies" (Lemaire & Siegler, 1995). In everyday words, **learners add new methods, use the best ones more, get faster at each, and choose among them better**.

A toolbox makes the four parts easy to see. You buy a new tool, you reach for the best one more often, you get handier with each, and you learn which job calls for which. **A full toolbox helps only if you choose the right tool**, and that choice is the fourth part of the list.

A toolbox



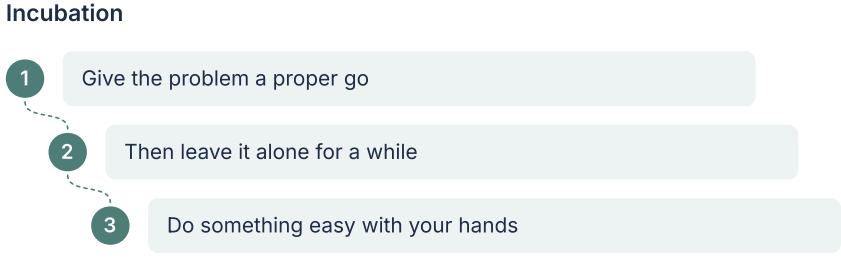
Hattie and colleagues reviewed 51 studies of training in study skills. Their results "support the notion of situated cognition" (Hattie et al., 1996). **Situated cognition means skills are tied to the setting where they are learnt**, so study skills taught inside a subject tend to work best there. Learn each method where you will use it.

Two checking moves have support in the research. The first is to list a reason you might be wrong, which brings your confidence closer to your record (see 3.2.2). **One reason against does more than five**

reasons for. Ask what you would see if the answer were wrong, then look for it.

The second is to take a break, a step researchers call incubation. Sio and Ormerod pooled studies of it and found "a positive incubation effect" (Sio & Ormerod, 2009). Tasks with many possible answers gained more than some other kinds of puzzle with words or pictures. **A walk round the block can leave you seeing a stuck task fresh.**

Give the problem a proper go before you step away, so you return with the pieces already laid out. **Then leave it alone for a while**, and do something easy with your hands, such as washing up or a short walk. Then sit down and look again with fresh eyes.



Pólya saw this gap in good students. Once they have the solution and have "written down neatly the argument", they "shut their books and look for something else". Doing so, "they miss an important and instructive phase of the work" (Pólya, 1945/1957). **Looking back at a finished answer is part of the work**, and the exercise below shows one way.

> Exercise:
>
> Before and after.
>
> 1. Before your next task with a right answer, such as a bill or a timetable, write down your method in one line.
> 2. Do the task and note how sure you feel, from 1 to 10.
> 3. Check the answer by a second method.
> 4. Compare the two, and note whether your feeling matched the result.

Do this for a week, and you build a record of when your feeling of rightness can be trusted. **The record is better than the feeling**, because it shows where your errors cluster, by task and by time. For most people, the quick, confident answers are the ones to watch.

Back at the restaurant, the rounded check took twenty seconds. **The second method caught the skipped dish**, and the bill came out right. Next time, start with the rough check, and do the slow count only when the two disagree. Save your closest look for the answer that feels most certain.

Key idea:

Choose a strategy on purpose, and check most the answer that feels right.

Quick check:

In the study by Moore and Healy, did people overrate or underrate their results on easy tasks? Answer: they underrated them.

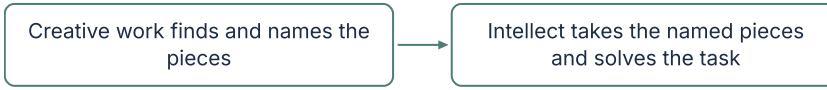
3.3.2 Using Intellect and Creativity Together

Your hallway is small and dark, with a coat hook, a narrow window and a door at each end. You want it to feel welcoming, and no right answer comes with it. I want to know if it is an intellect task or a creativity task. **The honest answer is that it starts as one and ends as the other.**

At the start, nothing is named. **You have to find the pieces before you can solve anything**, such as the light, the colour of the walls, the clutter and what a guest sees first. That finding is the creative part. Once the pieces are named, intellect can weigh them, measure them and check the plan.

The book's definition puts the line in the same place. Intellect solves tasks once the pieces are named, and creativity works before that, on tasks where the pieces are still open (see 1.1.2). **The hallway moves from one side of the line to the other** as you work on it.

The hand-over



> 🗝 **Key Concept:**
>
> The hand-over. Creative work **finds and names the pieces of an open task**. Intellect takes the named pieces and solves the task, checking each step. In a real project, the two take turns many times, and each hand-over makes the task a little more closed.

Cropley wrote that creative work involves both "generation of novelty" and "evaluation of the novelty" (Cropley, 2006). **Generation means making new options, and evaluation means judging them.** He added that knowledge "is a source of ideas", so what you already know feeds what you can invent. A keen gardener has more ideas for a bare bed than a beginner.

> **Key Concept:**
> Creative work = Generation + Evaluation. **Both halves are needed.** Generation without evaluation leaves a pile of untested ideas, and evaluation without generation has nothing to judge.

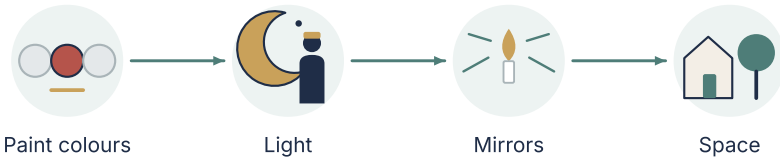
A photographer at a wedding shows the pair at work. She takes a hundred shots, many of them half-guesses, from odd angles and in poor light. **Afterwards she keeps three**, and the keeping is a slow, careful job. Taking shots is generation, and picking the best ones is evaluation.

At the wedding



The two halves draw on different abilities. Beaty and colleagues found "substantial effects of both associative and executive abilities" in creative work (Beaty et al., 2014). **Associative ability is linking one idea to another**, the way paint colours lead to light, light leads to mirrors, and mirrors lead to space. Each link opens a new option.

Associative ability



> **Science Says:**
>
> Executive ability is **the mind's steering**, the control that holds a goal and keeps you on it. Benedek and colleagues found that "Creativity was predicted by updating and inhibition" (Benedek et al., 2014). Shifting, the third control skill they measured, did not predict it. Updating means refreshing what you hold in mind, and inhibition means holding back the obvious answer.

Inhibition fits the hallway well. The first idea most people reach for is to paint it white. **Holding that idea back for a minute** leaves room for a warm colour, a mirror opposite the window or a lamp at the far end. Updating then keeps the best of these in mind while you compare them.

Silvia put the link between the two in a blunt title, "Intelligence and creativity are pretty similar after all" (Silvia, 2015). **In plain words, the title says the two are close.** The Benedek paper above names all three together in its own title, intelligence, creativity and cognitive control.



A table spread with paint sample cards, and three chosen cards taped to a hallway wall.

Sometimes the hand-over happens in a flash. Kounios and Beeman describe insight as what "occurs when a person suddenly reinterprets a stimulus, situation, or event to produce a nonobvious, nondominant interpretation" (Kounios & Beeman, 2014). **Insight is seeing the same thing in a new way.** Nondominant means it is not the reading that first springs to mind.

> 🗝 **Key Concept:**
>
> Insight. Insight is **a sudden new reading of something you already had in front of you**. Nothing new arrives from outside. The pieces stay the same, and the way they fit changes. For the hallway, it might be the moment you see the narrow window as the place for a mirror opposite.

Breaks can help, as the last section showed with incubation (see 3.3.1), and one study adds what to do in the break. Baird and colleagues found that "engaging in an undemanding task during an incubation period led

to substantial improvements in performance on previously encountered problems" (Baird et al., 2012). **An easy task in the break did the most good.**

Undemanding means easy, such as folding laundry. **It is a single study**, and its replication was not checked, so treat it as a hint. A short, easy task in a pause costs little to try. Look hard at the problem first, so the pause has something to work on.

Four stages



> **Key Concept:**
> Four stages. In 1926 Wallas described creative work in four stages, **Preparation, Incubation, Illumination and Verification** (Wallas, 1926/1949). Preparation comes first, and Incubation is the kind of break Baird studied. Illumination is his name for the appearance of the "happy idea", and Verification, the check, comes last. He built it from reports by Helmholtz and Poincaré, so it is a description and no experiment.

Many people reach for a group when they need ideas, because a room full of voices feels like a room full of ideas, and **the research on brainstorming groups points the other way**.

A meeting where everyone calls out ideas at once feels busy and full of energy. **Busy and productive are different things**, and counting the ideas tells them apart. Count them, then check how many are any good.

> Science Says:
>
> Mullen and colleagues pooled studies and found that **"brainstorming groups are significantly less productive than nominal groups, in terms of both quantity and quality"** (Mullen et al., 1991). A nominal group is a set of people who work alone and then pool their ideas. They are a group in name only.

Work alone first, then share. Each person writes ideas for the hallway on their own for ten minutes. Then the ideas go on one table, and the group judges them together. Generation happens alone, and evaluation happens in company.

Brainstorming and nominal groups



Creativity can be trained, when the training is good. Scott and colleagues reviewed "70 prior studies" and found that "well-designed creativity training programs typically induce gains" (Scott et al., 2004). **The better programmes taught skills through real tasks**, focused on "cognitive skills and the heuristics involved in skill application, using realistic exercises".

Realistic exercises are practice on tasks like the ones you face in life, such as a room to rearrange or a menu to plan. **Practise creativity on real problems**, and judge the results the way you would judge any plan. Real problems come with real limits, such as money, time and space.

> **Science Says:**
>
> A popular story says creativity lives in the right side of the brain. Dietrich and Kanso reviewed "72 experiments, reported in 63 articles" that recorded the brain during creative tasks, using EEG and other methods. EEG records the brain's electrical activity through sensors on the scalp. They called the data **"deeply self-contradictory"** (Dietrich & Kanso, 2010).

For tasks that ask for many answers, they found "no reliable changes above and beyond diffuse prefrontal activation" (Dietrich & Kanso, 2010). Diffuse prefrontal activation means a broad spread of activity at the front of the brain. **No single creative spot showed up**, on the right side or anywhere else.

Creativity in the brain



72 experiments, reported in 63 articles



Deeply self-contradictory



No single creative spot showed up

Tests of creativity have limits of their own. Kim's review of one creativity test asks in its title whether such tests can be trusted (Kim, 2006). **A creativity test is a sample of a skill**, a short task scored in a quiet room, and a hallway that works for real people is a different thing.

Use tests as a rough guide and nothing more. **Judge your own creative work by whether it works**, in the hallway, the garden or the report you write. A low score on a test says little about how your own hallway will turn out.

> **Exercise:**
>
> Open, then close.
>
> 1. Pick an open task at home, such as a cluttered shelf or a dull corner.
> 2. Spend ten minutes writing every idea you can, with no judging.
> 3. Take a short break doing something easy.
> 4. Come back and pick the best three, with a reason for each.
> 5. Choose one, then plan its steps and cost.

The exercise keeps the two halves apart on purpose. **Judging early shuts down ideas before they can grow**, and never judging leaves you with a list and no hallway. Open first, then close. Set a timer for each half, so neither one steals the other's time.

Open, then close

Judging early	Never judging
⊕ Shuts down ideas before they can grow	⊖ Leaves you with a list and no hallway

Back in the hallway, the ideas list held fourteen options and the short list held three. Say you chose a warm colour, a mirror opposite the window and a lamp at the far end. **Creativity found those pieces,**

and intellect now prices them, measures the wall and checks the light. The friend walks into a hallway that took both.

Key idea:

Creativity finds and names the pieces, and intellect solves the task once they are named.

Quick check:

A group of five people works alone and then pools ideas. What is that called, and how did it compare with a brainstorming group? Answer: a nominal group, and brainstorming groups were less productive than nominal groups in both quantity and quality.



Module

4

Growing Through Learning and Practice

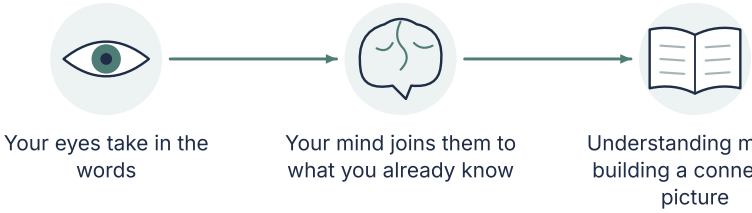
4.1 Building Knowledge You Can Use

4.1.1 Reading to Understand and Connect Ideas

Two friends read the same newspaper report of a cricket match. One has followed cricket since she was small, and the other has never watched a ball bowled. Next morning the fan can retell the match in order, and her friend remembers only the rain. **The page was the same, and what each reader brought to it was different.**

Reading looks like one job, and it is two. Your eyes take in the words, and your mind joins them to what you already know. The fan had a big store of cricket for the report to join onto. **Her friend had words with nowhere to go**, and most of them had slipped away by breakfast.

Reading is two jobs





Two friends on a park bench share one newspaper, one grinning at the sports page and the other frowning at it.

In Kintsch's model of this joining, as you read, "a network of interrelated items is created ... which can be integrated into a coherent structure" (Kintsch, 1988). A coherent structure is one whose parts hang together. **Understanding means building a connected picture**, with ideas tied to each other and to what you knew before.

Directions to a friend's house work the same way. You sketch a map as she talks, and each street name helps only if you can place it beside a street you know. **Streets with no neighbours drop off the map.** Kintsch's picture is a model, a proposed account of how reading may work, and no reading method on its own.

Directions to a friend

The sketch map		The page
A street name you can place	≈	A connected picture
Streets with no neighbours drop off	≈	Words with nowhere to go

The model gives you a fair test. Once you understand a text, "one might reasonably expect to be able to answer questions about it, recall or summarize it" (Kintsch, 1988). **If you can answer questions about a page with the book shut, you have understood it.** Nodding along with the page open shows the map is not built yet.

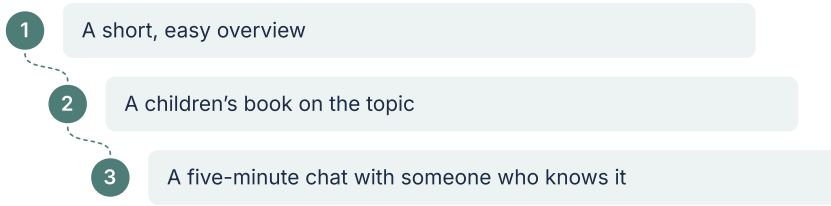
Try it with a bread recipe. Read it, shut the book and say why the dough must rest before baking. If all you can say is that the recipe told you to, **that step sits on your map with no neighbour**. A reason you can give in your own words is a street joined to the rest of the town.

> Science Says:
>
> Recht and Leslie gave 64 pupils in junior high school, the early years of secondary school, an account of part of a baseball match. Some pupils knew a lot about baseball and some knew little. They found "a significant main effect for prior knowledge on all measures. No interactions between prior knowledge and ability were found" (Recht & Leslie, 1988). **Knowing the sport helped on every measure.**

"Main effect" and "interaction" are researchers' words. A main effect here means knowing baseball helped across the board. **No interaction means the help was about the same size for good and poor readers.** With only 64 pupils, the study was small, and its result sits neatly with the two cricket friends.

The rule that follows is simple. **Before a hard text, build a little knowledge first.** A short, easy overview, a children's book on the topic or a five-minute chat with someone who knows it gives the new page something to join onto. The hard text then lands on ground that is ready for it.

Build a little knowledge first



A text that spells out every link sounds kindest for every reader. McNamara and Kintsch wrote two versions of the same material, one with every link stated and one with gaps. **The fully linked text did better on recall and multiple-choice questions** (McNamara & Kintsch, 1996). Readers who knew a lot showed something different on a third kind of question.

Open-ended questions ask you to explain in your own words. On those, "high-knowledge readers performed better on the open-ended questions after reading the low-coherence text", because "the low-coherence text requires more inference processes" (McNamara & Kintsch, 1996). **The gaps made knowledgeable readers do the joining.**

> 🔑 **Key Concept:**
>
> **An inference is a gap you fill in yourself**, using what you already know. A text that says "She grabbed an umbrella" leaves you to infer that rain was on the way. Every text leaves some gaps, and filling them is part of understanding.

A walk with a signpost at every corner is easy, and you may forget the way by morning. A walk where you check the map at each turn takes more effort, and **you come away knowing the town**. The gaps only

help if you know enough to fill them, so a beginner does best with the signposted text first.

Linked text or text with gaps

	Fully linked text	Low-coherence text
Who it suits	A beginner	High-knowledge readers
What it asks	Little joining	More inference processes

Fast reading is a popular shortcut with a limit of its own. Rayner and colleagues looked at how reading works and found "there is a trade-off between speed and accuracy" (Rayner et al., 2016). A trade-off is a swap, where you get more of one thing by giving up some of another. **Going faster costs understanding.**

A trade-off

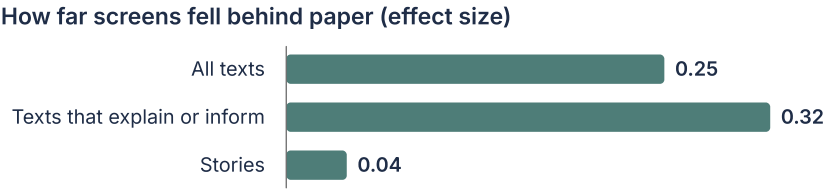


> **Science Says:**
> The same team judged it unlikely that readers could double or triple their speed, from around 250 to 500 or 750 words a minute, and still understand the text equally well. **Their route to faster reading was more reading.** The way to read faster and keep understanding high, they wrote, is "to practice reading and to become a more skilled language user (e.g., through increased vocabulary)" (Rayner et al., 2016).

Speed comes from knowing more words and more about the world, and the cricket fan shows how. **She reads match reports fast because almost nothing in them is new to her.** Her eyes are no quicker than her friend's. Her store of knowledge does the work, so each sentence joins on at once.

Where you read makes a small difference. A review pooling studies with 171,055 participants found paper gave slightly better understanding than screens, with an effect size of -0.21 (Delgado et al., 2018). **The minus sign shows screens came out a little behind.** The gap did not show up for texts that were only stories.

> Science Says:
>
> Clinton's review found the same small lead for paper, with an effect size of -0.25 (Clinton, 2019). **For texts that explain or inform, the effect size was -0.32**, and for stories it was -0.04, close to nothing. Readers on paper were "better calibrated", which means their sense of how well they had understood sat closer to the truth.



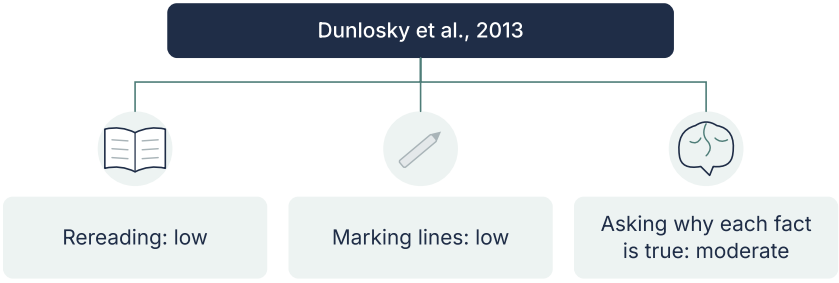
Being well calibrated is worth more than it sounds. If your sense of knowing runs ahead of the truth, you put the book down before the page has stuck. **A true sense of what you know tells you when to keep going**, and when you can safely stop.

The lesson from both reviews is modest. **For a text you need to learn from, choose paper when you can.** Screens are fine for a story or a quick look. Both reviews found only a small lead for paper.

Most people study by reading the text again. The review that gave self-explanation a middle mark (see 3.2.1) rated **rereading low** (Dunlosky et al., 2013), along with summaries, marking lines with a bright pen and two picture-based memory tricks. Of rereading and marking lines, the authors wrote that they "do not consistently boost students' performance".

The review gave a better mark to a method you can use while reading. Elaborative interrogation means **asking yourself why each fact is true**, and it received a moderate mark (Dunlosky et al., 2013). The authors added that the moderate methods "have not been adequately evaluated in educational contexts", meaning they still need more testing in real classrooms.

Study methods rated



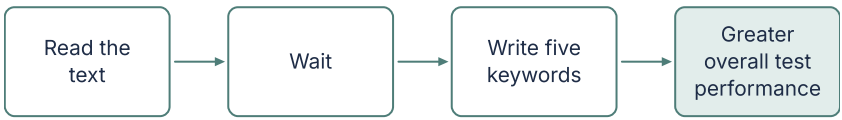


A student sits with her book shut, chin on one hand, working out the reason behind what she just read.

Asking why works on the same idea as Kintsch's model. Each answer ties a new fact to something you already know, and **every tie adds a street to your map**. A fact with a reason attached has a neighbour, and a fact with no reason stands alone on the page.

Checking yourself after reading works best with a short wait. Thiede and colleagues had readers write "a list of 5 keywords that captured the essence of each text". **"Accuracy was greater for a group that wrote keywords after a delay"** (Thiede et al., 2003). Accuracy here means how well readers judged which texts they knew and which they did not.

Five words later



The better judging paid off on the test. The delayed-keyword group got "greater overall test performance (reading comprehension)" (Thiede et

al., 2003). The paper's title puts the link plainly, "Accuracy of metacognitive monitoring affects learning of texts". **Waiting before you check gives you a truer picture** of what has stuck, because straight after reading everything still feels fresh.

> **Exercise: Five words later**
>
> *1. Spend five minutes with an easy overview of the topic.*
>
> *2. Read one section, on paper if you can, asking why after each paragraph.*
>
> *3. Put it away until later in the day.*
>
> *4. With the book shut, write five keywords that sum up the section.*
>
> *5. Answer two why questions from memory, then reread only the parts you missed.*

Back on the park bench, the friend who knows nothing about cricket reads perfectly well. **What she lacks is a store to join onto.** Ten minutes with a beginner's guide would give the next match report somewhere to land, and asking why each turn of the match happened would tie the pieces together.

Back on the park bench



What she lacks is a store to join onto



Ten minutes with a beginner's guide



Asking why each turn of the match happened

The fan has her own lesson to take from the bench. On a topic she knows well, **a page with gaps can teach her more**, because filling

them makes her do the joining. On a topic she knows nothing about, she would do best to start, like her friend, with the signposts.

Key idea:

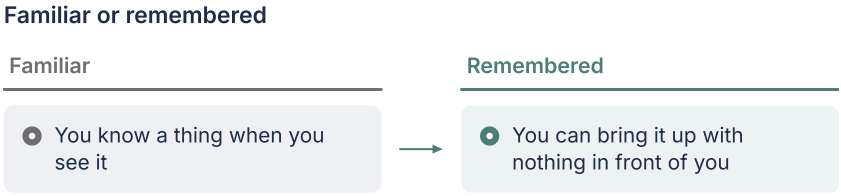
You understand a page when it joins what you already know, so build the knowledge first and check yourself after a wait.

Quick check:

In the study by Recht and Leslie, what helped pupils on every measure, being a good reader or knowing about baseball? Answer: knowing about baseball, and it helped good and poor readers alike.

4.1.2 Remembering, Explaining and Teaching What You Learn

Sam is learning the road signs for her driving theory test. Each evening she turns the pages of signs in her book, and each looks more familiar than the night before. At the practice test, a red triangle with a picture in it stares back, and its name will not come. **Seeing the signs again had felt like learning them.**



Familiar and remembered are two different states. Familiar means you know a thing when you see it. Remembered means you can bring it up with nothing in front of you. **The test asked for the second, and Sam had trained only the first.** Her evenings with the book had built a feeling of knowing and very little recall.



A theory-test book lies open on a table, the name under each road sign hidden by a strip of card.

> 🗝 **Key Concept:**
>
> **Retrieval practice means pulling something out of your memory on purpose**, with nothing to look at. Covering the names and saying them, writing what you recall on a blank page and answering questions from memory all count. Looking at the page again does not count, however carefully you look.

Finding your way home works the same way. Follow a map every day and the route stays on the map. Walk it once without the map, take a wrong turn and put it right, and **the route starts to live in your own head**. Each trip from memory makes the next one easier to find.

Retrieval practice



Pooled studies back this up. Rowland's review found "initial recall tests yielding larger testing benefits than recognition tests" (Rowland, 2014). Recall means bringing the answer up from nothing, and recognition means picking it from a list. **The harder kind of test helped more.** Picking the right sign from four options is easier than naming it, and it teaches less.

Two kinds of test

	Recall	Recognition
What you do	Bring the answer up from nothing	Pick it from a list
Testing benefit	Larger	Smaller

> **Science Says:**
>
> Adesope and colleagues pooled studies of practice tests and found "practice tests are more beneficial for learning than restudying and all other comparison conditions" (Adesope et al., 2017). Restudying means reading the material again, the method Sam had used each evening. **Testing yourself beat every other study method set against it** in their review.

Even a more active kind of studying lost to recall. Karpicke and Blunt compared retrieval practice with building concept maps, diagrams of ideas joined by lines. They found "practicing retrieval produces greater gains in meaningful learning than elaborative studying with concept mapping" (Karpicke & Blunt, 2011). **Recall won even when the final test asked students to draw concept maps.**

The last result surprises most people. Students who had spent their time drawing maps were beaten at drawing maps by students who had spent their time recalling. **Practising the test format counted for less than practising recall.** A map drawn with the book open is a copy, and a page written from memory is your own.

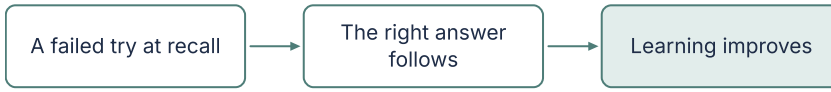
Making the answer yourself has its own name. Slamecka and Graf ran "Five experiments" in which people either read material or generated it themselves, and "performance in the generate condition was superior to that in the read condition" (Slamecka & Graf, 1978). **Making an answer beats reading it.** Researchers call this the generation effect.

> Science Says:
>
> Bertsch and colleagues pooled "445 effect sizes over 86 studies". "The size of the generation effect across the 86 studies was .40", which they called "almost half a standard deviation" (Bertsch et al., 2007). A standard deviation is the usual spread of scores around the average. **Generating an answer moved people almost halfway along that spread.**

Making an answer helps even when the answer you make is wrong. Kornell, Hays and Bjork found that failed tries at recall still improved learning, with both kinds of material they used (Kornell et al., 2009).

The help came when the right answer followed the failed try. **A wrong guess followed by the answer teaches more than the answer alone.**

A wrong guess that teaches



They concluded that taking hard tests, even ones you get wrong, may be one key to learning well (Kornell et al., 2009). **Getting it wrong first is part of the method.** Sam's blank moment at the practice test was useful, provided she looked up the name straight after and tried again later. The blank was the start of the learning.

When you recall counts as much as whether you recall. Kang reviewed the work and wrote that "Hundreds of studies ... have demonstrated that spacing out repeated encounters with the material over time produces superior long-term learning" (Kang, 2016). **Spreading sessions out beats cramming them together.** Spacing means coming back to the same material after a gap.

Kang found spacing helped "memory, problem solving, and generalization to new situations", and that "incorporating tests into spaced practice amplifies the benefits" (Kang, 2016). Generalisation means using what you learned somewhere new. **Recall and spacing work best together**, so each time you come back after a gap, test yourself first and reread second.

Paint on a wall gives a fair picture of spacing. Three thin coats on three days hold better than one thick coat slapped on at once, because each coat sets before the next goes on. **A gap lets each session set.** Cramming is the thick coat that looks finished on the night and runs by the morning.



Mixing topics in one session is a close cousin of spacing. Kornell and Bjork had people learn the styles of different painters from examples, and mixed examples beat examples grouped by painter, since "induction profited from spacing" (Kornell & Bjork, 2008). Induction means **working out a general rule from examples**.

> 🔑 **Key Concept:**
>
> **Interleaving means mixing different topics or types within one session**, such as paintings by several artists in one shuffled pile. Spacing leaves gaps between sessions on the same material, across days. Interleaving works inside a single sitting. Both feel harder than doing one thing in one long block.

> 🧪 **Science Says:**
>
> Learners did not trust the result. "Participants rated massing as more effective than spacing, even after their own test performance had demonstrated the opposite" (Kornell & Bjork, 2008). Massing here means seeing all of one painter's works in a row. **The method that felt easier taught less**, and people kept believing in it after their own scores showed otherwise.

Mixing helps some kinds of learning more than others. Brunmair and Richter pooled the studies and found "stronger interleaving effects for

learning material more similar between categories" (Brunmair & Richter, 2019). **Mixing helps most when the things you learn look alike**, such as two painters with similar styles or two road signs with similar shapes.

Spacing and interleaving

Spacing	Interleaving
Gaps between sessions on the same material, across days	Mixing different topics or types inside a single sitting

Their review carried a warning with it. They urged care with interleaving, "especially for expository texts and words" (Brunmair & Richter, 2019). Expository texts are ones that explain or inform. **For a textbook chapter or a list of new words, mixing may help less**, so keep it for telling look-alikes apart.

Sam's road signs suit mixing well. Many warning triangles look alike, with only the small picture inside telling them apart. **Mixing them forces her to spot the difference** each time, where a page of triangles in a row lets her coast from one to the next.



Six red warning triangles stand in a row, each with a different small picture inside.

Explaining to someone else is the last step, and it starts before you open the book. Nestojko and colleagues told some learners they would later teach what they read. In the end, "no one actually engaged in teaching" (Nestojko et al., 2014). **Just expecting to teach changed how people learned.**

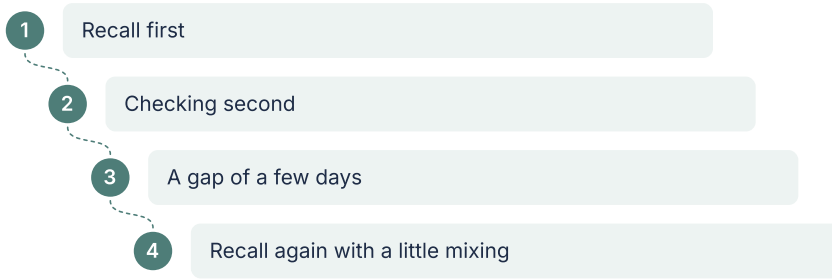


"Participants expecting to teach produced more complete and better organized free recall" (Nestojko et al., 2014). Free recall means writing down all you remember, in any order. They got more questions right, "particularly questions covering main points". The main points are what a teacher has to get across first. **Planning to teach made recall fuller and better organised.**

A tour guide learns a town differently from a tourist. The tourist looks at whatever is in front of her. The guide asks what someone new will need to know first, and **the main points rise to the top**. Telling yourself you will teach a topic puts you in the guide's shoes before you start.

Expecting to teach costs nothing. Before you open a book, tell yourself you will explain it to a friend at the weekend. **Then keep the promise, from memory**, and the teaching becomes one more round of recall, spaced a few days after the first.

The order of the work



> **Exercise: The blank page**
>
> *1. Before you study, decide who you will explain the topic to.*
>
> *2. Study for twenty minutes, then close everything.*
>
> *3. On a blank page, write all you can recall.*
>
> *4. Check against the source and mark what you missed.*
>
> *5. Two days later, do it again, mixing in an older topic that looks similar.*
>
> *6. At the weekend, explain it to your chosen person from memory.*

Back at her book, Sam covers the names with a strip of card and says each one aloud before she looks. She does ten signs on Monday and ten on Wednesday, and mixes the triangles in with the circles. **Every sign she misses comes with the answer straight after**, which is the kind of mistake that helps.

A strip of card, a blank page and a wall calendar are all the kit this needs. **What changes is the order of the work**, with recall first and checking

second, a gap of a few days, and then recall again with a little mixing. Teaching it to a friend at the end adds one more round.

Key idea:

Lasting learning = Recall + Spacing. Pull it out of your memory, spread the sessions over days, and learn it as if you will teach it.

Quick check:

Which helped more in Rowland's review, recall tests or recognition tests?
Answer: recall tests, where you bring the answer up from nothing.

4.2 Practising Effectively

4.2.1 Challenge, Feedback and the Quality of Practice

Your aunt Mira has baked a loaf every Sunday for twenty years. Each comes out the same, dense in the middle. Her daughter started last year at a weekly class, where the teacher cuts open each loaf and names one thing to change. **Twenty years gave Mira experience, and one year of comments gave her daughter skill.**

Mira's loaves fit a pattern Ericsson found among experts. Across fields, he reported "only a weak relationship" between experience or reputation and "actual, observed performance" (Ericsson, 2008). **Years on the job and real skill are only loosely tied.** For Mira, doing the same thing every week kept her at the level she reached in her first few months.

Experience and skill

E2

Ericsson, 2008

- Only a weak relationship between experience and actual, observed performance
- Years on the job and real skill are only loosely tied

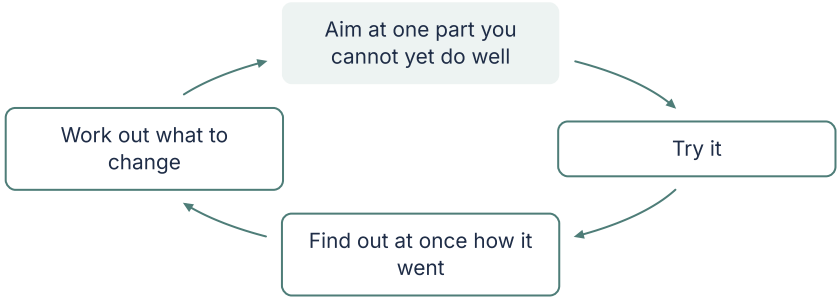


Two loaves sit side by side on a wooden board, one tall and open-crumbed, the other low and heavy.

Ericsson's name for the kind of practice that does build skill is deliberate practice. It "is focused on improving particular tasks", and it "involves the provision of immediate feedback, time for problem-solving and evaluation, and opportunities for repeated performance to refine behavior" (Ericsson, 2008). **Quality practice aims at a target and checks every try.**

> 🗝 **Key Concept:**
>
> **Quality practice aims at one part of a skill you cannot yet do well.** You try it, find out at once how it went, take time to work out what to change, and try again. Mira's daughter does this when she changes only the shaping and checks the crumb. Mira's Sunday bake has none of these parts.

Quality practice



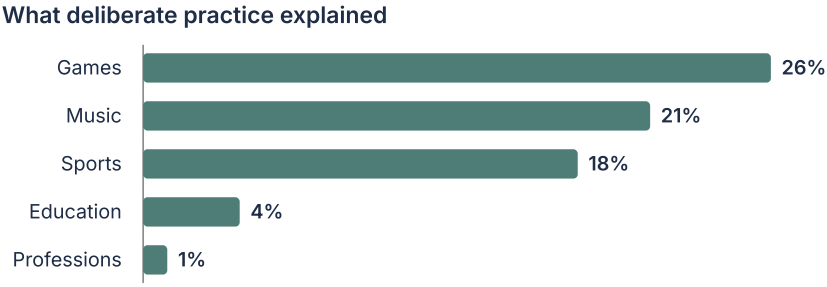
Driving to work every day for ten years makes you a smooth commuter and no better at parking in a tight space. **Practice improves what it aims at**, and an easy routine aims at nothing new. Mira's Sunday loaf is her commute, pleasant and familiar, and it never asks her to try the hard part again.

Picking the target is the first job. Break a skill into its parts and find the one that lets you down most often. For a baker that might be shaping, and for a speaker it might be the first minute. **A small, named weak spot gives practice something to aim at**, where "get better at baking" gives it nothing.

The 1993 paper that launched the idea made a big claim. Characteristics "once believed to reflect innate talent are actually the result of intense practice extended for a minimum of 10 years"

(Ericsson et al., 1993). Innate means present from birth. **Their claim was that years of hard practice explain what people call talent.**

The idea later spread as a popular "10,000-hour rule", with practice as the whole story. **That version is wrong.** A large review found deliberate practice explained 26% of the differences in performance in games, 21% in music, 18% in sports, 4% in education and under 1% in professions (Macnamara et al., 2014). Most differences came from other things.



> **Science Says:**
>
> A review of practice in sport found it explained "only 1% of the variance in performance among elite-level performers" (Macnamara et al., 2016). Variance here means the differences between people. **Among the very best athletes, hours of practice told them apart by almost nothing.** High-skill athletes "did not begin their sport earlier in childhood" either, so a late start did not hold the best ones back.

Ericsson's and Macnamara's findings disagree, and the dispute is still live. Ericsson found plain experience barely tracked skill, and he argued that deliberate practice is what builds it. Macnamara measured deliberate practice itself and found it explained little among elite

athletes. **Both sides agree only that hours alone decide less than the popular rule promised.**



Two bakers stand at neighbouring counters for the same hour, one repeating a single fold again and again.

What you do inside the hours is the part you can change. Two people who each bake for an hour a week can end up far apart, depending on what they do with that hour.

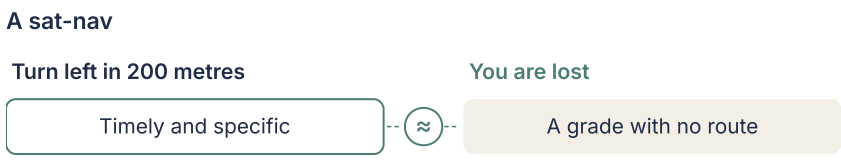
Feedback is the part Mira's Sunday bake was missing. Wisniewski and colleagues pooled "435 studies" and found "a medium effect (d = 0.48)" for feedback on learning (Wisniewski et al., 2020). The d is a kind of effect size. **On average, feedback helps by a fair amount**, enough to notice in a classroom.

> **Science Says:**
>
> The same review warned that "feedback cannot be understood as a single consistent form of treatment" (Wisniewski et al., 2020). **Feedback comes in many kinds, and they do not all work alike.** It had a "higher impact on cognitive and motor skills outcomes than on motivational and behavioral outcomes", meaning it helped skills of mind and body more than drive or habits.

Shute's review gathered what researchers advise. According to them, "formative feedback should be nonevaluative, supportive, timely, and specific" (Shute, 2008). Formative feedback is feedback given while you are still learning, as opposed to a final mark at the end. Nonevaluative means it describes the work and gives no grade. **Good feedback describes the work and comes fast.**



A sat-nav shows what that looks like. "Turn left in 200 metres" is timely and specific, and you can act on it at once. A screen that only said "You are lost" would be a grade with no route. **Feedback earns its keep when you can act on it at the next try.**



Outside a class, you can build your own feedback. Record yourself and listen back, compare your work with a good example, or count something you can measure, like the height of the loaf. **Any source that tells you quickly and precisely what happened will do.** The quicker it comes, the easier it is to link to what you just did.

Setting how hard practice should be is the trickiest part of designing it. Kapur gave groups of eleventh-grade physics students ill-structured problems, and they "struggled", with "poor quality of solutions", yet "outperformed their counterparts ... on individual near- and far-transfer measures subsequently" (Kapur, 2008). **Struggling first paid off later.** Kapur called this productive failure.

Kapur's was one study, in one subject, with students working in groups, so it is a hint and no rule. **Productive failure means wrestling with a hard problem before you have the method**, then getting more from the teaching that follows. A hungry diner notices every detail of the meal in the same way.

A big review pulls the other way. Kirschner, Sweller and Clark concluded that "minimally guided instruction is less effective and less efficient" (Kirschner et al., 2006). Minimally guided means learners work things out mostly alone. **Beginners learn more when someone shows them the way**, with worked steps and clear instructions.

The findings meet in one line. "The advantage of guidance begins to recede only when learners have sufficiently high prior knowledge" (Kirschner et al., 2006). **Guidance helps most at the start and less as**

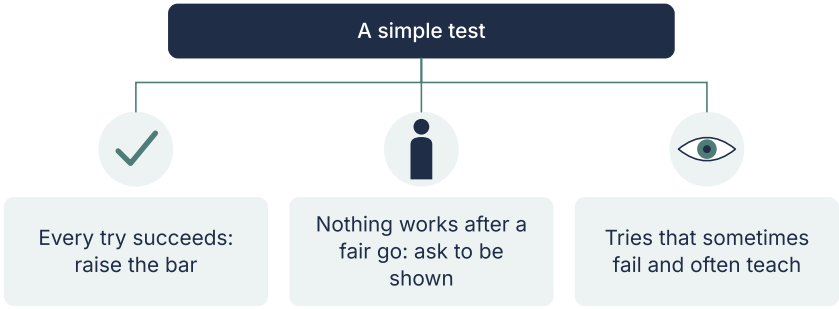
you know more. My reading of both is to get shown how while the basics are new, and to try hard problems alone later.

When guidance helps



A simple test tells you where you stand. If every try succeeds, raise the bar, because the practice has stopped stretching you. If nothing works after a fair go, ask to be shown, because you are still a beginner at this part. **Aim for tries that sometimes fail and often teach.**

Where you stand



> **Key Concept:**
> Soderstrom and Bjork found that "improvements in performance can fail to yield significant learning", and that "certain manipulations can have opposite effects on learning and performance" (Soderstrom & Bjork, 2015). Performance is how well you do while practising, and learning is what lasts. **Doing well in practice and learning a lot can come apart.**

Practice can fool you, then, about how much you are gaining. The same researchers warned that "people often mistakenly interpret their performance during acquisition as a reliable guide to long-term learning" (Soderstrom & Bjork, 2015). Acquisition means the time when you are first learning. **A smooth session is no proof of progress.**

Performance and learning

Performance	Learning
How well you do while practising	→ What lasts

Mira's Sundays are smooth performance. Every bake goes well and nothing changes. **Her daughter's loaves go wrong more often**, because she keeps changing one thing at a time, and each failure tells her what to try next. Her bad Sundays are where her skill is being built, and she has the notebook to prove which change did what.

For Mira, a hard case would be a wetter dough, or a loaf shaped by hand with no tin to hold it. **Each is one step past what she can already do.** If the first try slumps, she will know what to ask her daughter about, and she will listen to the answer more closely for having tried.

> **Exercise: One weak spot**
>
> *1. Name one part of a skill you do badly.*
>
> *2. Find quick, specific feedback, such as a recording or a measure.*
>
> *3. New skill, get shown how first. Known basics, try a hard case alone first.*
>
> *4. Practise only that part for fifteen minutes, checking each try.*

> *5. Change one thing at a time and note what you changed.*

In the end Mira let her daughter cut open her next loaf. The daughter pointed at the dense middle and told her to give the dough longer to rise and nothing else. **One comment, acted on the next Sunday, did more than a year of Sundays alone.** Mira has a target now, and the loaf has started to change.

Nothing about the class was magic. It gave her daughter a named weak spot each week and a teacher who said at once what had gone wrong. **Any learner can set that up at home**, with a notebook to name the weak spot and a ruler to check how high each loaf has risen. The next Sunday supplies the repeat.

Key idea:

Better practice = Focus + Feedback + Repeats, aimed at one weak spot and pitched a little beyond what you can do now.

Quick check:

In the review by Kirschner and colleagues, when does the advantage of guidance begin to fade? Answer: when learners have enough prior knowledge.

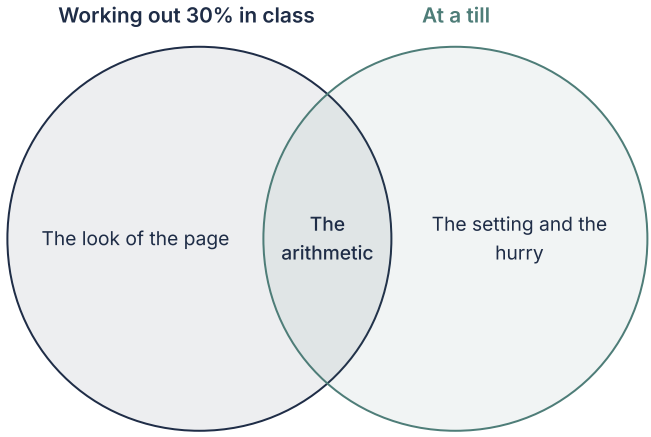
4.2.2 Taking a Skill Beyond the Original Exercise

Ana got top marks for percentages at school. On Saturday a shop window said "30% off everything, and a further 20% off at the till", and she told her sister the coat would be half price. At the till it came to a little more than half. **She had the skill, and the window looked nothing like a maths lesson.**

A skill that stays at home has a long history in research. Section 1.2.2 introduced transfer, with Thorndike and Woodworth's early limits. Their paper put the finding plainly, "spread of practice occurs only where identical elements are concerned" (Thorndike & Woodworth, 1901). **A skill spreads to a new task only as far as the two tasks share parts.**

> Key Concept:
>
> **Identical elements are the parts two tasks have in common.** Working out 30% of a number in class and at a till share the arithmetic. They do not share the look of the page, the setting or the hurry. In Thorndike and Woodworth's view, only the shared parts carry over to the new task.

Identical elements



The same paper went further. “Improvement in any single mental function rarely brings about equal involvement in any other function, no matter how similar” (Thorndike & Woodworth, 1901). “Equal involvement” is the reprint’s wording, and it most likely means equal improvement. **Even similar tasks gained less than the trained one.**

A key works the same way. It opens every lock whose pins match its teeth, however different the doors look, and no lock whose pins differ, however alike the doors. **What travels is the shape underneath**, and a lesson that hides the shape under the look of a worksheet leaves the learner holding a key with no door.

A key



Opens every lock whose pins match its teeth



No lock whose pins differ



What travels is the shape underneath



A ring of keys hangs on a hook beside three very different front doors.

A century later the picture is more mixed. S. M. Barnett and Ceci concluded that "evidence for transfer under some conditions is substantial, but critical conditions for many key questions are untested" (S. M. Barnett & Ceci, 2002). **Transfer is real under some conditions, and many of those conditions are still untested.** Part of the puzzle is solved and much is open.

Researchers still argue about it. Day and Goldstone called transfer "among the most challenging, contentious, and important issues for both psychology and education" (Day & Goldstone, 2012). Contentious means argued over. **After more than a hundred years, transfer remains an open problem.** Ana's coat sits right in the middle of it.

Part of the argument is about what counts as transfer. Bransford and Schwartz contrasted the "traditional" view "with an alternative that emphasizes the ability to learn during transfer" (Bransford & Schwartz, 1999). **Transfer can mean learning the next thing faster**, even when the old skill does not solve the new task on its own.

> Key Concept:
>
> **Preparation for future learning means an old skill makes a new one quicker to pick up.** The old skill may solve nothing in the new task on day one. Its value shows in how fast you learn once you start. A test that only asks you to solve the new task at once will miss it.

Two views of transfer





	Traditional view	Alternative view
Asks	Solve the new task at once	Learn the next thing faster
Spanish speaker in Rome	No transfer	Transfer

A woman who learned Spanish at school might not understand a word of Italian on her first day in Rome. She might still pick up Italian faster than a friend with no second language, because she knows how to learn one. **On the traditional view that is no transfer, and on the alternative view it is.**

Ana's coat fits both views. On the old view, her school rule should have fired at the till, and it failed. On the new view, the rule should make the till sum quick to learn, and it did, once she sat down with a pencil. **What she lacked was a way to spot the rule in a new setting.**

Comparing cases helps a skill travel. Section 3.1.2 told how a hint helped Gick and Holyoak's people carry a story to a new problem. Their 1983 paper added that the "quality of the induced schema was

highly predictive of subsequent transfer performance" (Gick & Holyoak, 1983). **The better the outline drawn from two cases, the better the new problem went.**

> **Science Says:**
>
> Gick and Holyoak tried ways to help people who had only one story to learn from. None of these tricks had much success, they reported (Gick & Holyoak, 1983). **Tricks built round a single example did little.** Comparing two examples with the same solution was what built a useful schema.

Two cases work like two photographs of the same friend in different clothes. Side by side, you see the face and stop noticing the clothes. **Comparing strips away the surface and leaves the shape**, and the shape is what you will need when the third case turns up looking different again.

Comparing two cases



Ana could do the same with discounts. One case is a coat with two discounts, and a second is a train fare with a railcard and then a group saving. **Side by side, both show a saving taken from a price that has already dropped.** The outline she draws from the pair is the rule she needed at the till.

Testing yourself helps a skill travel. Butler's final tests, one week later, included "new inferential questions from different knowledge domains", and "Repeated testing produced superior retention and

transfer" (Butler, 2010). An inferential question asks you to work out something the material never said outright. **Recall practice helped people use what they learned in new ways.**

For Ana, a plain recall question asks what 30% of 50 is. An inferential question asks what the coat costs after both discounts, which her lesson never covered. **The second kind of question is the shop window**, and a test full of them asks the skill to leave home.



> Science Says:
>
> Pan and Rickard pooled "192 transfer effect sizes" with "N = 10,382" learners and found an average of "d = 0.40" for transfer from testing (Pan & Rickard, 2018). After checks for bias, their results were "often indicating no positive transfer when none of the aforementioned moderators are present". Moderators are conditions that change the size of an effect. **Without the right conditions, testing often did not transfer.**

My reading of Pan and Rickard is a warning against easy hope. **Transfer has to be built on purpose.** Testing helps a skill travel when the practice already reaches a little way towards the place you want it to go, and on its own it may carry the skill no further than the test.

Music lessons for children carry a popular hope that one skill lifts many others. Sala and Gobet pooled "N = 6,984, k = 254", where k counts results, and found that "Once the quality of study design is controlled

for, the overall effect of music training programs is null" (Sala & Gobet, 2020). **Better studies found no gain beyond music.**



A row of young children in a school music room hold small violins under their chins.

Small effects showed up only in studies with "no random allocation" and "non-active controls" (Sala & Gobet, 2020). Random allocation means splitting children into groups by chance. A non-active control group does nothing new while the others learn music. **Only the weaker designs found any gain**, and the stronger designs found none.

None of this makes music lessons a waste. Children who learn the piano learn to play the piano, which is the point of the lessons. **A skill is worth learning for what it does**, and any extra gains have to be shown in good studies, never assumed from a hopeful story.

Music training studies



Putting the findings together gives a short method. Practise the skill in more than one setting, so the shared parts stand out, and compare two cases to say what they have in common. Test yourself with questions that ask you to use the skill somewhere new. **Name the rule underneath**, in words you could say to a friend.

One skill, many places



A travel adaptor is a good picture of what the method builds. The plug stays the same, and the adaptor gives it a shape that fits the wall in a new country. **Naming the rule and comparing cases make the adaptor** that lets your skill plug into a task it was never taught for.

> **Exercise: One skill, three places**

> *1. Pick one skill you learned recently, such as working out percentages.*
>
> *2. Write the rule underneath in one sentence.*
>
> *3. Find three places it could apply, such as a sale, a recipe and a pay rise.*
>
> *4. Solve one real case in each place.*
>
> *5. Compare the three cases and note what they share.*

Ana worked it out at home afterwards. 30% off leaves 70% of the price, and a further 20% off leaves 80% of that 70%, which is 56%. **Each discount takes its share of what is left.** Her school rule fitted once she saw the shared part, and she now checks every double discount the same way.

Each discount takes its share



A month later her sister asked about a pay rise of 3% a year for two years. Ana saw the same shape at once, two changes with each one

working on the result of the last. **The rule had found its third place**, and this time no one had to show her the way.

Key idea:

A skill travels when you practise it in more than one setting, compare cases and name the rule underneath.

Quick check:

In Gick and Holyoak's 1983 paper, what predicted how well people solved a new problem? Answer: the quality of the schema they built from the cases.

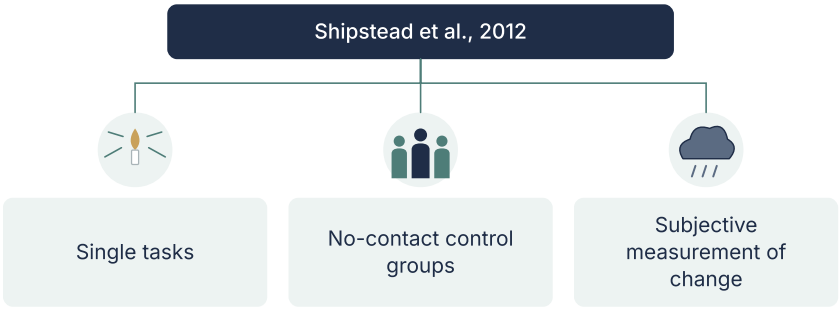
4.2.3 What Brain Training Can and Cannot Establish

Mia plays a brain-training app for ten minutes each morning with her coffee. After two months her score in the app has doubled, and she says she feels sharper at work. The app's home screen shows a line climbing steeply up the chart. **Her score has doubled, and the score measures one thing, how well she does the app's tasks.**

A rising score is real progress at something, and the work is in naming the something. Shipstead, Redick and Engle listed weak spots in working-memory training studies, including "single tasks", "no-contact control groups" and "subjective measurement of change" (Shipstead et al., 2012). **A gain on one task may be nothing more than skill at that task.**

Each weak spot has a plain meaning. A single task means the gain was measured with one test, and a no-contact control group is a comparison group that did nothing at all. Subjective measurement means asking people whether they feel better. **Mia's sense of feeling sharper is the third kind**, and it is the easiest to fool.

Weak spots in training studies

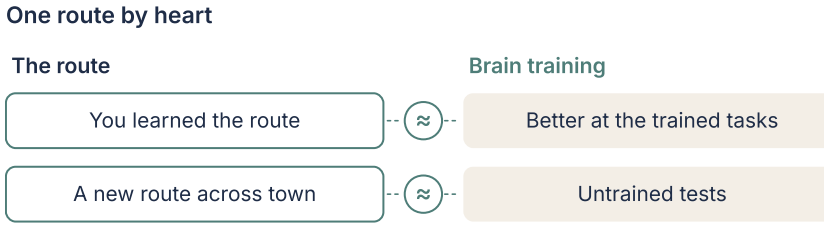


The authors concluded that "there is a need to directly demonstrate that WM capacity increases in response to training" (Shipstead et al., 2012). WM is short for working memory. **The proof has to come from tests the person never practised**, because practised tests only show the practice. A score in the app can never settle the question.



A commuter drives a familiar road on autopilot, then frowns at an unfamiliar junction on the far side of town.

Knowing one route to work by heart shows how. You can drive it half asleep, knowing where each pothole lies. **Put you on a new route across town and the skill is gone**, because you learned the route and never learned to read maps. Brain training can work like that route.



Melby-Lervåg and Hulme's review of the training studies found the same pattern, "short-term, specific training effects that do not generalize" (Melby-Lervåg & Hulme, 2013). **The gains stayed with the trained tasks and did not last.** Short-term means they faded, and specific means they belonged to the tasks people had practised.

> 🗝 **Key Concept:**
>
> **An n-back task asks whether each item in a stream matches the one a set number of steps back.** In 2-back, you compare each letter with the letter two before it. Holding and updating the stream loads working memory hard. Jaeggi and colleagues trained working memory with the aim of "improving fluid intelligence" (Jaeggi et al., 2008). Au and colleagues pooled "20 studies" of n-back training (Au et al., 2015).

Redick and colleagues trained people on working memory and found "no positive transfer to any of the cognitive ability tests" (Redick et al., 2013). Their title says it plainly, "No evidence of intelligence

improvement after working memory training". **The trained skill did not spread to intelligence tests.**

The hope goes back to a 2008 paper, "Improving fluid intelligence with training on working memory" (Jaeggi et al., 2008). Fluid intelligence, or Gf, is the ability to reason through new problems. A review of "20 studies" found "a small but significant positive effect of n-back training on improving Gf" (Au et al., 2015). **One review found a small gain.**

Au's finding is disputed. Redick's trial found no gain on intelligence tests, and a review of reviews, described below, found far transfer came to zero once placebo effects were removed. **Au's small effect is one review against several others.** The claim that n-back training raises IQ has not been shown.

Expectation alone can produce a gain. Foroughi and colleagues found that people who answered "a suggestive flyer showed improvements after a single, 1-h session of cognitive training that equates to a 5- to 10-point increase on a standard IQ test" (Foroughi et al., 2016). **One hour and a hopeful advert matched a big IQ jump.**

People who answered "a nonsuggestive flyer showed no improvement" (Foroughi et al., 2016). The training and the hour were the same, and the only difference was what the flyer led people to expect. **The gain came from hope.** That is a placebo effect, and any training study has to rule it out.

Two flyers

	Suggestive flyer	Nonsuggestive flyer
Training	One hour	One hour
Gain	5- to 10-point increase	No improvement

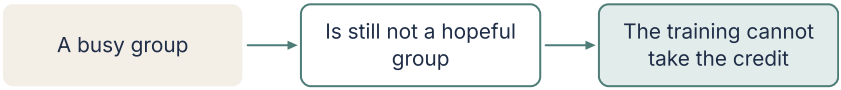
> **Key Concept:**
>
> **A placebo effect is a gain that comes from expecting to improve**, with nothing in the treatment causing it. The word comes from medicine, where a dummy pill is given to see how much of a drug's effect comes from belief. A training study has to rule it out before it can credit the training.

The usual fix is an active control group, a comparison group that does a different activity, so both groups are busy. Boot and colleagues showed why that falls short. **A busy group is still not a hopeful group**, and unless both groups expect the same gain, the training cannot take the credit.

> **Science Says:**
>
> Boot and colleagues wrote that "only when the active control group has the same expectation of improvement as the experimental group can we attribute differential improvements" to the training. The experimental group is the one that trained. They added that "almost no psychological interventions do so" (Boot et al., 2013). **Matching the hopes of both groups is rare.**

Taking placebo and publication bias out gave the strictest answer. Publication bias means studies with exciting results are more likely to be printed, so the printed record looks rosier than the truth. Sala and colleagues ran a second-order meta-analysis, a review that pools earlier reviews. **Far transfer from training came to nothing.**

Why an active control falls short



Their words were that "when placebo effects and publication bias were controlled for, the overall effect size and true variance equaled zero" (Sala et al., 2019). True variance zero means the studies differed no more than chance alone would make them. **No hidden group of programmes worked where the rest failed.**

The strictest answer





A tall stack of printed studies sits on a desk, with a single page on top showing a flat line at zero.

Video games give a more mixed picture. Bediou and colleagues pooled studies of action video games. Training studies showed an effect size of 0.34, which the team called "a smaller average effect", and they concluded the games improve top-down attention, the aiming of attention on purpose, and spatial skills (Bediou et al., 2018). **Their review found a gain.**

> Science Says:
>
> Bediou's team estimated published effects to be "30% larger than in the full literature", the whole body of studies (Bediou et al., 2018). Their larger figure, an effect size of 0.55, came from a cross-sectional comparison of regular gamers with non-gamers at one point in time. **That comparison shows only that gaming and these skills go together.** It cannot show the games caused the difference.

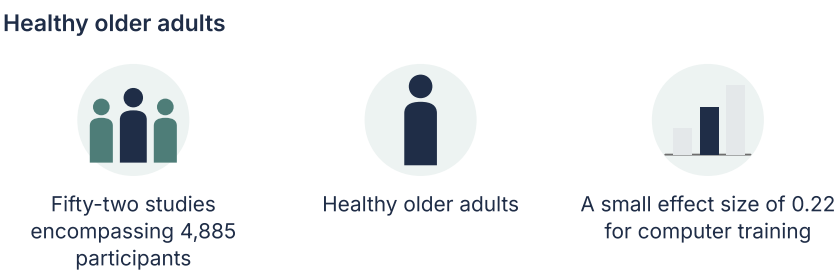
Sala, Tatlidil and Gobet reached the opposite view. Across video game training studies, they found no evidence that playing video games causes a gain in general mental ability (Sala et al., 2018). **The two reviews disagree**, and the dispute is still open. For now, a gamer's quick eye is no proof that gaming made her cleverer.

Chess lessons in schools tell a similar story. Sala and Gobet pooled "24 studies (40 effect sizes)" and found a moderate effect size of 0.338 on school and mental skills. Yet "no study used an 'ideal design'" (Sala & Gobet, 2016). **The effect looked moderate, and no study was built to pin it on the chess.**

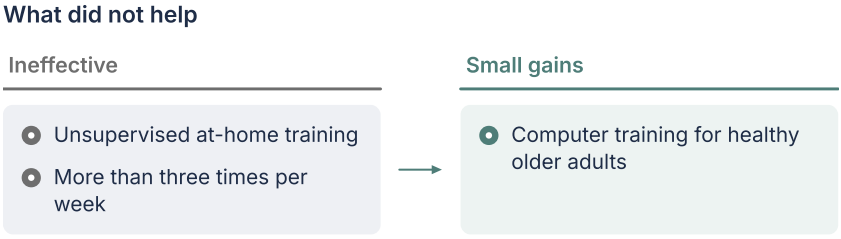
An ideal design includes a fair comparison group, so any gain can be pinned on the training. Without one, children who chose chess club may simply differ from those who did not. **A moderate effect from**

weak designs is a reason to run better studies, and no reason yet to sign a child up for the sake of maths.

Older adults are a separate case, and the next findings apply to them only. Lampit and colleagues pooled "Fifty-two studies encompassing 4,885 participants", all healthy older adults, and found a small effect size of 0.22 for computer training (Lampit et al., 2014). **For healthy older adults, computer training gave small gains on some tests.**



The same review found no clear effects on executive functions, the skills of planning and keeping yourself on track, or on attention. It added that "Unsupervised at-home training and training more than three times per week are specifically ineffective" (Lampit et al., 2014). **Training alone at home, or very often, did not help these older adults.**



Putting all this together, brain training can establish one thing well. **Practice on a task makes you better at that task.** Claims beyond it, such as a lift in intelligence or school results, need tests the person never trained on and a comparison group with the same hopes.

> **Exercise: Four checks for a training claim**
>
> *1. Find what people were tested on, and see whether it differs from what they trained on.*
>
> *2. Look for a comparison group that expected to improve as much.*
>
> *3. Note who took part, such as healthy older adults or students.*
>
> *4. Look for a review of many studies, and see whether the gain survives in the better-designed ones.*

Mia's doubled score is real, and it tells her she has got good at the app. **If she wants to be sharper at work, the surest practice is the work itself**, the reports she wants to write better, with feedback on each one. The app can stay as a pleasant habit with her coffee.

Key idea:

Brain training makes you better at the trained tasks, and any claim beyond that needs untrained tests and a fair comparison group.

Quick check:

In the study by Foroughi and colleagues, what produced a gain equal to 5 to 10 IQ points? Answer: a suggestive flyer that raised people's hopes, before one hour of training.

4.3 Making Development Part of Life

4.3.1 Real Projects, Everyday Problems, Habits and Plateaus

Rosa's kitchen tap has dripped for a week. The guide she finds online shows a tap with a single lever, and hers has two cross-shaped handles. She does not know what size of washer it takes, and the hardware shop shuts at six. A bowl sits under the drip. **Nothing in any lesson she ever had looked like this.**

Real problems arrive with pieces missing. Section 1.1.2 called problems like this ill-structured, a term from Simon (1973), and Rosa's tap fits the name well. **Her first job is to find the missing pieces**, starting with the type of tap and the size of washer it needs before six o'clock.



A dripping kitchen tap with two cross-shaped handles, an open toolbox on the counter beneath it.

Finding the pieces is a skill of its own, and school exercises usually skip it. An exercise hands you every number. **A real project makes you**

name the variables before you can solve anything. Once Rosa knows the tap type and the washer size, the task becomes one her intellect can work on, with every piece in view.

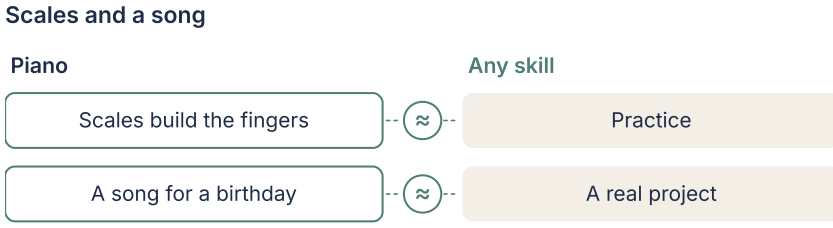
Rosa writes two lists on the back of an envelope. The first holds what she knows, that the tap has two handles, the drip comes from the hot side and the shop is ten minutes away. The second holds the washer size and how the handle comes off. **Two short lists turn a mess into a few clear gaps.**

Two lists on an envelope



I like real projects for practice for that reason. Fixing the tap, planning a trip on a budget or building a garden bench gives every skill a job. **The project supplies its own feedback**, because the tap stops or it keeps dripping. Nobody has to mark the work, and the result is plain to see.

Scales on a piano build the fingers, and a song for a friend's birthday puts them to work. **The song shows you which scales you still need.** A real project does the same for any skill, by showing you the parts you lack in the middle of something you care about finishing.



Everyday problems give the same practice on a smaller scale. A bus that never comes, a recipe missing one ingredient or a bill bigger than it should be each has pieces to find before any sum can be done. **Small daily problems are free practice in naming the pieces.**

Pick a project one step beyond what you can do now. A first repair should be a tap, and a whole new bathroom can wait. **The right project stretches you without leaving you stuck for weeks.** If you are new to the skill, ask someone to show you the first step before you start alone.

A project gets you started, and a habit keeps you going between projects. B. Gardner, Lally and Wardle wrote advice for doctors helping patients build healthy habits, and it reads “repeat a chosen behaviour in the same context, until it becomes automatic and effortless” (B. Gardner et al., 2012). **A habit grows from the same action in the same setting.**

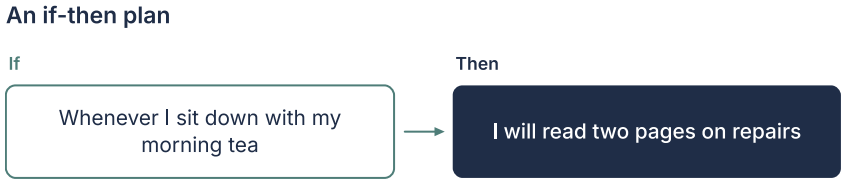
The advice was written for health habits, and using it for learning is my own suggestion. Context means the place or moment that comes just before the action. Automatic means the action starts without a decision. **Repeating a skill in one fixed slot lets the slot do the starting**, so you spend no willpower getting going.



Brushing your teeth after breakfast works this way for many people. Breakfast ends, and the toothbrush is in your hand before you have decided anything. **The setting does the remembering for you.** A learning habit can ride on a moment that already happens every day, such as the morning tea or the bus home.

In my experience, a slot works best when it is small and fixed. Twenty minutes after the same coffee is easier to keep than an hour whenever there is time. **A small fixed slot is easier to keep than a big loose plan**, because the loose plan waits for a free moment that rarely comes.

> Key Concept:
>
> **An if-then plan links a situation to an action in advance.** Gollwitzer described plans that link expected situations to responses in the form "Whenever situation x arises, I will initiate the goal-directed response y!" (Gollwitzer, 1999). For example, whenever I sit down with my morning tea, I will read two pages on repairs.



The plan does the deciding ahead of time. **When the situation comes, the action is already chosen.** Rosa writes that whenever she makes her Saturday coffee, she will spend twenty minutes on one repair skill. The coffee becomes the setting, and the setting brings the skill along with it each week.

Practice that keeps going brings its own puzzle. Gains come fast at first and then slow, until progress seems to stop. **A flat stretch in progress is called a plateau**, and most learners meet one sooner or later. Knowing its shape helps you read it calmly when it comes.

> Science Says:
>
> Heathcote, Brown and Mewhort studied "7,910 learning series from 475 subjects in 24 experiments". "The exponential function fit better than the power function in all the unaveraged data sets. Averaging produced a bias in favor of the power function" (Heathcote et al., 2000). **One person's curve and the average of many people's curves have different shapes.**

Both kinds of curve rise fast and then flatten. On an exponential curve, each round of practice wins a fixed share of the gain still left, so it levels off sooner. **Averaging many people's curves hides that shape**, so the smooth curve in a textbook may look different from your own week by week.

Learning curves

HE

Heathcote et al., 2000

- 7,910 learning series from 475 subjects in 24 experiments
- Averaging produced a bias in favor of the power function

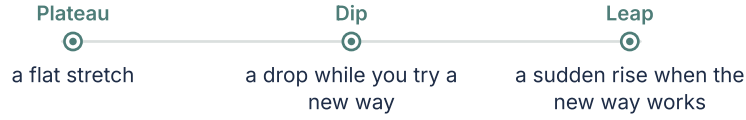
For a learner, the early fast gains feel like proof of talent, and the slow part feels like failure. **Both are simply the shape of the curve.** Knowing the shape ahead of time means a slow month comes as no surprise, and it is no reason to stop.

A flat stretch can still lead somewhere. W. D. Gray and Lindstedt wrote that "dips become the marker of exploration where performance suffers as new methods are invented and tested. Leaps mark the implementation of a successful new method" (W. D. Gray & Lindstedt, 2017). **A dip can mean you are trying something new.**

Read that way, a worse week is not always bad news. **A drop in score can be the cost of testing a better way**, paid before the better way starts to work. The trick is knowing which kind of drop you are in.

> Science Says:
>
> The title of W. D. Gray and Lindstedt's paper names three shapes, "Plateaus, dips, and leaps" (W. D. Gray & Lindstedt, 2017). A plateau is a flat stretch, a dip is a drop while you try a new way, and a leap is a sudden rise when the new way works. **A dip before a leap is part of the pattern.**

Plateaus, dips, and leaps

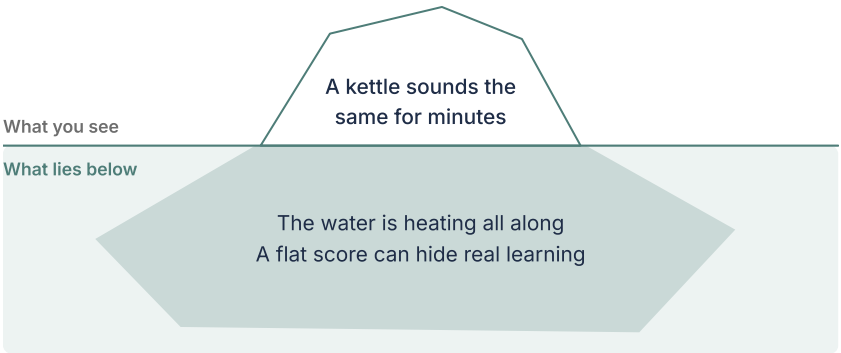


A kettle sounds the same for minutes and then boils. **Nothing seems to happen, and the water is heating all along.** Section 4.2.1 split performance, how you do in practice, from learning, what lasts.

Soderstrom and Bjork (2015) found that “learning can occur even when no discernible changes in performance are observed”.

Discernible means visible. **A flat score can hide real learning**, in the same way the kettle hides its heat until the boil. A plateau is a poor moment to give up, because you cannot tell from the score alone what is building underneath it.

A kettle





A kettle sits silent on a gas ring, a thin wisp of steam just starting to curl from its spout.

A plateau calls for a change of method more than more of the same. Try a new way of doing the hard part and expect a dip while it settles. **If the dip turns into a leap, keep the new method.** If it does not, go back and try another way.

Change the method



The new method can be small. A different grip on the spanner or a new order for the steps can count. **Small changes are easier to test**, because you can tell whether the dip and the leap came from them and nothing else.

Rosa meets her plateau a few months later. Her repairs take the same time every weekend, however many she does. She tries laying out every part in order before she starts, and for two weekends she is slower. **On the third weekend she finishes in half the time.** The dip was the new method settling in.

> **Exercise: One real project**
>
> *1. Choose a real project one step beyond what you can do now.*
>
> *2. List the pieces you know and the pieces still missing.*
>
> *3. Write one if-then plan that ties practice to a moment in your day.*
>
> *4. Track one simple measure, such as time taken.*
>
> *5. When the measure stays flat for two weeks, try one new method and expect a dip.*

Back in the kitchen, Rosa finds the washer size printed in tiny letters on the old washer. The shop has it, the tap has two screws, and by half past five the drip has stopped. **Every piece was named before she solved anything**, and the next tap will be easier because she knows which pieces to look for first.

She keeps her Saturday coffee slot after the tap is fixed. Next on her list is a sticking door, one step further on. **One real project leads to the next**, and the habit carries her from each one to the one after.

Key idea:

Real problems put your skills to use, habits keep you practising, and a flat stretch is often the time before a new method pays off.

Quick check:

In W. D. Gray and Lindstedt's account, what does a dip in performance often mark? Answer: exploring new methods, which can lead to a leap.



Module

5

Sleep, Movement and Food

5.1 Sleep and Recovery

5.1.1 How Sleep Supports Intellect, and a Workable Sleep Routine

You stay up past one in the morning to finish a report for work. **The next morning a simple sum on the household bills takes you three tries.** You check the numbers, lose your place, and start again. Nothing about the sum has changed since yesterday, yet your head feels like a room full of fog.



A desk lamp still glowing over a laptop and a cold cup of tea in a dark flat late at night.

The fog has a cause, and **sleep is one of the plainest supports for the skills this book trains**. Intellect, as I use the word, is solving tasks where the variables are already identified, such as a sum or a timetable. Those tasks lean on memory and attention, and both lean on the night before.

Start with memory. A long review of sleep research opens with a strong sentence, “Over more than a century of research has established the fact that sleep benefits the retention of memory” (Rasch & Born, 2013). **The same review describes sleep as playing an active role**, with deep, slow-wave sleep helping to lock memories in.

> **Key Concept:**
>
> Consolidation. Consolidation is **the brain’s way of turning a fresh, fragile memory into a lasting one**. Saving a document before you close the laptop is a fair comparison. A second review says sleep “optimizes the consolidation of newly acquired information in memory, depending on the specific conditions of learning and the timing of sleep” (Diekelmann & Born, 2010).

Consolidation



Sleep before learning helps too. In one brain-scan study, a sleepless night produced “a significant deficit in hippocampal activity during episodic memory encoding, resulting in worse subsequent retention” (Yoo et al., 2007). Episodic memory is memory for what happened to you, and encoding is taking it in. The hippocampus is a small brain part that helps store new memories.

Put the two findings side by side and **a simple rule appears for anyone who wants to learn something well**. A tired brain takes in less of the new material, and a missed night after learning leaves less of it saved. You need the night before to take the material in and the night after to keep it.

A simple rule

The night before	The night after
A tired brain takes in less of the new material	A missed night after learning leaves less of it saved

Six hours can feel like plenty, and **one careful lab study shows why the feeling misleads**. Adults in the study had their nights cut for two weeks and were tested every day. Their scores slid, yet their own sense of sleepiness gave a poor warning of how far they had slipped.

> **Science Says:**
>
> Researchers gave 48 healthy adults aged 21 to 38 either 4, 6 or 8 hours in bed for 14 days (Van Dongen et al., 2003). The shorter nights led to "cumulative, dose-dependent deficits in cognitive performance on all tasks". **People's sleepiness ratings "did not significantly differentiate the 6 h and 4 h conditions"**, so the six-hour group felt about as sleepy as the four-hour group, even though it scored better.

A slow puncture in a bike tyre works the same way. **Each night of short sleep lets out a little air**, and you keep riding because no single night feels flat. Two weeks later the ride is hard work, and you blame the hill. Your own feeling of being fine is a weak gauge after many short nights.

A slow puncture

The bike tyre		Short sleep
Each night lets out a little air	≈	Each night of short sleep
You keep riding	≈	Your own feeling of being fine is a weak gauge

> **Science Says:**
>
> In a study of 39 transport and army workers, **after 17 to 19 hours without sleep, performance on some tests was equal to or worse than at a blood alcohol level of 0.05%** (Williamson & Feyer, 2000). Blood alcohol level is the share of alcohol in your blood. Response speeds were up to 50% slower on some tests.

A study in mice suggests one more job for sleep. **During sleep the spaces between brain cells in the mice widened by about 60%**, and a waste protein called beta-amyloid was cleared faster (Xie et al., 2013). The authors wrote that the restorative role of sleep "may be a consequence" of this clearing, a careful claim from animal work.

Street cleaners work through the night while the city sleeps, and **the mouse study suggests the brain may run a similar night shift**. The picture helps, but the evidence is from mice and the wording is "may", so treat it as an interesting lead. Nobody has shown that the same cleaning explains the human results above.

The next step is how much sleep an adult needs. **A joint statement from two sleep medicine bodies says, "Adults should sleep 7 or more hours per night on a regular basis to promote optimal health"** (Watson et al., 2015). An expert panel of 18 members gave a range of 7 to 9 hours for adults (Hirshkowitz et al., 2015).

How much sleep adults need



Adults should sleep 7 or more hours per night



An expert panel of 18 members



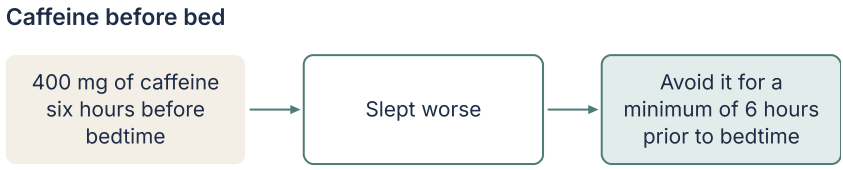
A range of 7 to 9 hours for adults

The panel added that needs "vary across the lifespan and from person to person", and **its range is meant for healthy people without a sleep disorder**. A panel range is agreed expert advice, never tested as a trial. **If you are worried about how much you sleep, please talk to your doctor.**

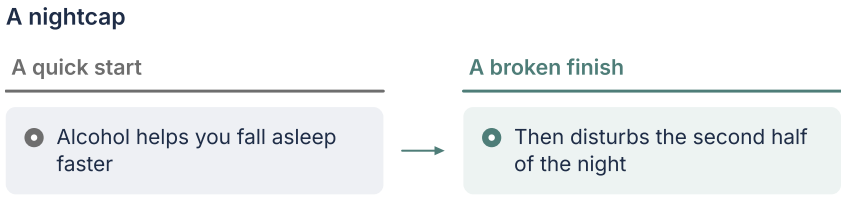
A tidy routine can help, though **the evidence for single bedtime tips is thinner than the magazines suggest**. Researchers group these tips under one name.

> 🗝 **Key Concept:**
>
> Sleep hygiene. Sleep hygiene is **the name for everyday sleep habits**, such as a regular bedtime or a dark room. A review found these habits do not work as a treatment in clinical sleep medicine, and the direct effects of individual tips "remains largely untested in the general population" (Irish et al., 2015).

Caffeine is one tip with a clear test behind it. **People given 400 mg of caffeine six hours before their usual bedtime still slept worse**, and the authors wrote that "caffeine taken 6 hours before bedtime has important disruptive effects on sleep" (Drake et al., 2013). They advised avoiding it "for a minimum of 6 hours prior to bedtime".



Alcohol works in a sneakier way. A review of studies in healthy volunteers found that **alcohol helps you fall asleep faster, then disturbs the second half of the night** (Ebrahim et al., 2013). The first period of REM sleep, the stage when most dreaming happens, was delayed at every dose. A nightcap buys a quick start and a broken finish.



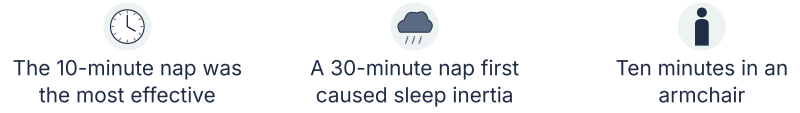
One lab study compared a light-emitting e-reader with a printed book at bedtime. Readers using the e-reader "took longer to fall asleep and had reduced evening sleepiness, reduced melatonin secretion, later timing of their circadian clock, and reduced next-morning alertness" (A.-M. Chang et al., 2015). Melatonin is a hormone that signals night, and the circadian clock is your body clock.

The study was small and tested one kind of device, so **it says nothing firm about every screen in your house**. It does give a sensible reason to swap a glowing e-reader for a paper book in the last hour before bed. A phone held close to your face may act alike, but nobody tested that here.

> **Science Says:**
>
> In 24 healthy young adults who were good sleepers, night sleep was cut to about 5 hours, then naps of different lengths were tried the next afternoon (Brooks & Lack, 2006). **The 10-minute nap was the most effective of the lengths tested.** A 30-minute nap first caused sleep inertia, the groggy feeling after waking, before it helped.

A nap is a patch after a short night, and **it works best when you keep it brief**. The study used people who rarely napped and had been short of sleep, so its result fits a bad night better than a normal week. Ten minutes in an armchair may clear more fog than half an hour in bed.

A nap after a short night



Some people lie awake night after night whatever they do. **For adults with chronic insomnia, a talking and training treatment called CBT-I has strong trial support.** CBT stands for cognitive behavioural therapy, and the "I" is for insomnia. The evidence comes from randomised controlled trials, which split people into groups by chance so that the groups can be compared fairly.

> **Science Says:**
>
> A review of 20 randomised trials with 1,162 adults with chronic insomnia found that CBT-I helped people fall asleep about 19 minutes sooner and cut time awake in the night by about 26 minutes (Trauer et al., 2015). **The authors concluded that "CBT-i is an effective treatment for adults with chronic insomnia".**

What CBT-I changed in 20 randomised trials



If poor sleep goes on for weeks, please see your doctor and ask about it. Long-term insomnia and other sleep disorders need a clinician, and this book cannot diagnose them. A doctor can point you to CBT-I or check for a different cause.

For an ordinary week, I keep my own evening plan short. **The table below is my own routine, built from the studies above**, and you can change any line to fit your life.

Time before bed	What I do	Study behind it
6 hours	Last cup of coffee or tea with caffeine	Drake et al., 2013
1 hour	Paper book in place of a glowing e-reader	A.-M. Chang et al., 2015
Most nights	Same bedtime, aiming for 7 hours or more	Watson et al., 2015
After a bad night	A 10-minute nap in the early afternoon	Brooks & Lack, 2006

> Exercise:
>
> A week of sleep notes.
>
> 1. Each morning, write down when you went to bed and when you woke.
> 2. Note the time of your last caffeine and any alcohol the evening before.
> 3. Rate how clear your head felt at ten o'clock, from 1 to 5.
> 4. **After seven days, look for the nights** that came before your clearest mornings.

Your notes cannot show cause, yet **they show your own pattern more honestly than memory can**. One change, kept for a fortnight, tells you more than five changes made at once.

Back at the bills, the sum was never the problem. **The report kept you up, and the fog came with the morning.** A night of seven hours or more, with the coffee finished by mid-afternoon, gives the same sum a fair chance. Your intellect does its best work on a rested brain.



A man stretching beside an open bedroom window in bright morning light, his bed neatly made behind him.

Key idea:

Learning that lasts = Sleep before + Sleep after. A rested brain takes new material in, and a full night afterwards helps keep it.

Quick check:

You have an exam on Friday morning and plan to study late on Thursday. Which night of sleep helps you more, Wednesday or Thursday? Answer: both, because sleep before learning helps you take material in and sleep after learning helps you keep it.

5.2 Physical Activity

5.2.1 Walking, Aerobic Exercise, Strength and Balance

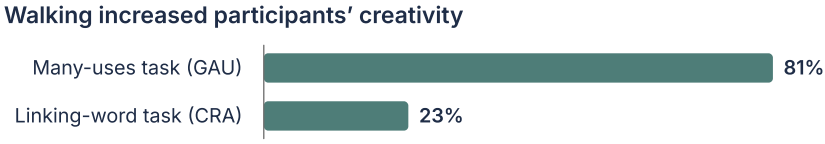
You have spent an hour at your desk on a plan for a family move, and **the same three ideas keep going round in circles**. You give up, put on a coat and walk round the block. By the time you reach your front door again, two new ideas have turned up from nowhere.



A woman walking along a canal towpath with her hands deep in her coat pockets as autumn leaves blow past.

Your stroll helped, and **a set of experiments found the same kind of lift**. People did idea tasks while walking or sitting. One task asked for new uses for an everyday object, and another asked for one word that links three others. Walking helped the first kind far more than the second.

> **Science Says:**
> "Walking increased 81% of participants' creativity on the GAU, but only increased 23% of participants' scores for the CRA" (Oppezzo & Schwartz, 2014). The GAU is the many-uses task and the CRA is the linking-word task. **People who sat down after a walk still showed "a residual creative boost".**



The split fits how this book uses the word. **Intellect is solving tasks where the variables are already identified**, such as a budget. Walking did most for open idea-finding, and the gain was short-term. A stroll is a good move when you are stuck for options, and a weaker tool for a sum with one right answer.

A review of 79 studies found that the effect of one session of exercise on mental performance was "positive and small" (Y. K. Chang et al., 2012). A cup of tea makes a fair comparison, since it gives a small lift that wears off and nobody expects it to change who you are.

> **Key Concept:**
> Aerobic and strength exercise. **Aerobic exercise keeps your heart and lungs working for a while**, such as brisk walking, cycling or swimming. Strength exercise, known to researchers as resistance training, makes your muscles push or pull against a load, such as weights, bands or your own body. Balance exercise trains you to stay upright and sure on your feet.

Aerobic and strength exercise



Aerobic exercise keeps your heart and lungs working



Brisk walking, cycling or swimming



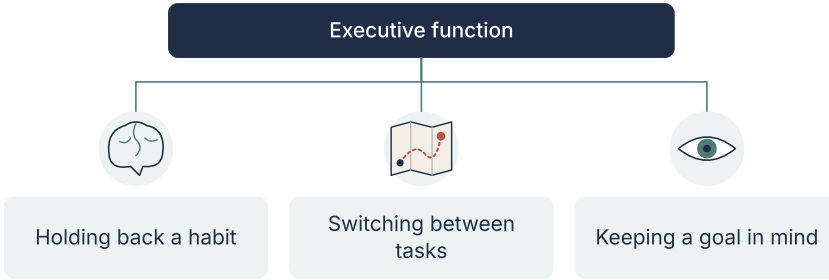
Strength exercise, known to researchers as resistance training

Over months, **regular exercise in healthy people gives small gains**. A review of 80 randomised trials in healthy people found that "The summary effect was small and did not differ between cognitive domains" (Ludyga et al., 2020). Benefits were higher after coordinative exercise, which asks for skill and timing.

A second review pooled 29 trials with 2,049 adults aged 18 and over, and **aerobic exercise brought "modest improvements in attention and processing speed", executive function and memory** (P. J. Smith et al., 2010). The effect on working memory, the mind's worktop that holds a few items at once, was less consistent.

> **Key Concept:**
>
> Executive function. Executive function is the set of skills that plan, start and stop what you do. **It covers holding back a habit, switching between tasks and keeping a goal in mind.** Those skills keep you on the right step of a task with identified variables.

Executive function



One trial tested low-fitness adults across a wide age range. **In 132 adults aged 20 to 67 with below-average fitness, six months of aerobic exercise four times a week "significantly improves executive function but not other measures of cognitive function"** (Y. Stern et al., 2019). The gain was real and narrow, in one family of skills.

Most exercise trials study older adults, and **here two careful reviews come to different answers**. Both are worth reading at full strength, because each was done well and each asked a slightly different question. Two weather forecasts can disagree when they are drawn from different maps.

> **Science Says:**
>
> A review of 39 studies in people over 50 found that "physical exercise improved cognitive function", and aerobic, strength, mixed and tai chi programmes all helped (Northey et al., 2018). **A Cochrane review of 12 aerobic trials in 754 people over 55 found "no evidence" of "any cognitive benefit in cognitively healthy older adults"** (Young et al., 2015).

A Cochrane review is a careful summary of trials from an independent research network. **The Cochrane review looked only at aerobic exercise and fewer trials**, while Northey's review took in strength and tai chi. Neither cancels the other. Northey found a benefit, Young found "no evidence" of one in healthy older adults, and the two reviews still disagree.

Two careful reviews

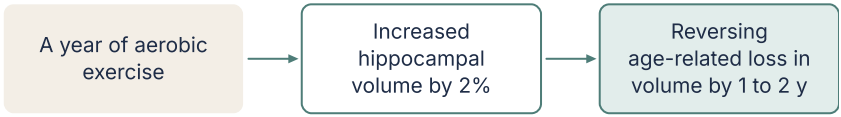
	Northey et al., 2018	The Cochrane review
Studies	39 studies in people over 50	Fewer trials
Exercise	Aerobic, strength, mixed and tai chi	Only aerobic exercise

> **Science Says:**
> A third review of healthy older adults agrees with the small size. **It found small positive effects on executive function and memory, and the amount of exercise "did not predict the magnitude"** of the benefit (Sanders et al., 2019). In older adults with cognitive impairment, the same review found a moderate effect on overall mental performance.

A review of 98 trials in older adults found that **"exercising for at least 52 hours is associated with improved cognitive performance"** (Gomes-Osman et al., 2018). The figure comes from comparing many trials, so it is a link that cannot show cause, and nobody tested 52 hours as a dose. Hours add up like coins in a savings jar.

Exercise can change the brain itself. **In a trial with 120 older adults, a year of aerobic exercise "increased hippocampal volume by 2%, effectively reversing age-related loss in volume by 1 to 2 y"** (Erickson et al., 2011). The hippocampus, the memory area deep in the brain, grew, and spatial memory, the memory for places and routes, improved.

A year of aerobic exercise



A 2% gain in size can look tiny on paper. **The authors set it against the shrinking that normally comes with age**, which turns a small number into one to two years won back. The trial measured brain size and memory for places, so it says little about other mental skills.



An older woman in a cardigan lifting a pair of small dumbbells beside a sunny sitting-room window.

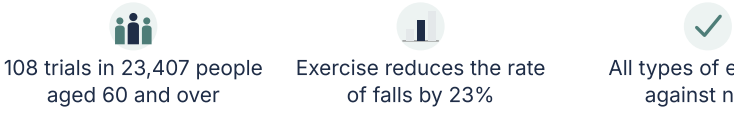
Lifting weights was tested in a separate trial. **The trial asked whether strength training once or twice a week could help older women's executive function.** It used the Stroop test, where you name the ink colour of a word that spells a different colour, such as the word "red" printed in blue.

> **Science Says:**
>
> A trial gave 155 women aged 65 to 75 either strength training or a balance and tone class for 12 months (Liu-Ambrose et al., 2010). **Strength training once or twice a week improved Stroop scores "by 12.6% and 10.9%"**, while the balance and tone group showed a "0.5%" decline.

In 170 adults aged 50 and over who "reported memory problems but did not meet criteria for dementia", 24 weeks of home exercise gave "a modest improvement in cognition over an 18-month follow-up period" (Lautenschlager et al., 2008). On the ADAS-Cog, a thinking-skills scale, the exercise group scored 1.3 points better than the others after 24 weeks.

Exercise has its strongest evidence in a different area. **A review of 108 trials in 23,407 people aged 60 and over found that "Exercise reduces the rate of falls by 23%"**, for all types of exercise against none, with high-certainty evidence (Sherrington et al., 2019). The review says nothing about intellect, but a fall can stop every plan.

Exercise and falls



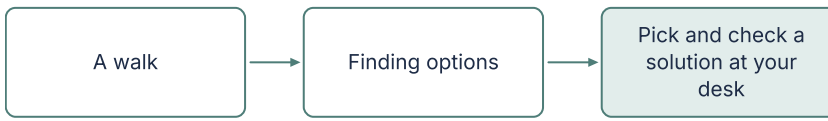
If you have had a fall, feel unsteady or live with a health condition, please talk to your doctor before you start a new balance or strength programme. A doctor or physiotherapist can suggest safe moves for your body. The trials above used supervised or tested programmes.

You may have read that exercise makes everyone cleverer for good. **No study I have seen shows a lasting gain for everyone.** The trials cover mainly older adults, with a few in younger adults, and the effects are small. The table below sums up what each kind of movement showed in one study and who took part.

Kind of movement	What one study found	Who was studied
A walk	More new uses for an object, short-term	Volunteers in idea tasks
Aerobic, six months	Better executive function only	Adults 20 to 67, below-average fitness
Aerobic, one year	Hippocampus grew by 2%	120 older adults
Strength, 12 months	Better Stroop scores	Women aged 65 to 75
All types, against none	23% fewer falls	Adults aged 60 and over

Walking works best for finding options, so **use it before you pick and check a solution at your desk**. I suggest a mix through the week, with some walks, some strength work and a little balance. The weekly plan in 5.2.2 turns that mix into minutes and days.

Walk first, desk second



Back at your front door, the two new ideas still need checking. **The walk opened them up, and the desk will test them.** Neither step replaces the other, and both are cheap. Movement gives your mind a small, real push, and on a stuck afternoon a short walk is one of the easiest pushes you can give it.

> Exercise:
>
> Walk on it.
>
> 1. Next time a plan or a list of options stalls, write the problem in one line.
> 2. Walk for ten to fifteen minutes with no phone call or podcast.
> 3. Sit down straight after and write every option that comes, without judging them.
> 4. **Compare the new list with your list from before the walk.**

Key idea:

Movement gives the mind small, real gains, and a short walk can loosen fresh options when you are stuck on a plan.

Quick check:

A friend says a daily walk will make her twice as clever within a month. What does the evidence support instead? Answer: small gains in some mental skills over months, a short-term lift in finding new ideas after a walk, and fewer falls in adults aged 60 and over when exercise programmes were compared with no exercise (Sherrington et al., 2019).

5.2.2 Your Weekly Movement Plan, Including Sedentary Days

On a working Monday you sit on the train, sit at your desk, sit for lunch and sit on the train home. **By the time you reach the sofa, your step counter shows a few hundred steps.** You did nothing wrong, and the day still left your body almost still from breakfast to bedtime.



A crowded commuter train carriage full of seated passengers in winter coats under grey morning light.

A plan for the week starts with the official targets. **The World Health Organization sets out weekly minutes of effort for adults**, and it adds a gentle line for anyone far from the target. Moderate effort warms you and quickens your breath, and vigorous effort is harder work that leaves little breath for talk.

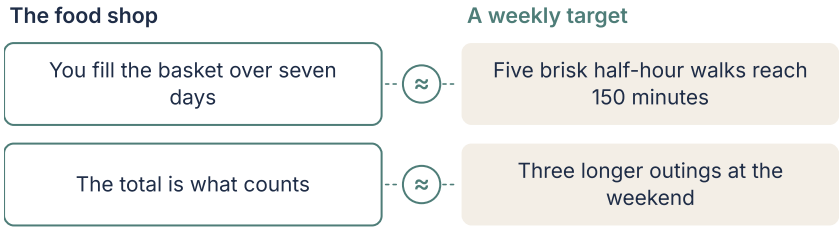
> **Science Says:**
>
> The WHO's 2020 guidelines say "All adults should undertake 150 to 300 min of moderate-intensity, or 75 to 150 min of vigorous-intensity physical activity" each week (Bull et al., 2020). **They call for "regular muscle-strengthening activity for all age groups", and add that "some physical activity is better than none".**

WHO weekly targets



A weekly target works like the weekly food shop. **You fill the basket over seven days**, a little on some days and more on others, and the total is what counts. Five brisk half-hour walks reach 150 minutes, and so do three longer outings at the weekend with a short walk on Wednesday.

The weekly food shop

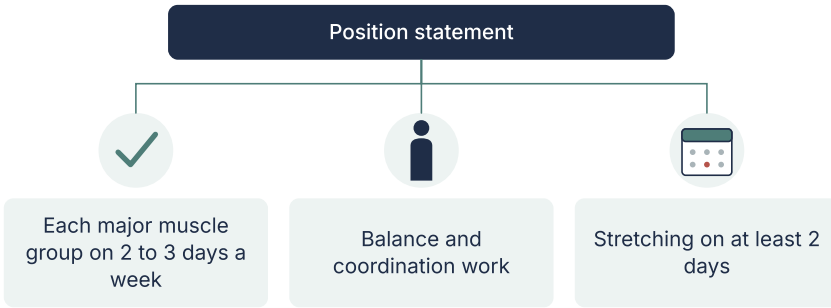


> **Science Says:**
>
> The United States guidelines give the strength part a number. **They ask for "muscle-strengthening activities on 2 or more days a week"**, and they add that older adults should do mixed activity "that includes balance training" (Piercy et al., 2018). The same report found that about 80% of US adults and teenagers are not active enough.

A sports medicine body goes into more detail. **Its position statement asks adults to train each major muscle group on 2 to 3 days a week**, plus balance and coordination work, and stretching on at least 2 days (Garber et al., 2011). People who cannot meet the targets "still can benefit from engaging in amounts of exercise less than recommended".

Garber's statement adds a line for anyone with a long-term illness. **People with chronic conditions should exercise "when appropriately evaluated and advised by a health professional"** (Garber et al., 2011). **If you have a heart, lung or joint condition, please talk to your doctor before you raise your effort.**

Garber et al., 2011

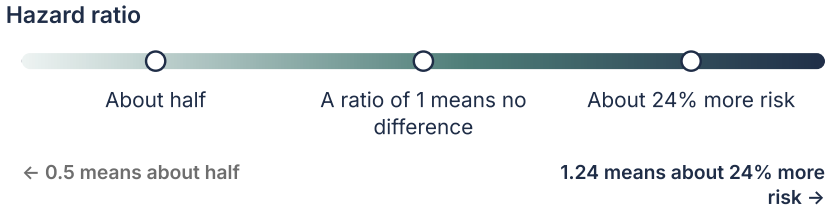


Every target above is a health guideline. **None of them was written as a prescription for intellect**, and the trials on movement and mental skills, with their small effects, are told in 5.2.1. I follow the guidelines because they are the best-tested plan for the body, and the mind lives in that body.

> Science Says:
>
> Researchers have studied long sitting on its own. **A review of 47 studies found that sitting for long periods carried a higher risk of death, with a hazard ratio of 1.240**, whatever people's activity levels (Biswas et al., 2015). The link was stronger in less active people, and most of the sitting was self-reported.

> Key Concept:
>
> Risk and hazard ratio. **Risk is the chance that something bad happens over a set time.** A hazard ratio compares that chance in two groups. A ratio of 1 means no difference, 1.24 means about 24% more risk, and 0.5 means about half. Studies of death rates, which researchers call mortality, use it often.

The sitting studies are links that cannot show cause. **People who sit a great deal may differ in other ways**, such as their health or their jobs, and the studies cannot fully separate those things. They are worth taking seriously, and they cannot prove that standing up would change your own risk.



One large review went further and named a number. **Across 34 studies and 1,331,468 people, "a threshold of 6-8 h/day of total sitting and 3-4 h/day of TV viewing was identified, above which the risk is increased"** (Patterson et al., 2018). The WHO panel read the same field differently two years later.

> **Key Concept:**
>
> A threshold or none. The WHO guidelines say "evidence was insufficient to quantify a sedentary behaviour threshold" (Bull et al., 2020). **One review found a threshold, and the guideline panel judged the evidence not strong enough to set one.** Treat 6 to 8 hours as one review's finding and never as a fixed rule.



Activity seems to soften the sitting link. **Pooled data on 1,005,791 people found that "about 60-75 min per day" of moderate**

activity "seem to eliminate the increased risk of death associated with high sitting time" (Ekelund et al., 2016). For television viewing, the same activity weakened the link without removing it.

Intensity counts for less than you might expect. **A pooling of 8 cohorts with 36,383 people found that "Any physical activity, regardless of intensity, was associated with lower risk of mortality"** (Ekelund et al., 2019). A cohort is a group followed over years, and activity was measured with an accelerometer, a small motion sensor worn on the body.



A small group of walkers chatting along a park path at dusk, their breath misting in the cold air.

Steps are the measure most people know, and **the popular figure of 10,000 has a thin base**. A pooling of 15 studies with 47,471 adults said of the 10,000 target that "there is little evidence to support this recommendation" (Paluch et al., 2022). The risk of death fell as steps rose and then levelled off below 10,000.

> **Science Says:**
>
> In 4,840 adults aged 40 and over who wore step counters, **8,000 steps a day was linked with a much lower risk of death than 4,000, a hazard ratio of 0.49** (Saint-Maurice et al., 2020). How fast people walked was "not significantly associated" with risk once total steps were counted.

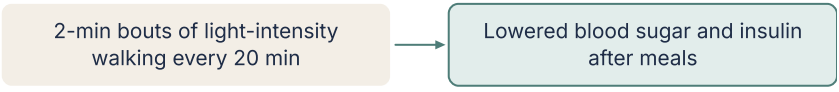
Steps a day and risk of death (hazard ratio)



A day like Monday still has room for small moves. **Breaking up long sitting with short walks has been tested in small trials.** A long stretch in a chair is like a bent garden hose, and a few minutes on your feet straightens the kink before the flow slows for good.

In 19 overweight adults aged 45 to 65, **"2-min bouts of light-intensity walking every 20 min" lowered blood sugar and insulin after meals** (Dunstan et al., 2012). In one day-long study of older adults, a morning walk raised BDNF, a growth substance for brain cells, with or without 3-minute walks every 30 minutes later (Wheeler et al., 2020).

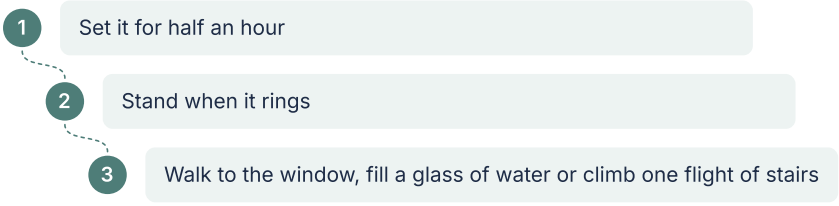
Breaking up long sitting



> **Science Says:**
> Wheeler's study found gains in working memory or executive function, and **which gain appeared depended on whether the sitting afterwards was broken up** (Wheeler et al., 2020). The study was small and ran for one day, so it cannot set a rule for everyone. It does give a reason to stand up between long meetings.

A kitchen timer or a phone reminder makes the breaks easy to remember. **Set it for half an hour and stand when it rings**, then walk to the window, fill a glass of water or climb one flight of stairs. I suggest this for desk days, and the trials above used breaks of two or three minutes.

A desk-day break



Walking with other people makes the habit easier to keep. **A review of 42 studies with 1,843 people found that walking groups lowered blood pressure, resting heart rate and body fat**, and eased depression (Hanson & Jones, 2015). The authors concluded that "Walking groups are effective and safe with good adherence", meaning people kept going.

My own sample week puts the pieces together. **The table below is my own plan**, built to reach the WHO minutes, two strength days and some balance work. Change the days to fit your diary.

Day	Movement	Minutes
Monday	Brisk walk at lunch, stand every half hour at the desk	30
Tuesday	Strength session at home, with balance moves	30
Wednesday	Brisk walk to and from the station	30
Thursday	Walking group or walk with a friend	30
Friday	Brisk walk after work	30
Saturday	Longer walk or cycle ride, with a few strength moves after	45 of walk or ride

The table reaches 165 aerobic minutes, inside the WHO range of 150 to 300, plus two strength days. **A desk-bound day like Monday still gets its stand-ups**, a few minutes every half hour, like the breaks in the trials above. If a week goes badly, the WHO line still holds and some movement beats none.

Back on the sofa



A brisk walk at lunch



A stand every half hour at the desk



No single day has to be perfect

Back on the sofa after the train, Monday can end differently. **A brisk walk at lunch and a stand every half hour at the desk** turn the few hundred steps into a few thousand. No single day has to be perfect, because the plan is counted across the week.

> Exercise:
>
> Count one week.
>
> 1. For seven days, write down the minutes of brisk movement you do each day.
> 2. Mark each strength or balance session with a tick.
> 3. Note your longest unbroken stretch of sitting each day.
> 4. **At the end of the week, add up the minutes** and pick one day to add a walk and one long sitting stretch to break.

Key idea:

A movement week = Aerobic minutes + Strength days + Sitting breaks. Spread them across seven days, and remember that some movement is better than none.

Quick check:

A colleague says you must walk 10,000 steps a day or the effort is wasted. What does the evidence say? Answer: the 10,000 figure has little evidence behind it, and in large studies the risk of death fell as steps rose and levelled off below 10,000.

5.3.1 Dietary Patterns and Adequate Nutrition

In the supermarket queue a magazine cover names one food that will "power your brain". **The next week, a different magazine names a different food**, with the same bright photograph and the same promise. You put a punnet of each in your basket and wonder which writer read the research.

The research tells a slower and more useful story, and **food does affect health on a very large scale**. A global study estimated that in 2017, 11 million deaths and 255 million DALYs "were attributable to dietary risk factors" (Afshin et al., 2019). A DALY is a year of healthy life lost to illness or early death.

The leading risks in that study were **high salt, low whole grains and low fruit**. The figures come from a model that links diet data with death and illness data across countries, so they are estimates that cannot show cause in any one person. They are about general health, and they say nothing direct about intellect.

The leading risks



High salt



Low whole grains

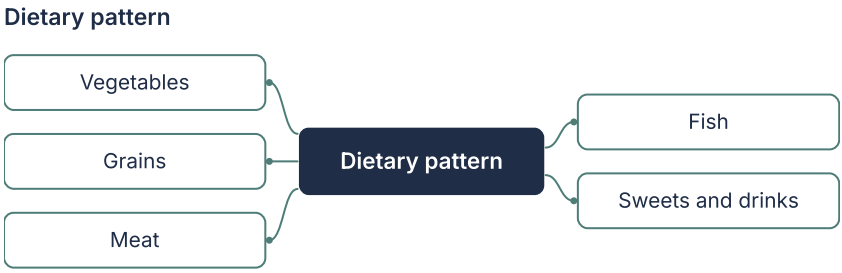


Low fruit

> **Science Says:**
> A Lancet Commission report lists risk factors that can be changed: "less education, hearing loss, hypertension, smoking, obesity, depression, physical inactivity, diabetes, excessive alcohol consumption", serious head injury, air pollution and social isolation (Livingston et al., 2024). Hypertension means high blood pressure. **Its 2024 report added "untreated vision loss and high LDL cholesterol"**, a kind of blood fat, and its model estimated that "Modifying 14 risk factors might prevent or delay nearly half of dementia cases".

The report said the evidence is "now stronger than before" that tackling those risks "reduces the risk of developing dementia" (Livingston et al., 2024). **That "nearly half" is modelled from links that cannot show cause, and diet is not on the list.** Rich countries now see less dementia at each age, likely helped by less smoking and treated blood pressure.

For the mind, researchers have moved away from single foods. **They now study the whole way a person eats, over months and years.** A single food in a headline is easy to sell, while a way of eating is easy to live by and harder to fake in a study.



> **Key Concept:**
> Dietary pattern. A dietary pattern is **the whole mix of foods you eat over time**, with its balance of vegetables, grains, meat, fish, sweets and drinks. A football team wins or loses as a side, whatever its star player does, and a diet works the same way.

The pattern studied most is the Mediterranean diet, **a traditional way of eating from countries around the Mediterranean Sea**. One trial below added extra olive oil or nuts. A review of 56 articles linked it to better scores "in 9 of 12 cross-sectional studies, 17 of 25 longitudinal studies, and 1 of 3 trials" (van den Brink et al., 2019).



A long family table in afternoon sun with bowls of walnuts and almonds beside a green bottle of olive oil.

A cross-sectional study takes one snapshot of people at one moment. **A longitudinal study follows people over years**, which is stronger, though it can still only show a link. The same review said the "strongest associations are observed for the MIND diet". Most support comes from watching studies that cannot show cause.

Two large cohorts show how much those watching studies can differ. **In 2,258 people in New York without dementia, those who followed the Mediterranean diet most closely had a hazard ratio of 0.60 for Alzheimer's disease**, a form of dementia (Scarmeas et al., 2006). The top third of followers had about 40% less risk than the bottom third.

The second cohort pointed the other way. **In 6,174 women aged 65 and over in the Women's Health Study, the authors "observed no association of the Mediterranean diet with cognitive decline"** (Samieri et al., 2013). Both are links that cannot show cause, and together they say the link is far from settled.

> 🗝 **Key Concept:**
>
> The MIND diet. It is **an eating plan built from what the researchers call "10 brain healthy food groups" and 5 food groups to limit** (Morris, Tangney, Wang, Sacks, Barnes, et al., 2015), and their study shows only a link. The ten are green leafy vegetables, other vegetables, nuts, berries, beans, whole grains, seafood, poultry, olive oil and wine. The five are red meat, butter and stick margarine, cheese, pastries and sweets, and fried or fast food.

A hunch is worth having, and a fair test is what settles it. **The MIND diet gives a clear example of a hunch meeting a fair test.** An observational study found a strong link, and a randomised trial years later looked for the same benefit and did not find it.

Two large cohorts

	New York	Women's Health Study
People	2,258 people in New York without dementia	6,174 women aged 65 and over
Finding	A hazard ratio of 0.60 for Alzheimer's disease	No association of the Mediterranean diet with cognitive decline

The MIND team followed 960 people for about 4.7 years, and closer MIND eating went with slower mental decline. Top against bottom third was "equivalent to being 7.5 years younger in age" (Morris, Tangney, Wang, Sacks, Barnes, et al., 2015). It is a link that cannot show cause, and the authors said a trial "would be required".

> Science Says:
>
> In 923 people aged 58 to 98, those in the top third for following the MIND diet had a hazard ratio of 0.47 for Alzheimer's disease (Morris, Tangney, Wang, Sacks, Bennett, & Aggarwal, 2015). **A later 3-year trial gave 604 older adults the MIND diet or a control diet, both with a mild cut in calories, and changes in cognition and brain scans "did not differ significantly"** (Barnes et al., 2023). Test scores improved in both groups.

The trial enrolled older adults with a family history of dementia and a BMI over 25. **BMI is a weight-for-height measure**, and over 25 counts as overweight. Both groups cut their calories a little, which may

have hidden a difference. Even so, the trial gave no support to the strong link from the earlier study.

The MIND diet

960 people for about 4.7 years → A hazard ratio of 0.47 for Alzheimer's disease → A later 3-year trial

The wider trial picture looks similar. **Trials of the Mediterranean diet show mostly small or no effects**, and a review of five of them makes the point with numbers.

> **Science Says:**
>
> A review of 5 randomised trials with 1,888 people found that "Only 8/66 (12.1%) of individual cognitive outcomes ... significantly favored a Mediterranean diet" (Radd-Vagenas et al., 2018). **The authors wrote that "The data are mostly nonsignificant, with small ESs"**, and found no benefit for new cases of impairment or dementia. ES is short for effect size.

Cognitive outcomes in 5 Mediterranean diet trials



One trial is more hopeful for a narrow group. **In 447 volunteers with a mean age of 66.9 "at high cardiovascular risk", a higher chance of heart and blood-vessel disease, some memory and thinking tests differed** after a Mediterranean diet with extra olive oil or nuts (Valls-Pedret et al., 2015). Only 334 were retested, and the control group's scores declined.

Diet has been tested inside bigger programmes. **In 1,260 people aged 60 to 77 at raised dementia risk, two years of "diet, exercise, cognitive training, vascular risk monitoring" gave a small benefit** over general health advice (Ngandu et al., 2015). Vascular risk monitoring means checks on things that harm blood vessels. With four parts, diet alone cannot take the credit.

> Science Says:
>
> A second programme found nothing. **In 1,680 people aged 70 and over with memory complaints, a mixed programme with or without omega-3 capsules "had no significant effects on cognitive decline over 3 years"** (Andrieu et al., 2017). The two programmes studied different groups and different mixes, so the honest summary is mixed results in older adults at risk.

Two mixed programmes

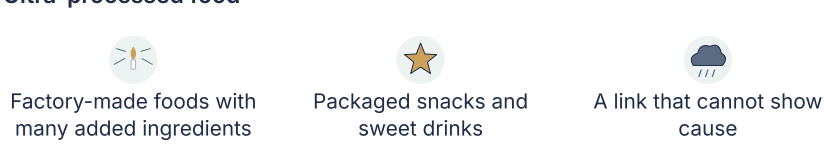
A small benefit	No significant effects
⊕ 1,260 people aged 60 to 77 at raised dementia risk	⊖ 1,680 people aged 70 and over with memory complaints
⊕ Diet, exercise, cognitive training, vascular risk monitoring	⊖ With or without omega-3 capsules

The WHO's 2019 dementia guidelines said "The Mediterranean-like diet may be recommended" to "adults with normal cognition and mild cognitive impairment", people whose thinking is normal or a little weak, on moderate evidence, as a conditional recommendation, a weaker grade than strong (World Health Organization, 2019). It added that "A healthy, balanced diet should be recommended to all adults".

One group of foods shows up on the risk side in a large cohort. **The study tracked how much ultra-processed food people ate**, and the term needs a plain meaning first.

> **Key Concept:**
>
> Ultra-processed food. **Ultra-processed foods are factory-made foods with many added ingredients**, such as packaged snacks and sweet drinks. In 10,775 adults aged 35 to 74 followed for a median of 8 years, eating more than the lowest quarter "showed a 28% faster rate of global cognitive decline" (Gomes Gonçalves et al., 2023).

The ultra-processed study used food questionnaires and is a link that cannot show cause. **People who eat many packaged foods may differ in income, work or health**, and the study cannot fully separate those things. It fits the wider findings, in which a varied diet of plain foods sits on the healthier side.



Alcohol carries the clearest warning sign. **A 30-year study of 550 adults found that "even those drinking moderately (14-21 units/week) had three times the odds of right sided hippocampal atrophy"** (Topiwala et al., 2017). The NHS says "One unit equals 10ml or 8g of pure alcohol" (NHS, n.d.), units/week means units drunk per week, and atrophy means shrinking.

Moderate drinking

Drinking moderately (14-21 units/week) → Three times the odds of right sided hippocampal atrophy

> **Key Concept:**
>
> Odds. **Odds are another way of measuring chance**, comparing how often something happens with how often it does not. In the alcohol study, moderate drinkers were compared with people who did not drink, and their odds of hippocampal shrinking were three times higher.

The same study found "no protective effect of light drinking" on the brain. **Drinking was not linked with scores on mental skill tests taken at one point in time.** The study was small and observational, so it is a link that cannot show cause.

Put together, the studies give a pattern of their own. **The watching studies often find links, and the fair tests mostly find small effects or none.** The table below lines up the kinds of study and how much each can show.

Kind of study	What it found here	How much it can show
Model of world diets	11 million deaths linked to diet in 2017	Estimate, general health
Cross-sectional	Better scores in 9 of 12 studies	A link at one moment
Longitudinal cohort	Better scores in 17 of 25 studies	A link over time
Randomised trial	MIND trial found no difference	Cause, if well run
Review of trials	8 of 66 outcomes favoured the diet	Best overall picture

My own reading is plain. **No single food has been shown to sharpen your mind**, and the strongest trials of whole diets find small effects or

none. A varied pattern with plenty of whole grains and fruit, little salt and little alcohol is good sense for general health.



A wooden chopping board with a wholemeal loaf, a heap of sliced apples and a small salt dish pushed to one side.

Adequate nutrition means getting enough of what your body needs, and **a real shortage of a vitamin is a separate problem from a poor pattern**. Shortages, and when a pill may help, are covered in 5.3.2. For an ordinary varied diet, I suggest putting your effort into the pattern.

Back in the queue, the magazine still promises a brain food. **You can leave it on the rack and keep the basket.** The fruit and the bread belong to a pattern that helps your general health, and no headline food can stand in for that pattern.

Exercise:

A pattern week.

1. For seven days, write down everything you eat and drink, without changing anything.
2. At the end, count the portions of whole grains and fruit across the week.
3. Mark the salty foods and the units of alcohol.
4. **Pick one swap for next week**, such as wholemeal bread for white, and keep it for a month.

Key idea:

Judge the whole way you eat, and give a food promise only as much weight as the study behind it.

Quick check:

An observational study links a diet with less dementia, and a later trial finds no difference. Which result carries more weight on cause? Answer: the trial, because splitting people by chance is the fair test, while the observational link cannot show cause.

5.3.2 Practical Meals, Hydration and When Supplements May Matter

The alarm goes late, and **you leave the house with a coffee in your hand and no breakfast**. By eleven o'clock the figures on your screen blur, and you read the same email twice. At home that evening you notice a pot of vitamin pills at the back of the cupboard and wonder whether you should start taking them.



A kitchen counter at dawn with a half-drunk mug of coffee, a set of car keys and an untouched bowl of cereal.

Breakfast has been studied mostly in children. **The research on children gives a modest result and a clear warning about its limits.** Two reviews of 45 studies each looked at breakfast and mental performance in school-age children and teenagers. Neither looked at adults, so the findings stay with the young people studied.

> **Science Says:**
>
> One review found that eating breakfast "has a short-term (same morning) positive domain-specific effect on cognition", and that "Firm conclusions cannot be made" about what the breakfast should contain (Adolphus et al., 2016). **A second review found breakfast more helpful than skipping it, "more apparent in children whose nutritional status is compromised"** (Hoyland et al., 2009).

The second review found not enough research to name a best breakfast. **No study in these reviews tells an adult what to eat at seven in the morning.** What they do show is a short lift on the same morning in children, clearest in children who were short of good food.

For adults, I lean on the patterns from 5.3.1 and keep meals simple. **My own advice is three regular meals built from plain foods**, with whole grains and fruit in the mix. A slice of wholemeal toast with a banana takes two minutes, and it gives a rushed morning something besides coffee.



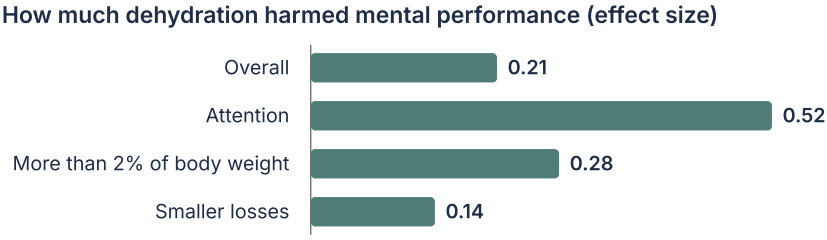
> Science Says:
>
> **A review found that "particular cognitive abilities and mood states are positively influenced by water consumption"** (Masento et al., 2014). The same authors pointed to "methodological weaknesses" in the studies and a lack of objective measures of how much water people had in their bodies.

Dehydration means your body has lost more water than it has taken in. **A plant in hot sun droops before it dies**, and a mild loss of water shows first in small ways. A pooling of lab studies measured how much those small ways add up to.



> Science Says:
>
> A review of 33 studies with 413 people found that dehydration harmed mental performance overall (effect size -0.21) and attention most (-0.52) (Wittbrodt & Millard-Stafford, 2018). **The harm was greater when people lost more than 2% of their body weight in water**, -0.28 against -0.14 for smaller losses.

Most of those studies dried people out on purpose, through exercise, heat or going without drinks. **Say you weigh 70 kg, then 2% of your body weight is 1.4 kg**, about 1.4 litres of water. A loss that size is more likely after a long run on a hot day than at a desk in an office.



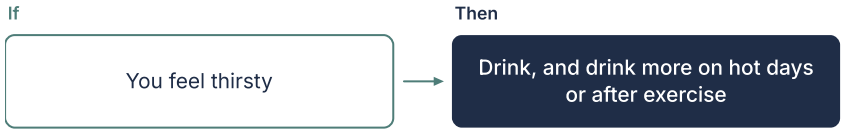
A small study looked at thirst. **In 34 people who had gone without drinks overnight, 500 ml of water sped up reaction times "but only for those participants with relatively high subjective thirst"** (Edmonds et al., 2013). Water helped the thirsty and did little for the rest, a hint that thirst is a useful guide.



A tall glass of water standing on a garden bench beside a folded towel after an evening run.

My own rule follows from those studies. **Drink when you feel thirsty, and drink more on hot days or after exercise.** Nobody needs to force down litres at a desk to stay sharp, and the studies above give no reason to try.

My own rule



The vitamin pot in the cupboard needs a different kind of question. **Supplements are pills, capsules or drinks that add vitamins, minerals or other substances to your diet.** The research splits sharply between people who are short of something and people who already eat enough.

> **Key Concept:**
> Deficiency. A deficiency is **a real shortage of a vitamin or mineral in your body**, usually found with a blood test. A car's fuel gauge makes a handy comparison. Filling an empty tank gets the car moving, and pouring more fuel into a full tank does nothing.

A fuel gauge



For healthy adults, **a Cochrane review of 28 studies with more than 83,000 people found no evidence "that any vitamin or mineral supplementation strategy for cognitively healthy adults in mid or late life has a meaningful effect on cognitive decline or dementia"** (Rutjes et al., 2018). The authors added that the evidence "does not permit definitive conclusions".

Two multivitamin trials

	Grodstein et al., 2013	Yeung et al., 2023
Who	5,947 male doctors aged 65 and over	3,562 older adults
Result	Did not provide cognitive benefits	Equivalent of 3.1 y of age-related memory change

Multivitamins are where the trials disagree, and **both sides deserve their full weight**. A long trial in male doctors found no benefit, and a newer trial in older adults found a small memory gain. Each trial compared a daily multivitamin with a placebo, a dummy pill that looks the same.

> Science Says:
>
> In 5,947 male doctors aged 65 and over, 12 years of a daily multivitamin "did not provide cognitive benefits" (Grodstein et al., 2013). **The authors noted that the doctors may have been so well fed that a pill had little to add.**

> Science Says:
>
> In 3,562 older adults, those taking a daily multivitamin remembered more straight after seeing the items on an online test after one year, with "no significant effects on secondary outcomes", the other, less central things the trial measured (Yeung et al., 2023). **The authors estimated the gain as the "equivalent of 3.1 y of age-related memory change".**

The WHO weighed this kind of evidence in its 2019 guidelines on cognitive decline and dementia. **It said "Vitamins B and E, polyunsaturated fatty acids and multi-complex supplementation should not be recommended to reduce the risk of cognitive decline and/or dementia"** (World Health Organization, 2019). Polyunsaturated fatty acids include omega-3, and multi-complex means pills that mix many vitamins and minerals.

Its panel rated the evidence moderate and the recommendation strong. **The advice is for people without a nutrient shortage**, because the guidelines assume shortages "have been assessed and treated" first. Yeung's trial came out four years later, so the WHO panel did not weigh it.

The two trials studied different people with different tests. **Grodstein's 12 years, Rutjes's review and the WHO advice sit on the no-benefit side**, and Yeung's single memory gain at one year sits on the other. I read the multivitamin evidence as mixed, and I make no recommendation either way.

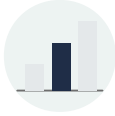
The multivitamin evidence



Grodstein's 12 years, Rutjes's review and the WHO advice sit on the no-benefit side



Yeung's single memory gain at one year



I read the multivitamin evidence as mixed

B vitamins have their own trials. **An older Cochrane review found "no adequate evidence of benefit from folic acid supplementation with or without vitamin B12" in unselected healthy older people** (Malouf & Grimley Evans, 2008). One trial in people with high

homocysteine showed a benefit. Homocysteine is a substance in the blood that rises when certain B vitamins run low.

> **Key Concept:**
>
> Mild cognitive impairment. **Mild cognitive impairment means memory problems larger than normal ageing that fall short of dementia.** A Cochrane review of 5 trials with 879 people with this problem found "no evidence for beneficial effects on cognition" from B vitamins over six to 24 months, and called the evidence "very limited" (McCleery et al., 2018).

In a brain-scan trial **of 271 people over 70 with mild cognitive impairment, B vitamins slowed brain shrinking to 0.76% a year against 1.08%** with a dummy pill (A. D. Smith et al., 2010). The effect was tied to homocysteine above 13 μmol/L, and the rate of brain shrinking was the main measure of the trial.



Omega-3 fats have been tested in people who already have dementia. **A review of 3 trials with 632 people with mild to moderate Alzheimer's disease found "no evidence of a benefit from omega-3 PUFAs on cognitive function"** at six months (Burckhardt et al., 2016). PUFAs is short for polyunsaturated fatty acids.

The omega-3 result applies to people with Alzheimer's disease. **It tells us nothing either way about healthy people**, because nobody

healthy was in those trials. Reading who took part before reading the result is a habit worth keeping for any health headline.

The table below gathers the supplement trials by group, so **you can see who was studied before you read what was found**.

Supplement	Who was studied	Result
Vitamins and minerals	Healthy adults in mid or late life	No evidence of a meaningful effect
Multivitamin	Male doctors aged 65 and over	No benefit over 12 years
Multivitamin	Older adults, online test	Better recall at one year
B vitamins	Over 70, mild impairment, high homocysteine	Slower brain shrinking
B vitamins	Mild cognitive impairment	No benefit on mental skills
Omega-3	Mild to moderate Alzheimer's disease	No benefit at six months

Supplements may help when a doctor finds a real shortage, and **the clearest signals in the table come from groups with a measured problem**, such as high homocysteine. **If you suspect you are short of a vitamin, please ask your doctor for a blood test** before you buy anything. A doctor can treat a deficiency safely.

Back at the cupboard



Toast, fruit and a glass of water



Drinking to thirst



A deficiency is a job for a test

Back at the cupboard, the vitamin pot can wait for a doctor's view. **The rushed morning has a cheaper fix in toast, fruit and a glass of water.** The breakfast studies were in children and teenagers only, so regular meals and drinking to thirst are my own advice for adults, and a deficiency is a job for a test.

> Exercise:
>
> Breakfast and water notes.
>
> 1. For one working week, note whether you ate breakfast and what it was.
> 2. Note how many drinks of water you had by midday, and whether you felt thirsty.
> 3. Rate how clear your head felt at eleven o'clock, from 1 to 5.
> 4. **Compare the clear mornings with the foggy ones** at the end of the week.

Key idea:

Eat regular meals, drink when you are thirsty, and leave vitamin pills to a doctor's test.

Quick check:

A friend in good health with a varied diet asks whether a daily multivitamin will protect her memory. What does the evidence show?
Answer: the trials are mixed, a large review found no evidence of a meaningful effect in healthy adults, though the evidence "does not permit definitive conclusions", and the WHO advises against such pills for this purpose, so she should ask her doctor.

5.4 Stimulants and Enhancement Claims

5.4.1 Caffeine, Supplements and "Smart Drugs"

THE REPORT IS DUE at five, and **you are on your third coffee by two o'clock**. Your phone shows an advert for capsules that promise "laser focus" and a sharper memory. A colleague mentions a friend who takes a prescription pill before exams. All three promise the same thing, a better mind by the afternoon.



An office desk late in the afternoon with three empty coffee cups lined up beside a keyboard and a wilting plant.

Caffeine is the one of the three that most people already use. **A review found that "Caffeine is consumed by over 80% of U.S. adults"** (McLellan et al., 2016). It is a mild stimulant, a substance that speeds up the brain and body, found in coffee, tea and many soft drinks, and the review set out what it helps.

> **Science Says:**
>
> After low to moderate doses, from about 40 mg to about 300 mg, **"alertness, vigilance, attention, reaction time and attention improve"** (McLellan et al., 2016). The review found "less consistent effects" on memory and "higher-order executive function". Caffeine makes you quicker and more watchful, and its effect on careful reasoning is patchier.

Low to moderate doses



A study with a blunt title, "Faster but not smarter", asked how much of the lift is real for regular coffee drinkers. **The answer was that much of it simply undoes the slump of going without.** People who drink coffee every day start each morning a little short, and the first cup puts them back to normal.

> **Science Says:**
>
> Researchers tested 369 regular caffeine consumers after a night without it (Rogers et al., 2013). **Caffeine mainly improved measures that withdrawal had pulled down.** The authors concluded that "tolerance to its effects on sleepiness means that frequent consumption fails to enhance mental alertness and mental performance".

> **Key Concept:**
> Tolerance and withdrawal. **Tolerance means your body gets used to a drug**, so the same dose does less over time. Withdrawal is the dip you feel when the usual dose is missing, such as a morning headache before coffee. Refilling a tank you drained overnight brings you back to full, and it never takes you above full.

For most healthy adults, caffeine is safe within limits set by food safety agencies. **The European Food Safety Authority looked at the evidence and set figures for different groups.** The figures are the agency's safety limits, never a target to aim for, and they were set for health, with no claim about performance.

> **Science Says:**
> The European agency found that "Single doses of caffeine up to 200 mg ... do not give rise to safety concerns" (EFSA Panel on Dietetic Products, Nutrition and Allergies, 2015). **Habitual intake "up to 400 mg per day does not give rise to safety concerns for non-pregnant adults"**, with a lower figure of 200 mg a day for pregnant women. For children, the information was "insufficient".

EFSA safety limits for caffeine



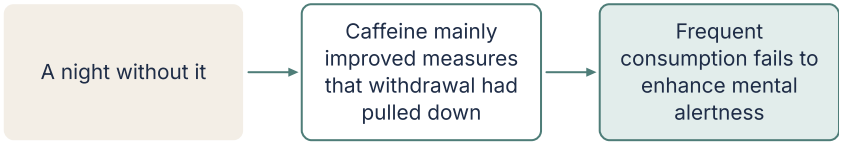
A review of caffeine safety drew the same line. **For healthy adults, it found caffeine "relatively safe", and for some vulnerable groups "could be harmful"** (Temple et al., 2017). The groups it named

include pregnant and breastfeeding women, children and teenagers, and people with heart or mental health conditions.

If you are pregnant, have a heart or mental health condition, or are choosing for a child, please ask your doctor about caffeine. Sensitivity varies from person to person, and a doctor can judge what is safe for you. Nothing in this section is a dose for you to take.

The bedtime study in 5.1.1 found that caffeine six hours before bed still disrupted sleep, and tolerance adds a twist. That sleep result came from one 400 mg dose taken 6 hours before bed. For a daily drinker, caffeine gives little real lift above normal, so a big late dose costs sleep for little gain.

Faster but not smarter



Some products pair caffeine with L-theanine, a substance found in tea. **A review of 11 studies with dummy-pill controls found "moderate effect sizes in favor of combined caffeine and L-theanine in the first 2 hours"** for alertness and switching attention (Camfield et al., 2014). The studies were small, and caffeine seemed to drive more of the change.



A tall ginkgo tree with fan-shaped golden leaves standing in a quiet park on an autumn morning.

Herbal pills make bigger claims. **Ginkgo, an extract from the leaves of the ginkgo tree, was tested in a large trial in older adults** to see whether it could prevent dementia. The trial ran for years and gave clear answers on two questions.

> **Science Says:**
>
> In 3,069 volunteers aged 75 and over, followed for a median of 6.1 years, ginkgo was "not effective in reducing either the overall incidence rate of dementia or AD incidence" (DeKosky et al., 2008). **A second report from the same trial found it "did not result in less cognitive decline"** in older adults "with normal cognition or with mild cognitive impairment" (Snitz et al., 2009).

> Science Says:
>
> Ginseng has a weaker evidence base. **A Cochrane review found "a lack of convincing evidence to show a cognitive enhancing effect of Panax ginseng in healthy participants"** (Geng et al., 2010). The review searched studies up to 2009, so newer trials may exist, though none in my sources has changed the picture for healthy people.

Vitamin pills fare no better for this purpose. **The WHO guidance told in 5.3.2 says B and E vitamins, fatty acids and multivitamin-type pills "should not be recommended" to reduce cognitive decline** (World Health Organization, 2019). Put beside the ginkgo and ginseng results, the shelf of brain pills has little trial support for healthy people.

The ginkgo trial



3,069 volunteers aged 75 and over



A median of 6.1 years



Did not result in less cognitive decline

"Smart drugs" are prescription medicines taken to boost the mind, such as stimulants and modafinil. **Stimulants are drugs that speed up the brain and body**, and methylphenidate is one of them. Modafinil is a medicine doctors prescribe to help people stay awake. The studies below gave these drugs to healthy people, and two terms help in reading them.

> **Key Concept:**
> Inhibitory control and episodic memory. **Inhibitory control is the skill of stopping a habit**, such as holding back the automatic answer. Episodic memory is your memory for events, such as what happened at lunch.

> **Science Says:**
> A review of 48 studies with 1,409 healthy people found "small but significant" effects of prescription stimulants on inhibitory control and short-term episodic memory (Ilieva et al., 2015). **The authors judged the benefit "probably modest overall"**, and suggested that users may seek "energy and motivation more than their cognition".

Small gains in inhibitory control and episodic memory are real, and **they are a long way from the "limitless mind" of the adverts**. A louder engine on the same car makes more noise without changing where the road goes.

Stimulants in healthy people

IE

Ilieva et al., 2015

- 48 studies with 1,409 healthy people
- Probably modest overall

Modafinil gives a mixed picture in rested, healthy people. **A review found that most basic tests showed better executive function, "only half show improvements in attention and learning and memory", and a few found harm to creative idea generation**

(Battleday & Brem, 2015). A drug that helps one skill and harms another is no reliable boost.

A further review looked at the gap between hope and result. **It concluded that "expectations regarding the effectiveness of these drugs exceed their actual effects"** (Repantis et al., 2010). Methylphenidate improved memory with no consistent sign of other gains, and modafinil may cause "overconfidence", a poor partner for any task where you must check your answer.

The claim that smart drugs reliably make healthy people sharper is not supported by these reviews. **These are prescription medicines with real risks, and they should never be taken without a prescription. If you are tempted, please talk to your doctor first**, and never take a pill prescribed for someone else.

Product	What the studies found	Who was studied
Caffeine	Faster and more alert, weaker on reasoning	Adults in many studies
Caffeine in daily users	Mostly undoes withdrawal	369 regular consumers
Caffeine with L-theanine	Moderate short-term lift, caffeine leads	11 small studies
Ginkgo	No fewer dementia cases, no slower decline	3,069 adults aged 75 and over
Ginseng	No convincing evidence	Healthy people
Prescription stimulants	Small gains, "probably modest overall"	1,409 healthy people

The table puts the evidence in one place, and **the pattern across the rows is small, short or none**. My own rule follows from it. I keep caffeine for the morning, I get my sleep first, and I take no pill for my intellect unless a doctor has a medical reason to prescribe it.

Back at the desk, the report is still due at five. **The third coffee will make you quicker, and it will not make your argument any better.** The capsules in the advert have no good evidence behind them, and the prescription pill belongs to someone else. The fastest help for the afternoon was a good night before it.

> Exercise:
>
> A caffeine diary.
>
> 1. For one week, write down each drink with caffeine and the time you had it.
> 2. Rate your alertness from 1 to 5 an hour after each one.
> 3. Note the time of your last cup and how well you slept that night.
> 4. **Look at the afternoon cups**, and try moving them to the morning for the next week.

Key idea:

Caffeine makes you faster for a while, and no pill has been shown to make a healthy mind reliably sharper.

Quick check:

You drink coffee every morning and feel sharper after the first cup. What does the "Faster but not smarter" study suggest is happening? Answer: much of the lift is the cup undoing the dip from going without caffeine overnight, so for a daily drinker it brings you back to normal more than above it.



Module

6

Protecting Intellectual Function Over Time

6.1 Managing Strain

6.1.1 Stress, Anxiety, Mental Fatigue and Recovery

It is the hour before a big presentation, and **your mind goes blank on a figure you have known for weeks**. Your heart thumps, your palms are damp, and a simple sum on your own slide looks like a foreign language. An hour later, on the walk to the station, the answer floats back without any effort at all.



A woman in a navy coat pausing on a busy footbridge at rush hour, one hand pressed flat against her chest.

Researchers have studied that blank moment for decades. **Stress is the strain you feel when demands seem bigger than your means to meet them**, and a short burst of it changes how the brain handles careful work. In this book intellect means solving tasks where the variables are identified, and stress gets in its way.

Science Says:

A review of many experiments found that short bursts of stress "impaired working memory and cognitive flexibility, whereas it had nuanced effects on inhibition" (G. S. Shields et al., 2016). **Cognitive flexibility is your ability to switch between ways of tackling a problem.** Inhibition means holding back an automatic response.

Short bursts of stress



Impaired working memory



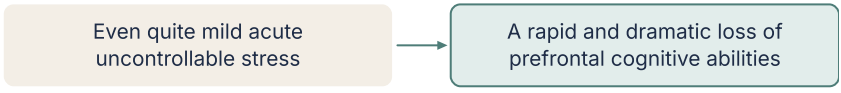
Impaired cognitive flexibility



Nuanced effects on inhibition

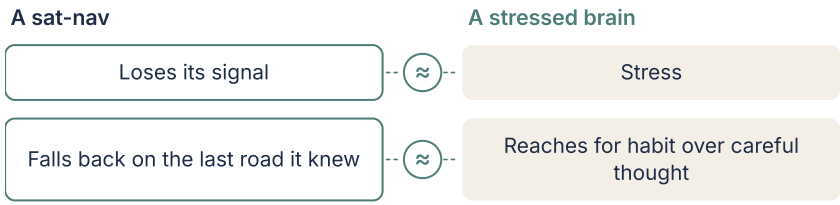
One brain researcher put the effect bluntly. **"Even quite mild acute uncontrollable stress can cause a rapid and dramatic loss of prefrontal cognitive abilities"** (Arnsten, 2009). The prefrontal cortex is the area behind your forehead that plans, holds goals in mind and keeps impulses in check.

Acute stress



In a later review she wrote that stress flips "the brain from reflective to reflexive control of behavior" (Arnsten, 2015). **A sat-nav that loses its signal falls back on the last road it knew**, and a stressed brain likewise reaches for habit over careful thought. Much of the detailed brain work behind both reviews comes from studies in animals.

A sat-nav that loses its signal



> **Key Concept:**
>
> Acute and chronic stress. **Acute stress is a short burst, such as a deadline or a near miss on the road.** Chronic stress drags on for weeks or months. A review of animal and human studies found that the effects of long exposure to stress hormones "emerge as a function of the timing and the duration of the exposure" (Lupien et al., 2009).

Long stress differs from one bad afternoon. **Arnsten's first review linked "more prolonged stress exposure" with "architectural changes in prefrontal dendrites"**, the branches that brain cells use to receive signals, a finding drawn largely from animal work. Her second review described chronic stress as leading "to persistent loss of PFC function", PFC being short for prefrontal cortex.

Anxiety is the close cousin of stress. **Anxiety is worry about what might happen**, and it can hang around long after the deadline has passed. A large review pooled 177 samples with 22,061 people and found self-reported anxiety "reliably related to poorer performance on measures of working memory capacity" (Moran, 2016).

Acute and chronic stress

	Acute stress	Chronic stress
How long	A short burst, such as a deadline	Drags on for weeks or months
What it does	Loss of prefrontal cognitive abilities	Persistent loss of PFC function

The link was small to moderate, an effect size of about -0.33, across simple and complex memory tasks. **This is a link that cannot show cause**, since a weaker working memory might make daily life feel harder and raise anxiety in turn. Most people in these studies rated their own anxiety on a questionnaire.

> Science Says:
>
> A theory of anxiety proposes that it "impairs efficient functioning of the goal-directed attentional system" (Eysenck et al., 2007). **The authors argued that anxiety "may not impair performance effectiveness (quality of performance) when it leads to the use of compensatory strategies"**, such as trying harder.

In plain terms, an anxious student may still reach the right answer and pay for it in extra effort and time. **A rowing boat with a dragging anchor can still reach the shore, at the cost of tired arms.** That idea comes from the authors' framework, and it is a theory waiting for further tests.



Depression calls for separate care. **A review of 113 studies found that major depression "is reliably associated with impaired performance on neuropsychological measures of EF"**, with effect sizes "ranging from 0.32 to 0.97" (Snyder, 2013). EF stands for executive function, the measures are tests of mental skills, and slower movement "cannot account for these results".

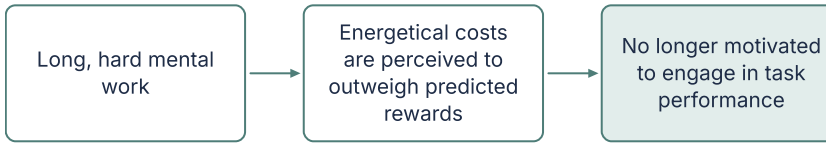
The people in that review had a diagnosis of major depression, so **these results do not describe an ordinary low day. If low mood or worry has lasted for weeks, or gets in the way of work or home life, please talk to your doctor or another health professional.**

> **Key Concept:**
>
> Mental fatigue. **Mental fatigue is the tired, foggy feeling that follows long, hard mental work.** One proposal says people "will no longer be motivated to engage in task performance when energetical costs are perceived to outweigh predicted rewards" (Boksem & Tops, 2008). On this view the mind weighs effort against payoff, like a shopper deciding whether a long queue is worth joining.

The proposal still waits for direct tests. **A review of 11 studies looked at what mental fatigue does to the body**, and found "a decline in endurance performance" with "higher than normal perceived exertion"

(Van Cutsem et al., 2017). Perceived exertion is how hard an effort feels to you.

Mental fatigue



Heart rate and similar body measures "were unaffected", and the legs kept their full strength and power. **The legs worked as before, and the run simply felt harder.** The tiredness seemed to live in the judgement of effort, which fits the cost and benefit idea. These were lab studies with a small evidence base.



A runner pausing on a wet park path at dawn, hands on her knees, steam rising from her shoulders.

A tired mind wanders more easily. **A review of 88 samples of adults found that "increases in mind-wandering were generally associated with decreases in task performance"**, and the link "was

more pronounced for more complex tasks" (Randall et al., 2014). Mind-wandering means thoughts drifting off the task, and this is a link that cannot show cause.

Recovery is where the research turns hopeful. **Short switches of task, a kinder reading of your own nerves and some forms of training all have evidence behind them**, each with limits I will spell out. Sleep is the biggest recovery tool of all, and 5.1.1 covers it in full, so I leave it there.

Recovery

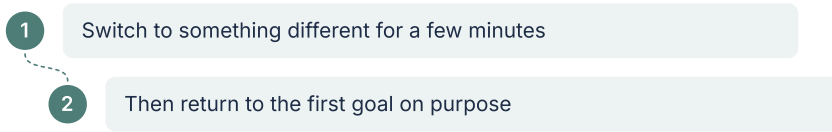


> **Science Says:**
> In a lab task, people watched a screen for a long time, and attention usually fades on such tasks, a drop called the vigilance decrement. **When people "were asked to sporadically recollect the digits during the vigilance task, the vigilance decrement was averted"** (Ariga & Lleras, 2011). The authors suggested the mind gets used to a goal, much as you stop hearing a ticking clock.

Ariga and Lleras ran one study of one visual task. **It gives no rule such as a break every twenty minutes**, and I would distrust anyone who sells a magic interval. My own advice is modest. When a long task starts

to blur, switch to something different for a few minutes, then return to the first goal on purpose.

When a long task starts to blur



How you read your own pounding heart may help. **In a lab experiment, people taught to see their stress arousal "as functional and adaptive" showed "more adaptive cardiovascular stress responses"**, healthier heart and blood-vessel reactions, and paid less attention to threats (Jamieson et al., 2012). It was a single study, so I treat it as a promising lead.

Reading your pounding heart



Mindfulness means paying calm attention to the present moment, often through breathing exercises. **Mindfulness-based stress reduction, or MBSR, is a structured course built on that practice.** A review of 29 studies with 2,668 healthy adults found MBSR "moderately effective in reducing stress, depression, anxiety and distress" (Khoury et al., 2015).

> **Science Says:**
> A review of 47 trials with 3,515 adults compared meditation programmes with other treatments. **Mindfulness programmes gave "moderate evidence of improved anxiety", an effect size of 0.38 at eight weeks**, and "no evidence that meditation programs were better than any active treatment (ie, drugs, exercise, and other behavioral therapies)" (Goyal et al., 2014). Evidence on attention and sleep was low or insufficient.

In clinical samples, **a review of 39 studies with 1,140 people found large drops in symptoms after mindfulness-based therapy**, with effect sizes of 0.97 for anxiety and 0.95 for mood in people with those disorders (Hofmann et al., 2010). These were before-and-after changes with no comparison group.

Mindfulness effect sizes



Mindfulness is a reasonable tool for everyday stress, and the trials give it no special power over exercise or other therapies. For an anxiety disorder or depression it is no replacement for care, so please see a clinician about the right treatment. The table below gathers what the reviews found and who took part.

Strain	What one review found	Who was studied
Short burst of stress	Poorer working memory and flexibility	Lab experiments
Anxiety	Small to moderate link with poorer working memory	Mostly general samples

Strain	What one review found	Who was studied
Major depression	Weaker executive function	People with a diagnosis
Mental fatigue	Effort felt harder, endurance fell	Lab studies
Recovery with MBSR	Moderate drop in stress and anxiety	Healthy adults

Back on the walk to the station, the lost figure returned once the pressure lifted. **The blank was stress doing what the reviews describe, and the return was recovery doing its work.** Short strain is part of a full life, and the habit worth building is a regular way back from it.

> Exercise:
>
> A strain and recovery log.
>
> 1. For one working week, note the hour when your head felt most strained.
> 2. Rate the strain from 1 to 5 and write one word for its cause.
> 3. Note what you did next, such as a short switch of task, a walk, a few slow breaths or nothing.
> 4. **At the end of the week, see which recoveries brought you back fastest.**

Key idea:

A clear head under strain = Short bursts of stress + Regular recovery.

Quick check:

A colleague says mindfulness will cure her anxiety disorder and sharpen her attention. What does the evidence show? Answer: in trials, mindfulness programmes eased anxiety a little, no better than other active treatments, with no clear effect on attention, so for a disorder she should see a clinician.

6.2.1 Blood Pressure, Blood Sugar and Cardiovascular Health

THE NURSE AT YOUR local surgery wraps the cuff round your arm, and **the number on the screen is higher than it was last year**. A letter the following week says your blood sugar sits on the high side of normal. You feel perfectly well, and you file the letter away.



A nurse fitting a blood pressure cuff on the arm of a middle-aged man in a small surgery room with a pot plant on the sill.

Your brain runs on the blood that your heart and vessels deliver, **so the health of that delivery system reaches your mind**. In this book intellect means solving tasks where the variables are identified. The conditions in this section do their damage slowly, over years, and often without a single symptom along the way.

> **Science Says:**
> The WHO's dementia fact sheet lists risk factors that include "high blood pressure (hypertension), high blood sugar (diabetes), being overweight or obese, depression, vision and hearing loss, poor sleep" (World Health Organization, n.d.). **Several of these are things a clinician can measure at a routine check.**

In 5.3.1 I mentioned the Lancet Commission's view that treating high blood pressure has likely helped lower the rate of dementia at each age in richer countries (Livingston et al., 2024). **This section adds what happened when trials tested blood pressure treatment directly.** The trials give a more careful answer than the headlines.

The largest single trial is known as SPRINT MIND. **In 9,361 adults aged 50 or older with high blood pressure, none with diabetes or a past stroke, one group aimed for a lower blood pressure and the other for the usual level** (SPRINT MIND Investigators for the SPRINT Research Group, 2019). Their average age was 67.9.

> **Science Says:**
> A hazard ratio compares risk in two groups, and below 1 means lower risk in the treated group. For probable dementia it was 0.83, with a range of 0.67 to 1.04 that crossed 1, so the result was not significant. **For mild cognitive impairment it was 0.81 (0.69 to 0.95), a significant drop**, and both combined fell to 0.85, also significant. The authors wrote that "the study may have been underpowered for this end point".

Underpowered means not enough people developed dementia during the trial to tell a small effect from chance. **The fair summary is that**

the lower target reduced mild cognitive impairment in people with high blood pressure, while the result for dementia itself stayed uncertain. The target suited that selected trial group, and I give no target here.



A pooling of trials gives the wider view. **Across 14 trials with 96,158 people, dementia or cognitive impairment appeared in 7.0% of those whose blood pressure was lowered and 7.5% of the others** (Hughes et al., 2020). The authors gave an "absolute risk reduction, 0.39%". Lowering blood pressure was "not significantly associated with a change in cognitive test scores".

> **Key Concept:**
>
> Absolute risk. **Absolute risk is the plain chance of something happening in a group**, such as 7 in 100. Hughes's trials moved it from 7.5 in 100 to 7.0 in 100. Say a train carriage holds 250 people. A drop that size means about one fewer person in the carriage with the condition.

The two kinds of evidence point in slightly different directions, and **both deserve a fair hearing**. SPRINT MIND, one large trial, found no significant drop in dementia itself. The pooled trials found a small, significant drop in dementia and cognitive impairment counted together. I leave the two results side by side for you to weigh.

Two kinds of evidence

	SPRINT MIND	Hughes et al., 2020
Design	One large trial	14 trials with 96,158 people
Dementia	No significant drop in dementia itself	A small, significant drop in dementia and cognitive impairment counted together

Counted together, mild impairment and dementia fell significantly in SPRINT MIND, as they did in Hughes's pooling. Dementia on its own is the result that stays uncertain.



A tall glass jar of white marbles on a sunny windowsill, a small handful of red ones scattered among them.

The fairest single line is that **lowering high blood pressure is linked with a small reduction in risk**. That wording claims less than "prevents dementia", and it fits both results. The people in Hughes's

trials had an average age of 69 and high readings at the start, so the finding belongs to people like them.

Studies of everyday patients add a third view. **In six cohorts with 31,090 adults over 55 without dementia, those with high blood pressure who used any blood pressure medicine had a lower hazard of dementia, 0.88** (Ding et al., 2020). No single type of medicine stood out, and among people with normal blood pressure there was "no association".

Ding's study observed people and gave no one a treatment, so **it is a link that cannot show cause**. Choosing a medicine is a job for your doctor. **If your blood pressure reading is high, please see a clinician, and never start, stop or change a medicine on your own.**

Everyday patients

DE

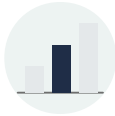
Ding et al., 2020

- Six cohorts with 31,090 adults over 55
- A lower hazard of dementia, 0.88

> 🔑 **Key Concept:**
>
> Type 2 diabetes. **Type 2 diabetes is a condition in which the body struggles to keep blood sugar in a healthy range.** A pooling of 28 studies found a "73% increased risk" of dementia with diabetes, and added that "Higher and medium quality studies did not show any significant difference for pooled RR" (Gudala et al., 2013). RR means relative risk.

Gudala's second sentence is a fair warning, since **the strongest studies in the pool found no clear difference**. A review of 14 population studies found higher rates of dementia with diabetes "in seven of ten studies" that measured it (Biessels et al., 2006). Data on how well the diabetes was controlled were "generally absent".

Diabetes and dementia



A "73% increased risk"



Higher rates "in seven of ten studies"



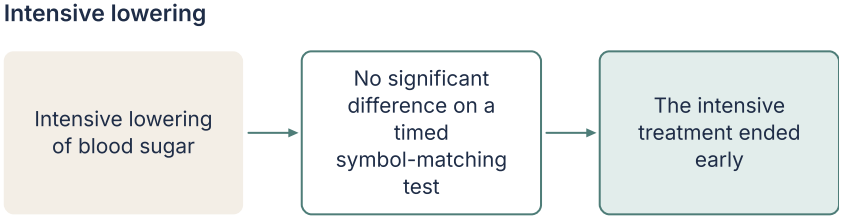
The strongest studies in the pool found no clear difference

> **Science Says:**
>
> A review of 25 long-term studies found "1.2- to 1.5-fold greater change over time in measures of cognitive function" in people with diabetes, and the "odds of future dementia increased 1.6-fold" (Cukierman et al., 2005). **All of these studies observed people, so each is a link that cannot show cause.**

A trial tested whether pushing blood sugar lower would help the brain. **In 2,977 adults with type 2 diabetes at high risk of heart disease, average age 62.5, intensive lowering gave no significant difference on a timed symbol-matching test after 40 months** (Launer et al., 2011). Brain volume scans favoured the intensive group.

The authors concluded that the findings "do not support the use of intensive therapy to reduce the adverse effects of diabetes on the brain". **The intensive treatment ended early because more people died in**

that group. If you have diabetes, please talk to your clinician before changing any part of your treatment.



Some studies look back at middle age. **In 8,845 health plan members checked at ages 40 to 44, smoking, high blood pressure, high cholesterol and diabetes were "each associated with a 20 to 40% increase in risk"** of later dementia (Whitmer et al., 2005). Having all four gave a hazard ratio of 2.37 against none.

> **Key Concept:**
>
> Amyloid. **Amyloid is a protein that can clump in the brain**, and large clumps are a mark of Alzheimer's disease. In 322 people without dementia, those with two or more risk factors around age 52 had odds of 2.88 for raised amyloid on scans taken at 67 to 88 (Gottesman et al., 2017). Risk factors measured late in life were "not associated".

Weight and smoking fit the pattern. **Across 15 studies, midlife obesity went with a higher risk of any dementia, 1.64**, while "Continuous BMI in late-life was not associated with dementia" (Anstey et al., 2011). Across 19 studies with an average age of 74, current smokers had a risk of 1.27 against people who never smoked (Anstey et al., 2007).



The midlife findings are about when a measure was taken, and **every one of them is a link that cannot show cause**. Taken together, they suggest that the vessel health you build in your forties and fifties may count for more than a single reading in old age. The table below sums up the evidence.

Factor	What was found	Kind of study
High blood pressure	Small drop in risk when lowered	Trials
Diabetes	Higher dementia risk in most studies	Observational
Intensive sugar lowering	No gain on tests, more deaths	Trial
Midlife risk factors	Higher later risk, more amyloid	Observational
Midlife obesity and smoking	Higher later risk	Observational

Back at the surgery, the letter about blood sugar deserves a place on the fridge door. **The higher reading is an early nudge, and early is the best time to act on it with your clinician.**

At your next check

1. Ask what each number means
2. Write it down
3. Book the next check before you leave the building

My own advice is to treat these numbers as part of looking after your mind. **Ask what each number means, write it down, and book the**

next check before you leave the building. A number you know is a number you can work on with your clinician.

> Exercise:
>
> Know when you were last checked.
>
> 1. Find the date of your last blood pressure reading.
> 2. If you cannot remember it, ask your surgery or pharmacy about a check.
> 3. Ask your clinician whether a blood sugar or cholesterol test makes sense for you.
> 4. **Write the results and the date of the next check on one card**, and keep it with your diary.

Key idea:

What keeps your blood vessels healthy is linked with keeping your mind healthy, and a clinician checks both.

Quick check:

A friend reads that lowering blood pressure "prevents dementia". What do the trials show? Answer: one large trial cut mild cognitive impairment without a significant drop in dementia, and pooled trials found a small drop in risk, so the fair word is "linked with", and the treatment is for a clinician to decide.

6.2.2 Hearing, Vision, Medication and Avoidable Risks

AT A FAMILY SUNDAY lunch your father nods along to the stories, **laughs a beat late at the jokes and says less with every course**. By the pudding he has gone quiet, and later he admits he caught about half of what was said. Nobody at the table thought of his ears, and he did not mention them either.



An older man at the end of a crowded Sunday lunch table, leaning one ear towards his laughing grandchildren.

Straining to hear is like listening to a radio with a weak signal. **You can follow the programme, and the effort leaves little over for anything else.** In this book intellect means solving tasks where the variables are identified, and a conversation you half hear leaves gaps in those variables before you start.



> **Science Says:**
> A review of 36 studies with about 20,264 people linked hearing loss with poorer mental skills. **In the long-term studies, hearing loss went with higher odds of dementia, 1.28**, and the link with Alzheimer's disease on its own was not significant (Loughrey et al., 2018). The authors called hearing loss a "possible biomarker and modifiable risk factor" and said trials were "warranted".

In 5.3.1 I listed hearing loss and untreated vision loss among the Lancet Commission's risk factors that can be changed (Livingston et al., 2024). **A list of risks leaves open the next step, whether treating the problem helps the brain.** For hearing, two kinds of evidence give different answers, and I set them out side by side.

A review of 31 studies with 137,484 people compared hearing aid or implant users with people whose hearing loss went uncorrected. **In 8 of the studies, with 126,903 people, users had a lower hazard of "any cognitive decline", 0.81** (Yeo et al., 2023). The authors said the benefit "should be further investigated in randomized trials".



A small hearing aid resting in an open palm beside a mug of cocoa on a bedside table.

Most of those studies observed people, **so the Yeo review is a link that cannot show cause**. People who get hearing aids may differ from people who do not in many ways. A trial removes those differences by deciding at random who gets the treatment.

> **Science Says:**
>
> The ACHIEVE trial gave 977 adults aged 70 to 84 with untreated hearing loss either hearing care or health education. **After three years, the change in test scores was "not significantly different" between the groups** (F. R. Lin et al., 2023). The effect differed between the trial's two sources of volunteers.

One source, a long-running heart study called ARIC, supplied volunteers who **"were older, had more risk factors for cognitive decline, and had lower baseline cognitive scores"** (F. R. Lin et al., 2023), and any benefit showed up in that higher-risk group only. The trial's main result for everyone was null.

The observational review found a lower hazard among users, and the trial found no overall difference. **I leave both results standing, with no verdict between them.** The trial is the stronger design for cause, and the review covered far more people over longer periods.

Hearing aids and cognitive decline

	Yeo et al., 2023	The ACHIEVE trial
Who	8 studies with 126,903 people	977 adults aged 70 to 84
Result	A lower hazard of "any cognitive decline", 0.81	"Not significantly different"

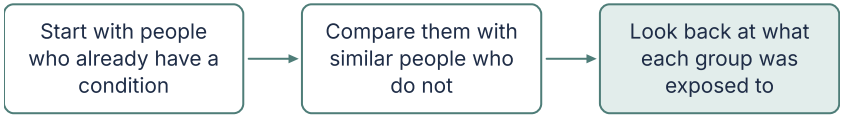
One point is clear on either reading. **Hearing aids are worth having for hearing and conversation**, and their effect on the brain is unproven, except possibly in higher-risk older adults. **If you or someone close to you struggles to follow conversation, please book a hearing test with a clinician.**

Cataracts have been studied in a similar way. **In 3,038 people with an average age of 74.4 when a cataract was found, those who had cataract surgery had a lower hazard of dementia, 0.71** (Lee et al., 2022). A cataract is a clouding of the lens of the eye. The authors wrote of the link "If validated in future studies".

Lee's was an observational study, so **cataract surgery has been linked with lower risk and has not been shown to prevent dementia**. It does restore sight, which is reason enough to ask an eye doctor about cloudy vision. Medicines come next, and they call for the most care in this section.

> **Key Concept:**
>
> Case-control study. **A case-control study starts with people who already have a condition, the cases, and compares them with similar people who do not, the controls.** Researchers then look back at what each group was exposed to in earlier years. It is a fast way to spot links and a weak way to prove cause.

A case-control study



Anticholinergic medicines block a chemical messenger the body uses in the brain, gut and bladder. **In 284,343 people with dementia, average age 82.2, and matched controls, the highest use of strong anticholinergics went with higher odds of dementia, 1.49** (Coupland et al., 2019). The authors wrote that such use "is associated with an increased risk of dementia".

A US study followed people for an average of 7.3 years, and **the heaviest long-term users had a hazard ratio of 1.54** (S. L. Gray et al., 2015). The common types named in that study were "tricyclic antidepressants, first-generation antihistamines, and bladder antimuscarinics", and these are links in older adults that cannot show cause.

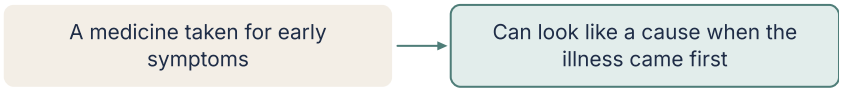
Strongest anticholinergics and dementia



> **Science Says:**
> In 40,770 people aged 65 to 99 with dementia and 283,933 controls, the strongest anticholinergics went with slightly higher odds, 1.11 (K. Richardson et al., 2018). **Risk rose with use for "antidepressant, urological, and antiparkinson drugs"**, and the authors noted the link could reflect "drugs being used for very early symptoms of dementia".

Reverse cause is when the effect comes first and only looks like the cause. **A medicine taken for early symptoms can look like a cause when the illness came first.** Benzodiazepines, medicines used for anxiety and sleep problems, face the same question.

Reverse cause



> **Key Concept:**
> Benzodiazepines. In 1,796 people over 66 with Alzheimer's disease and 7,184 controls, having ever used benzodiazepines went with odds of 1.51, higher with long use (Billioti de Gage et al., 2014). **The authors said use might be "an early marker" and that "Unwarranted long term use of these drugs should be considered as a public health concern".**

Please talk to your doctor or pharmacist before changing any medicine. Stopping some medicines suddenly can be dangerous, and each one was started for a reason. My own advice is to ask for a

medicines review once a year if you take several, and to bring the full list with you.

A medicines review

1. Ask for a medicines review once a year
2. Bring the full list with you
3. Talk to your doctor or pharmacist before changing any medicine

A traumatic brain injury, or TBI, is damage to the brain from a blow or jolt to the head. **In 2,794,852 Danes, a TBI went with a higher hazard of dementia, 1.24** (Fann et al., 2018). Risk was highest in the first six months and rose with the number of injuries, up to 2.83 for five or more.

The authors called for "Greater efforts to prevent TBI". **A cycle helmet, a grab rail on the stairs and a seat belt are my own everyday versions of that advice.** Air from traffic shows a much smaller link, and it needs a sense of scale.

Everyday versions of that advice



A cycle helmet



A grab rail on the stairs



A seat belt

In about 2.2 million adults aged 55 to 85 in Ontario, **living under 50 metres from a major road went with a hazard of 1.07 against living over 300 metres away** (H. Chen et al., 2017). There was no

link at 201 to 300 metres. The effect is very small and gives no reason to move house in a panic.

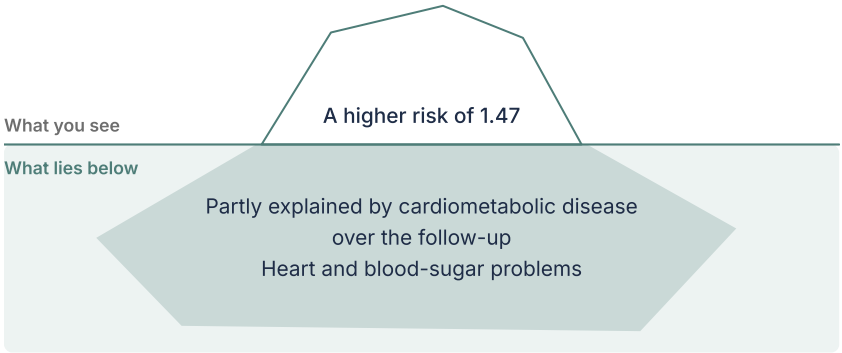
In 5.3.1 I described a study linking moderate drinking with a shrinking hippocampus, and two large studies add the link to dementia itself. Each is a link that cannot show cause. UK health advice counts drinks in units, and "One unit equals 10ml or 8g of pure alcohol" (NHS, n.d.).

> Science Says:
>
> In 9,087 civil servants aged 35 to 55 at the start, followed for 23 years, each extra 7 units a week above 14 was "associated with a 17%" higher risk of dementia (Sabia et al., 2018). **Midlife non-drinkers had a higher risk of 1.47 against people drinking 1 to 14 units**, likely confounded by other health differences.

The non-drinker result does not mean that drinking protects the brain. **The authors found that "the excess risk of dementia associated with abstinence in midlife was partly explained by cardiometabolic disease over the follow-up"**, meaning heart and blood-sugar problems (Sabia et al., 2018).

In a French study of over a million adults with dementia, "Alcohol use disorders were the strongest modifiable risk factor for dementia onset" (Schwarzinger et al., 2018). **If you are worried about your drinking, please talk to your doctor.** The table below gathers the risks in this section and the kind of study behind each.

Midlife non-drinkers



Risk	What was found	Kind of study
Hearing loss	Higher odds of dementia	Observational
Hearing aids	Lower hazard in one review, null overall in a trial	Both
Cataract surgery	Lower hazard of dementia	Observational
Strong anticholinergics	Higher odds in older adults	Case-control and cohort
Benzodiazepines	Higher odds of Alzheimer's disease	Case-control
Traumatic brain injury	Higher hazard, more with each injury	Cohort
Heavy drinking	Higher risk	Cohort

Back at the Sunday lunch, your father's silence may have been his ears all along. **A hearing test costs an afternoon and may give him back the conversation.** Whatever the trials finally show for the brain, being able to join in the jokes is worth having.

> **Exercise:**
>
> A senses and medicines check.
>
> 1. Write the date of your last hearing test and your last eye test.
> 2. List every medicine you take, including ones bought without a prescription.
> 3. Book any test that is overdue, and ask your pharmacist or doctor to review the list.
> 4. **Change nothing on the list until a clinician has looked at it with you.**

Key idea:

Look after your ears, eyes, head and medicine cabinet, with a clinician's help.

Quick check:

A neighbour says hearing aids are proven to prevent dementia. What do the studies show? Answer: an observational review found a lower hazard of decline among users, and a randomised trial found no difference overall, so the effect on the brain is unproven, though hearing aids help hearing.

6.3 Staying Engaged and Recognising Change

6.3.1 Social Connection and Meaningful Intellectual Activity

Your neighbour Ray once ran the allotment committee, **argued cheerfully about runner beans and knew everyone on the street by name**. Since he retired and his wife died, you see him less and less. The curtains stay drawn until noon, and the plot he loved has gone to seed behind its wire fence.



An overgrown allotment plot in late summer, bean canes leaning at odd angles beside a closed wooden shed.

Ray's story worries people for good reason. **Our ties to other people are linked with how long we live and how well our bodies run**, and several studies link them with the mind in later life. In this book intellect means solving tasks where the variables are identified, and company and new learning feed it.

> **Science Says:**
>
> A review of 148 studies with 308,849 people found "a 50% increased likelihood of survival for participants with stronger social relationships" (Holt-Lunstad et al., 2010). **A later review found higher odds of death with social isolation, 1.29, with loneliness, 1.26, and with living alone, 1.32** (Holt-Lunstad et al., 2015).

Those reviews measured survival, and **each finding is a link that cannot show cause**. People in poor health may see friends less, so illness could drive both. Isolation is having few contacts, and loneliness is the painful feeling of having fewer than you want.



An overview pulled the reviews together. **Across 40 reviews, "of mainly observational studies", it found loneliness and isolation tied to "increased all-cause mortality" and isolation tied to heart disease** (Leigh-Hunt et al., 2017). All-cause mortality means death from any cause.



A suspension bridge over a wide river at dawn, its many thin cables catching the early light.

The link reaches the body's own markers. **Across four large US samples, "a higher degree of social integration was associated with lower risk of physiological dysregulation in a dose-response manner"** (Yang et al., 2016). Dose-response means the effect grows step by step with the amount, and each step up in social ties went with healthier body readings.

A suspension bridge hangs on many cables, and losing one or two rarely brings it down. **People seem to work the same way, with each tie carrying a little of the load.** The question for this book is what those ties have to do with the mind, and the answer is smaller than the headlines suggest.

A suspension bridge

The bridge		People
Hangs on many cables	≈	Each tie
Losing one or two rarely brings it down	≈	Carrying a little of the load

> **Key Concept:**
>
> The size of a link. A review of 51 articles found that "Aspects of social isolation are associated with cognitive function in later life" (I. E. M. Evans et al., 2019). **The link measured 0.054 on a scale that runs from 0 for no link to 1 for a perfect one**, which is very small.

Dementia shows a clearer pattern. **A review of 19 long-term studies found higher risk with low social participation, 1.41, less frequent contact, 1.57, and more loneliness, 1.58** (Kuiper et al., 2015). Low satisfaction with one's social network was not significant. The authors concluded that a "lack of social interaction" is "associated with incident dementia".

Higher risk of dementia (Kuiper et al., 2015)



Loneliness is the point where studies disagree. **Kuiper's review and a study of 823 older people found significant links**, and a larger review did not. I set the three side by side, and I give no verdict between them.

> Science Says:
>
> In 823 older people followed for up to four years, the risk of Alzheimer's disease "more than doubled" in the loneliest against the least lonely (Wilson et al., 2007). **A review of 33 studies with 2,370,452 people found loneliness "non-significantly associated" with dementia, 1.38**, while a poor social network was linked, 1.59 (Penninkilampi et al., 2018).

The fair summary is that **loneliness is linked with dementia in several studies, though not in all of them**. Wilson's team found loneliness "unrelated to summary measures of AD pathology", where AD is Alzheimer's disease and pathology means the disease's changes in the brain. That leaves open how a lonely mood and a failing memory might connect.

Loneliness and dementia

	Wilson et al., 2007	Penninkilampi et al., 2018
Who	823 older people	33 studies with 2,370,452 people
Result	Risk "more than doubled"	"Non-significantly associated", 1.38

Across ordinary decline, the links stay small. **A review of 43 articles found odds of 1.08 for few social ties and 1.15 for poor support from them** (Kuiper et al., 2016). Odds of 1.08 are only 8% above those with more ties. The authors added that "evidence for publication bias was found, the association might be overestimated".

> **Key Concept:**
>
> Reverse causation. **Reverse causation means the effect may be driving the supposed cause.** A smoke alarm goes off because of the fire, and nobody blames the alarm for the flames. Early changes in memory can make people pull back from company, and withdrawal from social life is one of the warning signs in 6.3.2.

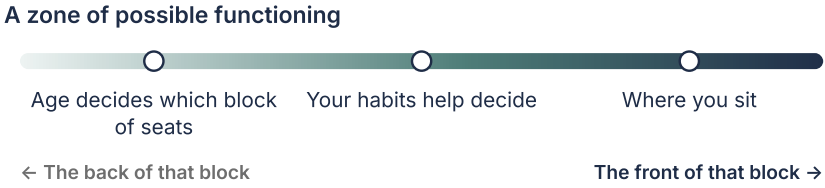
Because of that, **socialising has not been shown to protect your brain or prevent dementia**. The honest wording is that company "is linked with" better outcomes. Company is worth having for its own sake, and it may help the mind, and the studies cannot yet tell those two apart.

Reverse causation



Meaningful intellectual activity is the second half of this section. **One expert review described how "the course of normal aging shapes a zone of possible functioning"** (Hertzog et al., 2008). People influence where they fall in that zone by "engaging in or refraining from beneficial intellectual, physical, and social activities".

Imagine the zone as a theatre where age decides which block of seats you sit in. **Your habits help decide whether you sit at the front of that block or the back.** That review argued from the evidence as a whole and did not test any single activity.



> **Key Concept:**
>
> Cognitive reserve. **Cognitive reserve is a proposed store of mental resilience that helps explain why similar brain changes affect people differently.** One review describes reserve as explaining "differences between individuals in susceptibility to age-related brain changes", and says lifelong education, work and "leisure activities in later life, can increase this reserve" (Y. Stern, 2012). It works like a savings account built over a lifetime.

In Y. Stern's words, some people "can tolerate more of these changes than others and maintain function" (Y. Stern, 2012). The idea helps explain why schooling and absorbing work keep turning up in these studies, and it makes no promise for any one person.

Studies of late-life activity point the same way, with care. **A review of 12 studies with 13,939 people found that most saw less dementia among people who did more mental activity** (Sajeev et al., 2016). A bias analysis judged the link "likely only partially explained by reverse causation", and the authors added that "more data are needed".

Late-life mental activity

SE

Sajeev et al., 2016

- 12 studies with 13,939 people
- Likely only partially explained by reverse causation

Sajeev's result sits between two easy slogans. **It does not prove that mental activity protects the brain, and it does not wave the link away as pure illusion.** A careful reader can hold both halves at once, and I find that more useful than either slogan.

Brain-training games give a narrower result. **In 4.2.3 I showed that game practice improves the games themselves**, and one trial tested something closer to real life by teaching people demanding new skills over months. It studied older adults only.

> Science Says:
>
> Older adults learned quilting, digital photography or both, for about 16.51 hours a week over three months (Park et al., 2014). **Their episodic memory improved against groups doing gentler, receptive activities.** The authors found "limited cognitive benefits of sustained engagement in social activities" on their own.

A single trial in older adults is a start. **The skills were hard, new and practised for many hours a week**, which is a long way from a crossword over breakfast. My own reading is that a demanding hobby you enjoy is worth taking up, and that no one activity has been proven to protect the brain.

Demanding new skills



Quilting



Digital photography



Hard, new and practised for many hours a week

When I choose a new pursuit, **I look for one that keeps setting fresh problems**, where you must work out what is known and what is missing before you can act. A choir part, a woodworking joint or a new language all do that. Doing it with other people brings the two halves of this section together.

Tie or activity	What was found	Kind of study
Strong social ties	Higher survival	Observational
Social isolation	Very small link with later mental skills	Observational
Loneliness	Linked with dementia in some studies only	Observational
Late-life mental activity	Less dementia in most studies	Observational
Learning demanding skills	Better episodic memory in older adults	One trial

Back on the street, you knock on Ray's door with a spare packet of bean seeds and an offer of help at the plot. **A visit costs you an hour, and it may put a lost tie back under the bridge.** Whatever the studies finally show for the brain, it is a kind thing to do.

> **Exercise:**
>
> A company and new-skill plan.
>
> 1. Write the names of three people you would like to see more often.
> 2. Arrange one meeting, call or shared walk with one of them this week.
> 3. Pick one new skill that would take you months to learn, such as a craft, an instrument or a language.
> 4. **Book the first lesson or session before the week is out.**

Key idea:

Company and demanding new learning are linked with a healthier mind, and both are worth having for their own sake.

Quick check:

A magazine says loneliness doubles your risk of dementia. What does the evidence show? Answer: one study of older people found the risk more than doubled, Kuiper's review found a link, and a larger review found no significant link, so loneliness is linked in several studies though not in all, and none can show cause.

6.3.2 Ordinary Forgetting, Concerning Changes and Getting Help

You climb the stairs with a clear purpose, reach the landing and **stand there with no idea why you came up**. Later that evening, an old friend's name hovers just out of reach all through dinner. It drops into your head at breakfast the next morning, while you are buttering toast and no longer looking for it.



A woman standing halfway up a carpeted staircase, one hand on the banister, gazing back down towards the hall.

Moments like these frighten many people over fifty, and I understand why. **Most of them are signs of a memory doing its ordinary job**, with a few rough edges. This last section of the module sets out what normal forgetting looks like, which changes deserve a doctor's attention and how to get help without panic.

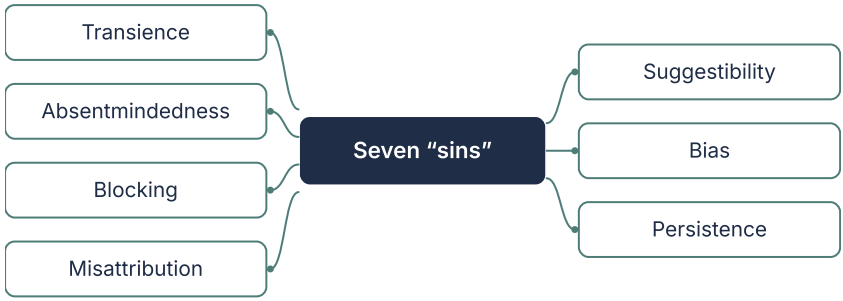
> **Science Says:**
>
> One review sorted everyday memory failures into seven "sins", namely "transience, absentmindedness, blocking, misattribution, suggestibility, bias, and persistence" (Schacter, 1999). **It argued that they are "by-products of otherwise adaptive features of memory".** Blocking is the name on the tip of your tongue, and absentmindedness is the forgotten reason for climbing the stairs. Transience is detail fading with time.



A librarian on a rolling ladder sliding a book onto a high shelf in a tall, sunlit reading room.

Imagine memory as a busy librarian who reshelves thousands of books a day. **Working fast means the odd book lands on the wrong shelf**, and the librarian is still good at the job. Fading detail and the occasional misfile are the price of a system built for speed and for keeping what you use most.

Seven "sins"



Some change with age is normal, and it starts earlier than most people expect. **One analysis found that "some aspects of age-related cognitive decline begin in healthy educated adults when they are in their 20s and 30s"** (Salthouse, 2009). Practice on repeated tests had been hiding the slide in earlier studies.

People age at very different rates. **A review noted that "Episodic memory and working memory decline with advancing age"**, and it pointed to "well-preserved memory functioning in some older individuals" (Nyberg et al., 2012). The authors proposed brain maintenance, keeping the brain's structure and chemistry in good repair, as "the primary determinant of successful memory aging".

Dementia is a different and serious illness, and it is common. **The World Health Organization says that "In 2021, 57 million people were living with dementia worldwide"**, with "nearly 10 million new cases" each year (World Health Organization, n.d.). The same fact sheet states that dementia is "not an inevitable part of ageing".

Dementia worldwide



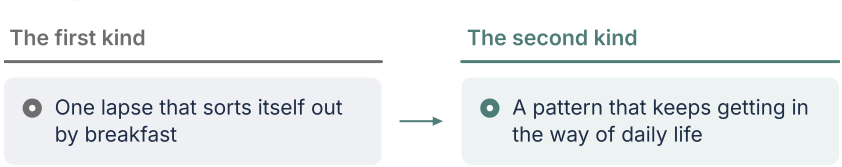
Telling the two apart is the hard part. **The Alzheimer's Association lists ten early signs, and it pairs each one with a typical age-related change** (Alzheimer's Association, n.d.). For the first sign, "Memory loss that disrupts daily life", the typical change is "Sometimes forgetting names or appointments, but remembering them later".

Early sign (paraphrased)	Typical age-related change (quoted)
Memory loss that disrupts daily life	"Sometimes forgetting names or appointments, but remembering them later."
Trouble planning or solving problems	"Making occasional errors when managing finances or household bills."
Difficulty finishing familiar tasks	"Occasionally needing help to use microwave settings or to record a TV show."
Confusion with time or place	"Getting confused about the day of the week but figuring it out later."
Trouble with pictures and distances	"Vision changes related to cataracts."
New problems with words	"Sometimes having trouble finding the right word."
Misplacing things without retracing steps	"Misplacing things from time to time and retracing steps to find them."
Poorer judgement	"Making a bad decision or mistake once in a while, like neglecting to change the oil in the car."
Withdrawal from work or social life	"Sometimes feeling uninterested in family or social obligations."
Changes in mood and personality	"Developing very specific ways of doing things and becoming irritable when a routine is disrupted."

The right-hand column quotes the typical changes from the same public awareness page (Alzheimer's Association, n.d.). **The list is a prompt to seek advice and was never meant as a home diagnosis.** On its own page the Association writes, "If you notice any of them, don't ignore them. Schedule an appointment with your doctor."

A cough after a cold is a different thing from a cough that lingers for months. **One lapse that sorts itself out by breakfast is the first**

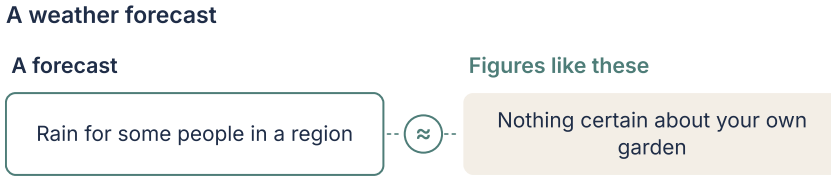
kind, and a pattern that keeps getting in the way of daily life is the second. Only a clinician can judge which one you have, which is why the doctor's visit comes first.



In 5.3.2 I explained mild cognitive impairment, MCI for short, and **this section adds how often it moves on to dementia**. An older guideline, since retired by its publisher and cited here as a historical record, reported that "Cumulative dementia incidence was 14.9% in individuals with MCI older than age 65 years followed for 2 years" (Petersen et al., 2018).

> Science Says:
>
> A review of 41 cohort studies of people with mild cognitive impairment found an annual move to dementia of about 5 to 10%, and 4.9% in community studies (Mitchell & Shiri-Feshki, 2009). **The authors concluded that "most people with MCI will not progress to dementia even after 10 years of follow-up".**

Figures like these work like a weather forecast. **A forecast of rain for some people in a region tells you nothing certain about your own garden.** The same guideline added that "No high-quality evidence exists to support pharmacologic treatments for MCI", meaning medicine-based treatments, so any decision about medicines belongs with a clinician.



Some people feel their memory has slipped while their test results stay normal. **Researchers have given that experience a name and a set of research criteria.**

> 🔑 **Key Concept:**
>
> Subjective cognitive decline. **Subjective cognitive decline is a feeling of slipping memory in people whose tests come back normal.** One framework says it "may represent the first symptomatic manifestation" of Alzheimer's disease in some people, and it sets "research criteria" with extra features that raise the likelihood (Jessen et al., 2014). It is a research tool, so please do not use it to label yourself.

The framework exists because researchers want to study the earliest stage of disease. **The criteria say nothing certain about any one person**, and a clinician is the person to look into a worry.

The numbers for these worries are calmer than the fear. **Among 29,723 older people with memory complaints and normal tests, about 2.33% a year, a little over 2 in 100, went on to dementia** (Mitchell et al., 2014). Their risk was about twice that of people with no complaints, a relative risk of 2.07, a link that cannot show cause.

A year's move to dementia

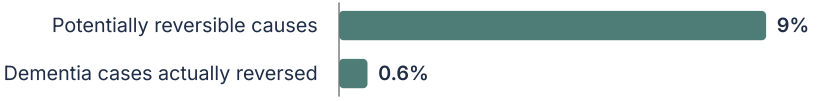


Many people hope that a memory problem will turn out to have a simple, curable cause. **Some do, though fewer than the hopeful stories suggest.**

> **Science Says:**
>
> A review of 39 studies with 7,042 patients found that "Potentially reversible causes were seen in 9%, and only 0.6% of dementia cases actually reversed" (Clarfield, 2003). **The author added that other health problems "should always be treated for its own sake".**

Clarfield's figures cut both ways. **A check can find another health problem worth treating, and it rarely makes dementia vanish.**

Reversible causes (Clarfield, 2003)



Doctors use short pencil and paper tests to spot dementia. **A review of 149 studies found the most common one picked up 81% of people with dementia and correctly cleared 89% of people without it** (Tsoi et al., 2015). Other brief tests did about the same, and one was better at spotting mild cognitive impairment.

The most common pencil and paper test



Picked up 81% of people with dementia



Correctly cleared 89% of people without it



A review of 149 studies

> **Key Concept:**
>
> Screening test. **A screening test is a quick check given to people with no diagnosis to see who needs a fuller assessment.** One review found that "Brief instruments to screen for cognitive impairment can adequately detect dementia, but there is no empirical evidence that screening improves decision making" (J. S. Lin et al., 2013). These tests belong in a clinic, and a home attempt can mislead you.

Preparing for an appointment is where I can offer my own advice. **Write down the changes you have noticed, when they began and how they affect your days.** Bring a list of every medicine and supplement you take, and ask a relative or friend to come with you. They often notice things you miss.

Preparing for an appointment

1. Write down the changes you have noticed
2. Bring a list of every medicine and supplement
3. Ask a relative or friend to come with you

Ask the clinician what happens next, and **write down the answers while you are still in the room**. If you are offered tests or a referral, ask what each one is for and when the results will arrive. If you are worried about your memory, a doctor is the right person to ask.

At the appointment

If	Then
You are offered tests or a referral	Ask what each one is for and when the results will arrive

Back on the landing, you remember at last that you came up for your reading glasses. **The lapse cost you a minute and told you nothing worrying about your brain.** If the minutes start to add up and get in the way of your life, the right next step is a calm visit to your doctor.

Exercise:

A memory diary for your next appointment.

1. For two weeks, note any lapse that worries you, with the date and what happened.
2. Beside each one, note whether it sorted itself out later.
3. List your medicines and supplements on the same page.
4. **Take the diary to your doctor if any lapse kept getting in the way of daily life.**

Key idea:

Ordinary forgetting is part of a working memory, and a change that disrupts daily life is a reason to see a doctor.

Quick check:

A friend with normal memory tests worries that her lapses mean dementia is coming. What did Mitchell's review find? Answer: among people with memory complaints and normal tests, about 2 in 100 a year went on to dementia, so most did not, and a doctor is the right person to assess her.



Module

7

Intellectual Development at Different Ages

7.1 Childhood

7.1.1 Play, Language and Curiosity, and Helping Without Pressure or Labels

My niece Isla is four, and last summer she spent an hour **digging a moat round a sandcastle that the sea kept filling in**. Each time the water drained away, she dug the channel deeper and tried a new route. I itched to show her the answer, and I nearly told her she was clever.

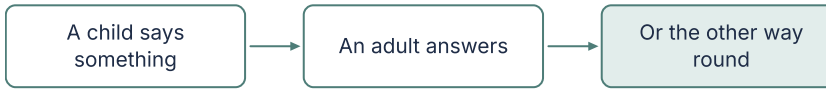


A small girl in a yellow sunhat kneeling by a lopsided sandcastle, scooping wet sand from a shallow moat as a wave rolls in.

In this book intellect means solving tasks where the variables are identified. **Isla was doing an early version of that work**, spotting what changed when the water moved. This section looks at what the research says about talk, play, curiosity and praise in early childhood, and where my own advice begins.

Talk is the first tool. A conversational turn is one exchange, where a child says something and an adult answers, or the other way round. **Only one of the studies below counted those turns**, and it set them against the sheer number of words a child hears.

A conversational turn



> **Science Says:**
> In 36 children aged 4 to 6, those "who had experienced more conversational turns with adults" showed "greater left inferior frontal (Broca's area) activation" in a brain scan (Romeo et al., 2018). **Broca's area is a region at the front of the left side of the brain that helps with speech and language.** That activity helped explain the link with verbal skill, and it held "over and above ... the sheer quantity of words heard".

Romeo's study was small and took a single snapshot, so **its result is a link that cannot show cause**. Talkative children may draw more replies from adults, and the scan cannot tell which came first. A conversation works like a tennis rally, where the ball has to come back for the game to go on.

A tennis rally



A second study pointed the same way. **In 60 families, the quality of shared talk at 24 months "accounted for 27% of the variance in expressive language 1 year later"** (Hirsh-Pasek et al., 2015). Expressive language means the words a child can say, and variance means how much children differ from one another.

Shared talk at 24 months

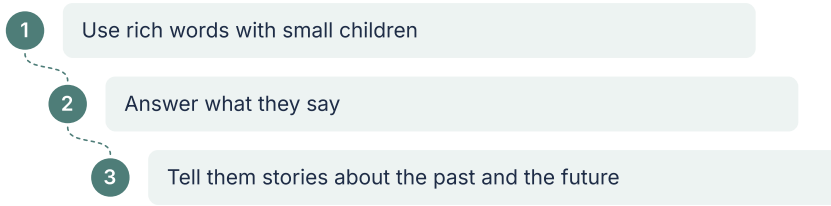
The quality of shared talk at 24 months → Accounted for 27% of the variance in expressive language 1 year later

The same team found that quality indicators "were considerably more potent predictors of later language ability than was the quantity of mothers' words". **Good talk with a toddler beat a large volume of words in that study**, and it, like the brain study, is a link that cannot show cause.

> Science Says:
>
> In 50 parents and children followed from 18 to 54 months, **"using a diverse and sophisticated vocabulary with toddlers; and using decontextualized language (e.g., narrative) with preschoolers explains additional variation in later vocabulary ability"** (Rowe, 2012). Decontextualised language means talk about things that are out of sight, such as yesterday's trip or a story.

My own advice follows from those three studies, and it is gentle. **Use rich words with small children, answer what they say and tell them stories about the past and the future.** None of the studies proves that this causes better language, and each one is small.

My own advice



Play comes next, and the claims about it run ahead of the evidence. **One review found that "existing evidence does not support strong causal claims about the unique importance of pretend play for development"** (Lillard et al., 2013). The authors added that "much more and better research is essential". Play is still a fine thing for children to do.

> **Key Concept:**
>
> Guided play. **Guided play is play that an adult sets up and gently steers while the child stays in charge of the activity.** One review says it "lies midway between direct instruction and free play", and argues that such approaches "often outperform direct-instruction approaches" (Weisberg et al., 2013). That is the authors' argument from the evidence they reviewed, and the review did not pool results.

Showing a child the answer has a cost. **In lab studies with one toy, preschoolers who saw a teacher demonstrate one use "focused almost exclusively on the target function"** (Bonawitz et al., 2011). Teaching "promotes efficient learning but at a cost", the authors wrote. Those children were less likely to try odd actions and less likely to find something new.



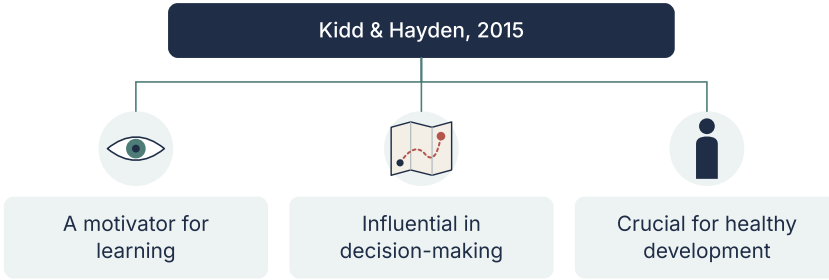
A sat-nav that reads out every turn gets you there fast and teaches you nothing about the streets. **Telling Isla the best route for her moat would have worked the same way**, getting the water out quickly and closing off her own trial and error. Guided play sits between the two, with a hint and room to explore.



A boy steering a large cardboard box across a garden lawn, a metal colander on his head for a helmet.

Curiosity is the third tool, and its definition is still argued over. **One review calls curiosity "a motivator for learning, influential in decision-making, and crucial for healthy development"** (Kidd & Hayden, 2015). The same authors note that the field has no agreed definition of what is and is not curiosity. Their paper argues a view and runs no new test.

Curiosity

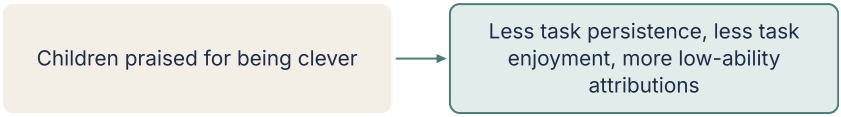


> **Science Says:**
>
> In a lab study of adults, people "showed improved memory for information that they were curious about and for incidental material learned during states of high curiosity" (Gruber et al., 2014). **Incidental material means things they saw while curious that they were never asked to learn.** The gain showed up straight away and a day later.

The Gruber study tested adults, so **applying it to children is my own inference**. A child who asks why the tide comes in has a mind ready to keep what comes next. My advice is to follow the question for a while before you answer it, and to admit when you do not know.

Praise is where good intentions can go wrong, and **across six lab studies, children of about ten praised for being clever did worse after a failure than children praised for effort** (C. M. Mueller & Dweck, 1998). After failing, the clever group showed "less task persistence, less task enjoyment, more low-ability attributions, and worse task performance".

Praise for being clever

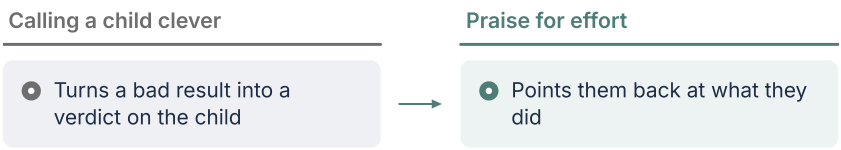


A low-ability attribution means blaming a failure on not being bright enough. **Calling a child clever turns a bad result into a verdict on the child**, and the lab children behaved as if it had. Praise for effort points them back at what they did, which they can change next time.

> **Key Concept:**
>
> Process praise. **Process praise is praise for effort, strategy or action, such as "you tried a new way".** In 53 families, "process praise to toddlers predicts children's academic achievement (in math and reading comprehension) 7 years later", through the children's beliefs about ability (Gunderson et al., 2018). The sample was small and observational, so it is a link that cannot show cause.

Mindset effects in wider studies are weak on average, as 7.2.1 shows, so **process praise is a sensible habit with modest evidence behind it**. Praise works best when it is honest. A set of three studies found that adults "are especially inclined to give inflated praise to children with low self-esteem" (Brummelman et al., 2014).

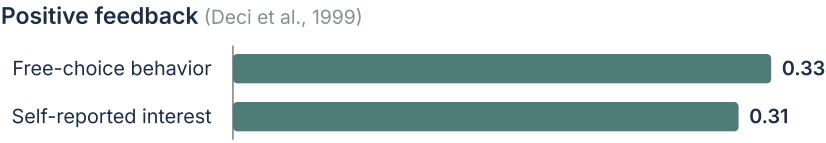
Two kinds of praise



Inflated praise means over-the-top praise, such as “incredibly beautiful” for a quick drawing. **In children with low self-esteem, inflated praise made them less willing to take on hard tasks** (Brummelman et al., 2014). Accurate, warm praise is my own recommendation in the light of that finding.

> **Science Says:**
>
> A review of 128 experiments with children and college students found that rewards people expected for taking part, finishing or doing well lowered their later free-choice interest (Deci et al., 1999). **The effect sizes were -0.40, -0.36 and -0.28, where the minus sign means less interest after the reward.** An effect size is the gap between groups in standard-sized steps. Free-choice interest means how much people went back to the task when nobody asked them to.

Rewards and praise are both fine in their place, and **the trouble came when a prize was promised in advance for doing the task**. The same review found that “positive feedback enhanced both free-choice behavior (d = 0.33) and self-reported interest (d = 0.31)”. The letter d marks an effect size, and a plus figure means more.



If you have any worry about a child’s speech, hearing or development, talk to a health visitor or doctor. This section gives

no milestones and cannot judge one child's progress, and a professional can.

What helps	What was found	Kind of study
Back-and-forth talk	More language-area activity in the brain	One small brain scan
Quality of shared talk	Stronger later language than word count	Observational
Rich words and stories	Larger later vocabulary	Observational
Guided play	Often beats direct instruction	Argued review
Praise for effort	Better results after failure than praise for cleverness	Lab experiments
Expected rewards	Less free-choice interest	Review of experiments

The next morning Isla went back to her moat, and **this time I asked what she had noticed about the water**. She said it always ran out at the low corner. We packed that corner with wet sand, and the moat held until lunch.

Exercise:

A week of talk and play.

1. Once a day, keep a conversation with a child going for at least five back-and-forth turns.
2. Tell one story about something that happened yesterday or will happen tomorrow.
3. Set up one play activity, give a single hint and then step back.
4. **Each time you praise, name the effort or the strategy you saw.**

Key idea:

Talk with children, let them explore and praise their effort honestly.

Quick check:

A child fails a puzzle after you have told her she is clever. According to the lab studies, how is she likely to respond? Answer: with less persistence and enjoyment, more blame on her own ability and worse results than a child praised for effort.

7.2 Adolescence

7.2.1 Growing Independence and Strong Learning Habits

My nephew Sam is fifteen, and last winter I found him **revising for a chemistry test at eleven at night** with his phone face down beside the textbook. Every few minutes it buzzed with the group chat. He told me firmly that he had a system, and that he did not need anyone to plan his evenings for him.



A teenage boy hunched over a textbook under a desk lamp late at night, a phone face down beside him lighting up the dark wood.

Sam wanted to run his own learning, and **the research on teenage learners has a good deal to say about helping him do it**. In this book intellect means solving tasks where the variables are identified. The studies below look at the teenage brain, self-control, beliefs about ability, effort and sleep.

Laurence Steinberg proposed a framework for the teenage years. **He describes "increased reward-seeking, especially in the presence of peers"** in adolescence, the years between childhood and adulthood (Steinberg, 2008). A separate "cognitive control system" in the brain grows more slowly, and with it the "capacity for self-regulation", meaning the ability to manage your own impulses.

Two systems



> **Science Says:**
>
> Steinberg argues that the "differing timetables" of the two systems "make mid-adolescence a time of heightened vulnerability to risky and reckless behavior" (Steinberg, 2008). **A framework is a proposed way of fitting findings together, and it is tested piece by piece.** My own analogy is a car fitted with a strong accelerator before its brakes are fully tuned.

Another team reads the evidence differently. **They write that "developmental neuroimaging studies do not support a simple model of frontal cortical immaturity"** (Crone & Dahl, 2012). Neuroimaging means taking pictures of the brain at work, and the frontal cortex is the outer layer at the front of the brain, which helps with planning and control.

Crone and Dahl add that the teenage changes "may confer some adaptive advantages, such as greater flexibility". **One account stresses risk and the other stresses flexibility**, and the evidence I have does not settle which fits better. A teenage brain is a brain still developing, and nobody in these studies calls it broken.

Two accounts

Steinberg, 2008	Crone & Dahl, 2012
A time of heightened vulnerability to risky and reckless behavior	May confer some adaptive advantages, such as greater flexibility

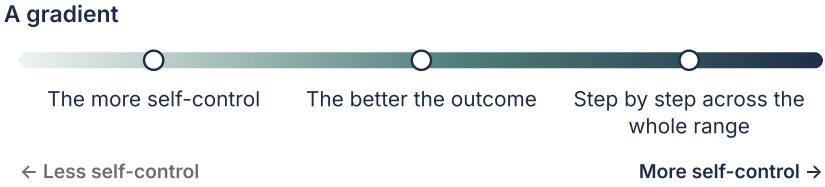


A girl in a school blazer laughing on a skateboard ramp while two friends film her on their phones from the edge.

Social life is part of the picture. **One review describes big changes in the brain's social systems "during the second decade of life, possibly reflecting a sensitive period"** (Blakemore & Mills, 2014). A sensitive period is a stretch of time when the brain responds more

strongly to certain experiences. The authors say plainly that on this point “we speculate”.

Self-control grows through childhood, and it has long-reaching links. **A study followed “a cohort of 1,000 children from birth to the age of 32”** (Moffitt et al., 2011). A cohort is a group of people born around the same time and followed together. Self-control means the ability to hold back impulses and stick to a plan.

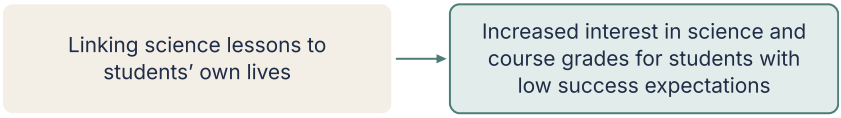


> **Key Concept:**
> A gradient. Childhood self-control “predicts physical health, substance dependence, personal finances, and criminal offending outcomes, following a gradient” (Moffitt et al., 2011). **A gradient means the more self-control, the better the outcome, step by step across the whole range.** The team compared “500 sibling-pairs” as a further check. The study is observational, a link that cannot show cause.

Interest can be nudged. **In a randomised field experiment, linking science lessons to students’ own lives “increased interest in science and course grades for students with low success expectations”** (Hulleman & Harackiewicz, 2009). Randomised means chance decided who got the task, and a field experiment runs in real classrooms. The gain showed in students who expected to do badly.

My own reading of that trial is modest. **Asking students how a topic touches their own lives costs a teacher or a parent nothing**, and the trial found gains in "students with low success expectations", the ones who expected to do badly. One trial is one trial, though, and it ran in one kind of science class.

Relevance lessons



A growth mindset is the belief that ability can grow with effort and learning. **Two large reviews found that "overall effects were weak for both meta-analyses"** (Sisk et al., 2018). A meta-analysis pools many studies, and these pooled 273 effect sizes from 365,915 people and 43 effect sizes from 57,155 people. An effect size measures how big a difference is.

Other trials found effects in particular places. **A "less than one hour, online" lesson "improved grades among lower-achieving students"** in a national trial (Yeager et al., 2019). Lower-achieving means students whose grades were already low. The gain held where "peer norms aligned with the messages", meaning the students' classmates backed the idea.

A short online lesson

YE

Yeager et al., 2019

- Less than one hour, online
- Improved grades among lower-achieving students

Sam did a lesson of this kind in Year 9, half an hour on a school laptop, and shrugged it off. **The Paunesku trial below tested two short online modules, one on growth mindset and one on purpose in learning.** Among students at risk of dropping out, each one raised grades in core courses.

> **Science Says:**
> In 1,594 students in 13 high schools, a short online mindset lesson raised the share of satisfactory grades in students at risk of dropping out **"by 6.4 percentage points"** (Paunesku et al., 2015). A percentage point is one step on a 100-point scale. Two of that study's authors write that mindset effects "are meaningfully heterogeneous across individuals and contexts", meaning they differ by person and place (Yeager & Dweck, 2020).

Yeager and Dweck argue that the replications "justify confidence", and they are the theory's own backers. **Sisk's reviews found weak effects overall.** Both readings come from careful work, and the fairest summary I can give is small average effects that show up mostly in lower-achieving students in supportive settings.

Effort and confidence come next, and **a review of 241 data sets on university students found "medium-sized correlations with GPA: academic self-efficacy, grade goal, and effort regulation"** (M. Richardson et al., 2012). GPA, or grade point average, is a student's average mark, and a correlation is a measure of how closely two things move together.

Non-intellective constructs

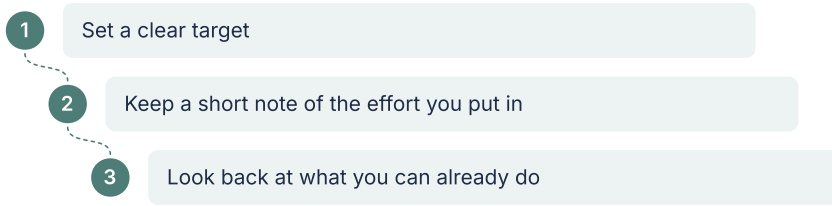


> **Key Concept:**
>
> Self-efficacy. **Self-efficacy is your belief that you can do a particular task.** Effort regulation means keeping going when work is dull or hard, and a grade goal is the mark you aim for. In the same review, performance self-efficacy, a student's belief in how well they will do, was "the strongest correlate" of grades (M. Richardson et al., 2012). These are links that cannot show cause.

Sam told me he was "rubbish at chemistry" after one bad mark, and **that belief is the kind the review measured**. The review called self-efficacy, grade goals and effort regulation "non-intellective constructs", meaning qualities other than raw ability. None of them is a test score.

Those links suggest a habit, and **the habit is my own suggestion, untested in the review**. Set a clear target, keep a short note of the effort you put in and look back at what you can already do. Confidence built on a record of real work is harder to shake.

A habit



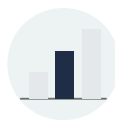
Sleep is the last habit here. **A survey of 3,120 high school students found that "most of the adolescents surveyed do not get enough sleep, and their sleep loss interferes with daytime functioning"** (Wolfson & Carskadon, 1998). The students reported on themselves, so nobody measured their sleep directly, and **the survey caught one moment in time**.

In 5.1.1 I showed how sleep helps memory, and **the new point in this section is that teenagers often fall short of it on school nights**. One review of six studies found that when school start times were "delayed 25-60 min", "total sleep time increased from 25 to 77 min per weeknight" (Minges & Redeker, 2016).

School start times



Delayed 25-60 min



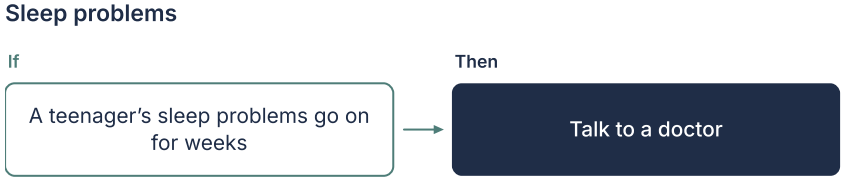
Total sleep time increased from 25 to 77 min per weeknight



One review of six studies

School start times are for schools to decide, and the review's authors call for "rigorous randomized study designs" to test them properly. **If a teenager's sleep problems go on for weeks, or they are very sleepy**

in the day, talk to a doctor. Sleep problems have many possible causes, and a clinician can look into them.



On independence, my advice is simple. **Let a teenager build the plan, and offer to check it with them.** Sam's system needed only one change, and he chose it himself. Respecting his control seemed to me the way to keep him using it.

Topic	What was found	Kind of study
Teenage brain	Risk framework and flexibility account disagree	Framework and review
Self-control	Better adult outcomes along a gradient	Long observational study
Relevance lessons	More interest and better grades in students expecting to do badly	Randomised field experiment
Growth mindset	Weak overall effects, larger in lower-achieving students in supportive settings	Reviews and large trials
Self-efficacy and effort	Medium-sized links with grades	Review of observational data
Sleep	Most surveyed teenagers short of sleep	Self-report survey

A week after our talk, Sam moved his revision to straight after dinner and **left the phone in the kitchen until he had finished**. His test went better, and he credits his own system, which is fine by me. **He kept the group chat for the bus ride home**, where it cost him nothing.

Exercise:

Your own learning plan.

1. Write down one subject or skill you want to improve this month.
2. Set a grade goal or a clear target, and write one sentence on why it is useful in your life.
3. Choose a study time that leaves a full night's sleep before your usual waking time.
4. **Put the phone in another room for that session**, and note at the end how much you did.

Key idea:

Teenagers learn best with their own plan, enough sleep and a link to what they care about.

Quick check:

According to the large reviews, how strong are the effects of growth mindset lessons on average? Answer: weak overall, with small gains seen mostly in lower-achieving students in supportive settings.

7.3 Adulthood

7.3.1 Learning and Keeping Skills Through a Busy, Changing Life

My friend Tom is forty-one, a nurse retraining as a software tester, and **he studies on the early train with a laptop on his knees**. Between night shifts, two children and a mortgage, the train is his classroom. Last month he told me he had left it late, and that his brain was not what it was at twenty.

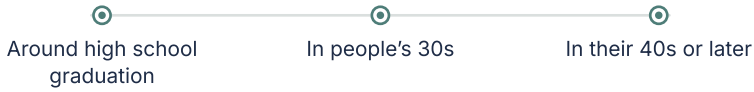


A man in a nurse's tunic asleep against a train window at dawn, an open laptop sliding slowly off his knees.

Tom's worry is familiar, and **the research on adult minds is more mixed and more hopeful than he feared**. In this book intellect means solving tasks where the variables are identified. This section looks at how abilities change across adult life, what keeps them in use and what the evidence on work and retirement can and cannot say.

Abilities do not all move together on one timetable. **A study of 48,537 online participants found that "some abilities peak and begin to decline around high school graduation"**, others in people's 30s, and "still others do not peak until subjects reach their 40s or later" (Hartshorne & Germine, 2015). The authors added test norms, the scores from earlier standard testing.

Ability peaks



> **Key Concept:**
>
> Cross-sectional and longitudinal. **A cross-sectional study tests different people of different ages once, and a longitudinal study follows the same people over years.** Hartshorne and Germine's study is cross-sectional, so it compares people at different ages. It cannot show how any one person's abilities will change, and different generations had different schooling and lives.

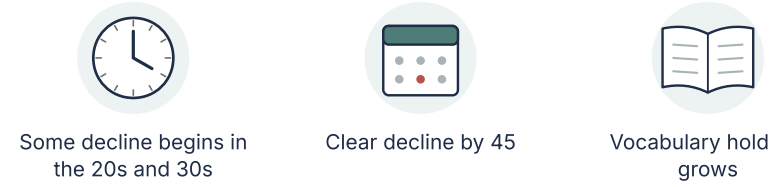
Longitudinal studies give a second view. **In 7,390 civil servants aged 45 to 70, tested three times over 10 years, "all cognitive scores, except vocabulary, declined"** (Singh-Manoux et al., 2012). Civil servants are people who work for the government. Cognitive scores are results on tests of memory, reasoning and similar skills.

Two kinds of study



The team concluded that “Cognitive decline is already evident in middle age (age 45-49).” **They warned that cross-sectional figures can “overestimate decline ... because of cohort differences in education”**, where a cohort is a group born around the same time. In their large study, that overstatement showed up for some of the groups tested.

In 6.3.2 I quoted Salthouse’s finding that some decline begins in the 20s and 30s. **The new point is that the timing is disputed**, since Singh-Manoux’s team placed clear decline by 45. Taken together, the fair summary is that some abilities start to slip in early or middle adulthood while vocabulary holds or grows.



Abilities that change tend to change together. **A review of 22 data sets and more than 30,000 people found that “an average of 60% of the variation in cognitive changes was shared across cognitive abilities”** (Tucker-Drob et al., 2019). Variation means how much people differ, and shared means that someone who slips on one test tends to slip on others.

Key Concept:

A general factor. **A general factor is one common thread running through many separate test results.** The same review found strong evidence "for a general factor of cognitive aging that strengthens with advancing adult age" (Tucker-Drob et al., 2019). It describes groups of people on average, and it leaves plenty of room for single lives to differ.

Science Says:

A review of 92 samples followed the same people over time and found increases in "social dominance (a facet of extraversion), conscientiousness, and emotional stability, especially in young adulthood (age 20 to 40)" (Roberts et al., 2006). **Extraversion means being outgoing, and social dominance means confidence and drive in company.** Conscientiousness means being organised and dependable, and emotional stability means staying calm under strain. Of the traits, "4 demonstrated significant change in middle and old age".

Personality keeps developing, and so does the way people handle company. **In a lab experiment with 306 participants, people took more risks in peer groups than alone**, and that pull from friends shrank as people grew up, with peer effects "stronger among adolescents and youths than adults" (M. Gardner & Steinberg, 2005).

Peer effects



People took more risks in peer groups than alone



Stronger among adolescents and youths than adults



A lab experiment with 306 participants

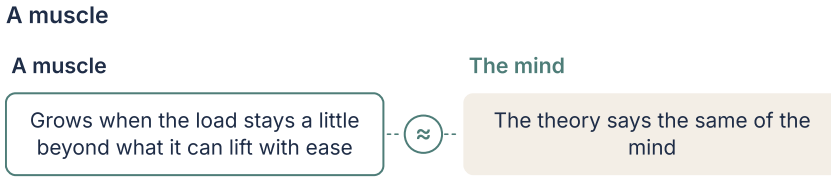
M. Gardner and Steinberg's study describes how people change as they mature, and it says nothing about intelligence. **Its finding is about risk taking in a lab task**, and stretching it further to Tom's studies would be my own guess.

A theory of how adult minds keep growing says that **adult plasticity "is driven by a prolonged mismatch between functional organismic supplies and environmental demands"** (Lövdén et al., 2010). Plasticity is the brain's ability to change with experience. In plain words, the brain adapts when life asks more of it than it can easily give, for a long time.



A woman in a garage gym sliding one small extra disc onto each end of a barbell before her next lift.

A muscle grows when the load stays a little beyond what it can lift with ease. **The theory says the same of the mind**, and the analogy is my own. Lövdén's paper is a theory, so it proposes how change works and leaves the testing to later studies.



Tom's course asks him to learn test scripts, a load well beyond his old routine. **Lövdén's team predict two kinds of change from that sort of demand**, "alterations in processing efficiency and alterations in representations". The first means handling information faster and more smoothly, and the second means changes in the knowledge and skills stored in the brain.

> Science Says:
>
> Trainee London taxi drivers spent four years learning the city's streets. Those who qualified showed "a selective increase in gray matter (GM) volume in their posterior hippocampi" (Woollett & Maguire, 2011). **Gray matter is the brain tissue that holds most nerve cell bodies, and the hippocampi are two curved structures deep in the brain that help with memory and navigation.** No changes showed in trainees who failed or in non-trainees.

The taxi trainees were a small and unusual group, learning one huge task full time for years. **Everyday study should not be expected to grow the brain in the same way.** What the study shows is that adult

brains can change with very heavy, long practice. Most of us learn in odd hours, on a far smaller scale.

Tom's old job was full of judgement calls on the ward. **A long national study found that "intellectual functioning and substantive complexity of work continue to reciprocally affect each other"** (Schooler et al., 1999), meaning demanding jobs and ability shape each other. It reports that such work "significantly increased the level of intellectual functioning", yet it is a link that cannot show cause.

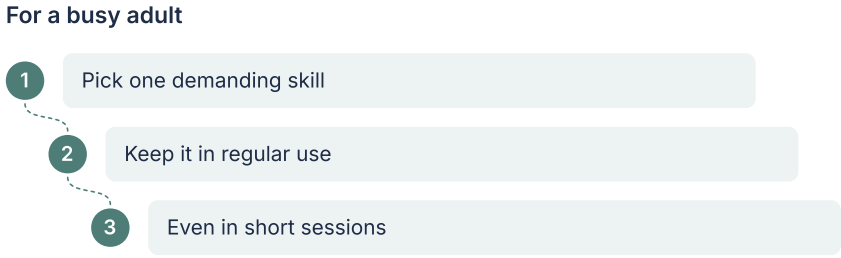
> Science Says:
>
> A second study followed 4,182 people for 18 years. **Higher mental demands at work were "associated with higher levels of cognitive functioning before retirement, and a slower rate of cognitive decline after retirement"** (G. G. Fisher et al., 2014). The researchers observed people without assigning jobs, so the result is a link that cannot show cause.

> Key Concept:
>
> A natural experiment. **A natural experiment uses a difference created by rules or events in place of a coin toss.** Two economists used pension rules. They report that "early retirement has a significant negative impact on the cognitive ability of people in their early 60s that is both quantitatively important and causal" (Rohwedder & Willis, 2010). The claim of cause is the authors' own, based on data from 2004, and I treat it as suggestive.

Nothing in these studies means anyone should delay retirement, and **I would not give that advice on this evidence**. Retirement depends on health, money, family and much else. What the work studies share is

a pattern in which demanding work and strong abilities go together. **Which comes first is still an open question.**

For a busy adult like Tom, my own advice is to **pick one demanding skill and keep it in regular use**, even in short sessions. A train ride, a lunch break or a quiet half hour after the children are asleep all count. None of the studies above tested that advice directly.



Finding	What was found	Kind of study
Ability peaks	Some peak in the late teens, some plateau in early adulthood and decline from the 30s, and others peak in the 40s or later	Cross-sectional
Change in middle age	All scores except vocabulary declined from 45	Longitudinal
Shared change	About 60% of change shared across abilities	Review of longitudinal data
Personality	Gains in calm, dependability and confidence in company, mostly from 20 to 40	Review of longitudinal data
Taxi trainees	Larger memory areas in those who qualified	Small special sample
Mental work demands	Higher scores and slower decline after retirement	Observational
Early retirement	Lower scores in the early 60s	Economic analysis

Tom passed his first certificate in the spring, on the strength of **those train rides and one stubborn evening a week**. He still finds new

terms slower to stick than he would like. His vocabulary, he says, is better than ever, and **he now explains the jargon to newer classmates on his course**.

> Exercise:
>
> Your adult learning audit.
>
> 1. List the three most demanding tasks in your working or home life.
> 2. Mark which ones push you a little beyond what feels easy.
> 3. Choose one skill to stretch this month, and book three short sessions a week for it.
> 4. **Note after each session one thing you can do now that you could not do before.**

Key idea:

Adult abilities change at different rates, and demanding work and learning go with keeping them strong.

Quick check:

Why can a cross-sectional study overstate how much abilities decline with age? Answer: it compares different generations, and in one large study, differences in education between generations made decline look bigger for some groups.

7.4.1 What Changes, What Stays Strong, and Keeping Independence

My neighbour Margaret is seventy-eight, and last week I watched her **lose a battle with the self-checkout at the supermarket**. The machine kept asking her to place items in the bagging area faster than she could. That evening she finished the cryptic crossword in the paper before I had solved two clues. She laughed about it later.

Margaret's day shows two sides of later life, and **the research shows both sides of it**. In this book intellect means solving tasks where the variables are identified. This section looks at what tends to change in later life, what tends to stay strong and what the evidence says about keeping independence.

Very long studies give strong evidence. **One project "assessed mental abilities in more than 5,000 adults and has followed some for as long as 35 years"** (Schaie, 1994). Its reports cover "age changes, cohort differences ... and interventions", where a cohort is a group born around the same time. **Following the same people for decades shows change within each life.**

A very long study

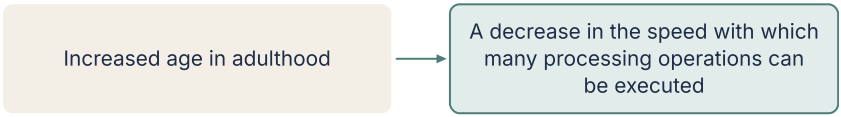
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Schaie, 1994

- More than 5,000 adults
- Followed some for as long as 35 years

Speed is the clearest change. **One theory starts from the finding that "increased age in adulthood is associated with a decrease in the speed with which many processing operations can be executed"** (Salthouse, 1996). Processing operations are the small mental steps inside any task, such as reading a sign or comparing two numbers.

Speed



My own reading is that **slower speed shows most when something else sets the pace**, such as a machine, a fast talker or busy traffic. When you set the pace yourself, the same task can feel far easier. That is an everyday guess, and the studies here did not test it. Margaret is quick with a pen at home.

> **Science Says:**
>
> When Salthouse's analyses took processing speed into account, there was a "large attenuation of the age-related influences on cognitive measures" (Salthouse, 1996). **Attenuation means weakening, so much of the link between age and test scores ran through speed.** The support for the theory is correlational, a link that cannot show cause. A self-checkout that hurries you is a speed test in disguise, and that comparison is my own.

What stays strong is knowledge. **A review of 210 articles on vocabulary tests found that "the average effect size, favoring the old, was 0.80 SD"** (Verhaeghen, 2003). An effect size measures how

big a difference is, and SD, or standard deviation, is the typical spread of scores around the average. A gap of 0.80 SD is large.

The review compared people of different ages at one time, and **in these one-time comparisons older adults scored higher on vocabulary than younger adults**. Comparisons of that kind cannot show what happens to one person over the years. Margaret's crossword skill fits the picture, though the review says nothing about any single life. She has done that crossword for decades.

Hearing and sight are bound up with the mind in later life. **In 156 adults with an average age of 84.9, "visual and auditory acuity accounted for 49.2% of the total and 93.1% of the age-related reliable variance in intelligence"** (Lindenberger & Baltes, 1994). Acuity means sharpness of sight and hearing. Variance means how much people differ in their scores.



The study was in very old adults and took one snapshot, so **it is a link that cannot show cause**. It does not show that better glasses or hearing aids would raise intelligence. In that one testing, sharpness of sight and hearing was linked with most of the age-related differences in intelligence. **The direction of the link is unknown.**



A very old man adjusting a small hearing aid behind his ear while his granddaughter leans in close to talk.

Feelings often hold up well. **A review notes "decreased biological, physiological, and cognitive capacity" in old age**, alongside findings "that people are generally satisfied in old age and experience relatively high levels of emotional well-being" (Charles & Carstensen, 2010). Well-being means how good people feel about their lives. The review sets both findings side by side and lets each stand.

> 🗝 **Key Concept:**
>
> Scaffolding. **One theory says that the extra activity often seen at the front of older brains "is a marker of an adaptive brain that engages in compensatory scaffolding"** (Park & Reuter-Lorenz, 2009). Compensatory means making up for a loss. The authors read the evidence as showing that the ability to build this support "is strengthened by cognitive engagement, exercise".

Builders put up scaffolding to hold a structure while they work on it. **The theory says the ageing brain does something similar**,

recruiting extra areas to hold performance up. The analogy is my own, and the theory is still being tested. Scaffolding helps a building stand, and it cannot replace the wall.

Scaffolding

Builders		The ageing brain
Put up scaffolding to hold a structure	≈	Recruiting extra areas to hold performance up



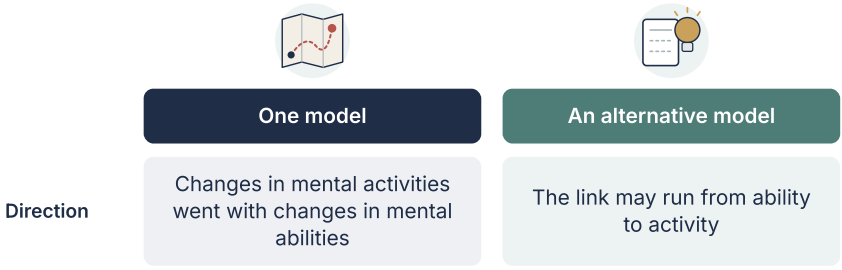
A Victorian terraced house wrapped in metal scaffolding, a builder on the top platform passing a bucket to a colleague below.

"Use it or lose it" is a popular slogan, and the evidence behind it is weaker than it sounds. **A study of 250 adults over 6 years found that changes in mental activities went with changes in mental abilities** (Hultsch et al., 1999). The same team noted that "an alternative model suggested" a different direction.

In that model, "high-ability individuals lead intellectually active lives until cognitive decline in old age limits their activities" (Hultsch et al.,

1999). **The link may run from ability to activity**, with sharp people staying busy until decline slows them. A later review found that "very few studies have found an interactive effect of age and mental activity" (Salthouse, 2006).

Use it or lose it



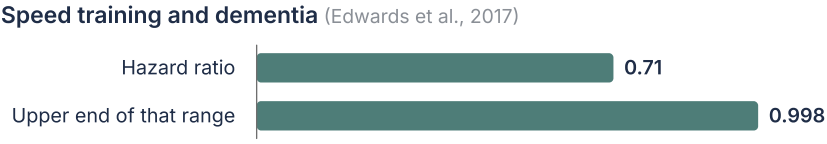
> **Science Says:**
>
> Salthouse concluded there was "the current lack of empirical evidence for the idea that the rate of mental aging is moderated by amount of mental activity" (Salthouse, 2006). **In plain words, active people tend to score higher, and nobody has shown that activity slows the rate of decline.** A larger review reached a similar verdict on schooling, finding that "associations between education and aging-associated cognitive declines are negligible" (Lövdén et al., 2020).

The same review found that "educational attainment has positive effects on cognitive function", and that "cognitive abilities are associated with selection into longer durations of education" (Lövdén et al., 2020). **Education goes with a higher level of ability**, and it has a negligible link with how fast ability falls. Brighter people tend to stay longer in school.

In 4.2.3 I showed that brain training mostly improves the trained tasks. **The new point is a follow-up on dementia from one large trial.** Dementia is a loss of memory and other mental abilities severe enough to disrupt daily life. In a randomised controlled trial (RCT), chance decides who gets which treatment.

> **Science Says:**
> In an RCT of 2,802 healthy older adults, the group given speed training had a lower risk of dementia over ten years, a hazard ratio (HR) of 0.71 (Edwards et al., 2017). **An HR of 0.71 means a risk about 29% lower.** The 95% confidence interval (CI), the range the true figure probably lies in, ran from 0.50 to 0.998. Memory and reasoning training showed no such link.

The upper end of that range, 0.998, sits just below 1, the point of no difference, so **the result is near the edge of chance**. It came from a secondary analysis, meaning one the trial was not mainly set up to test. Speed training has not been shown to prevent dementia, and this is one link in one trial.



Independence rests on many things beyond test scores, including health, money, family and the help that is around. **If you or someone close to you has worries about memory, safe driving or managing at home, talk to a doctor.** In 6.3.2 I set out how ordinary forgetting differs from changes worth checking, and a clinician is the person to judge.

For Margaret and for anyone else, my advice is to **lean on what stays strong and give yourself time for what has slowed**. Margaret now uses the staffed till, and nobody hurries her. **The cashier knows her by name and asks after her grandson.** She saves her energy for the crossword, the library and her grandchildren.

For Margaret and for anyone else

1. Lean on what stays strong
2. Give yourself time for what has slowed

Topic	What was found	Kind of study
Speed	Slower processing with age, linked to much of the age effect	Theory with correlational support
Vocabulary	Higher scores in older adults, an effect of 0.80 SD	Review of one-time comparisons
Senses	Sight and hearing linked with intelligence in very old adults	One snapshot study
Feelings	High well-being in old age	Review
Mental activity	Higher levels of ability, no shown slowing of decline	Observational studies and review
Education	Higher level of ability, negligible link with rate of decline	Review
Speed training	Lower dementia risk, near the edge of chance	One trial follow-up

When I helped Margaret with her shopping last Tuesday, **she read the small print on a jar of chutney that I had to squint at**. She turned the jar to the light, and nobody was rushing her. Her eyes are fine with her glasses on. Her pace is slower, and her judgement is as sharp as ever.

Exercise:

A strengths and supports list.

1. Write down three things you or an older relative do as skilfully as ever, such as a craft, a word game or giving advice.
2. Write down two tasks that now feel rushed, such as a machine at a till or a busy junction.
3. For each rushed task, note one way to take the time pressure off.
4. **If any change worries you, book a visit to a doctor.**

Key idea:

Speed tends to slow with age, while knowledge and well-being often hold up.

Quick check:

Does keeping mentally active slow the rate of decline with age? Answer: the evidence for that is lacking, since active people score higher and the link may run from ability to activity.

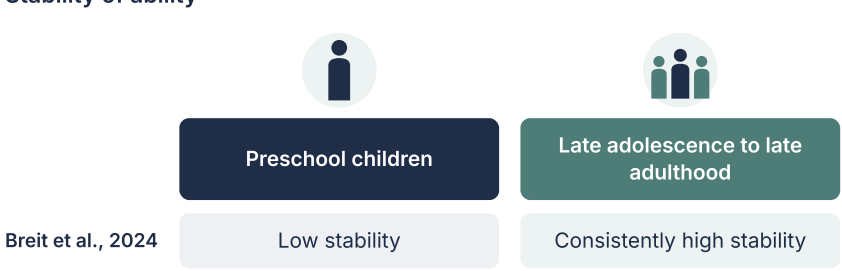
7.5 Individual Differences

7.5.1 Adapting Practice to Different Strengths and Needs

AT MY OLD OFFICE, two colleagues sat through **the same hour-long spreadsheet training video on the same afternoon**. Ben had never built a formula, and he followed every click with relief. Ana had run the finance team's spreadsheets for ten years, and by minute twenty she was making mistakes she never normally made.

The video was fine for Ben and poor for Ana, and **the research has a name for what happened to her**. In this book intellect means solving tasks where the variables are identified. This section looks at how much people differ, how stable those differences are and how to fit practice to the person.

Differences between people are real, and their stability changes with age. **A review of 205 studies and 87,408 participants found "low stability in preschool children" and "consistently high stability from late adolescence to late adulthood"** (Breit et al., 2024). Stability here means how far people keep their place relative to one another over time.



> 🗝 **Key Concept:**
>
> Rank-order stability. **Rank-order stability asks whether the people who score highest now still score highest later**, even if everyone's scores rise. At age 20, over 5 years, the review found "mean rank-order stability of ρ = .76" (Breit et al., 2024). The Greek letter ρ, rho, marks a correlation, a measure from 0 to 1 here of how closely two sets of scores line up.

In 1.3.2 I showed that heritability is a crowd fact, a figure about groups of people. **The new point is that a young child's place in the crowd is not settled.** One team says heritability compares genes and environment "to the variation of traits within and across populations" (Visscher et al., 2008), so it is about how people differ.

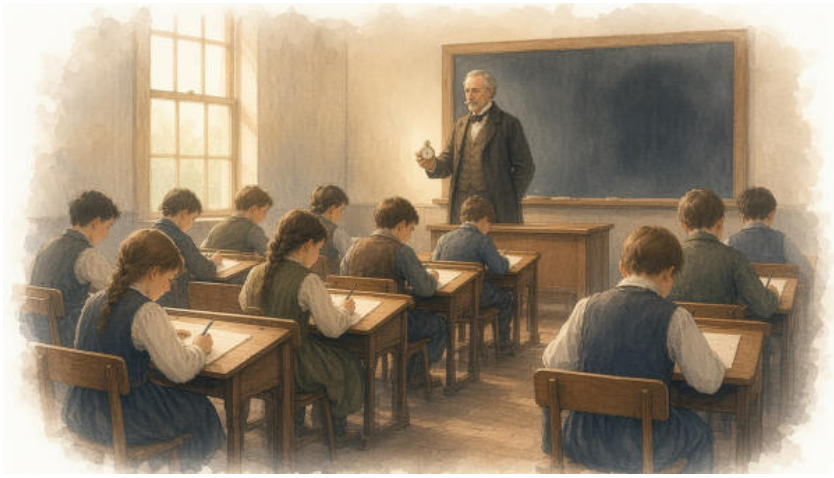


A row of toddlers' wellington boots of different sizes lined up by a nursery door, one pair far bigger than the rest.

With low stability in preschool children, **my own view is that labelling a small child as bright or slow puts weight on a result likely to move**. The review itself made no claim about labels. A

four-year-old who struggles with a puzzle today may be ahead of the class at nine, or the other way round.

Long records have looked at the question across the rest of life. **Two Scottish surveys of "almost everyone born in 1921 and 1936" (N = 89,498 and 70,805) studied "the stability of IQ scores from age 11 to age 80"** (Deary et al., 2004). N is the number of people, and IQ is a score from a standard intelligence test.



A row of eleven-year-olds in an old-fashioned classroom bent over test papers at wooden desks, their teacher at the front holding a pocket watch.

Heritability is "an estimable, dimensionless population parameter" in the same team's words (Visscher et al., 2008). **In plain words, it is a figure for a population and has no units**, so it describes groups and says nothing fixed about one person. A trait can be partly heritable and still change with schooling and experience.

Heritability



An estimable, dimensionless population parameter



A figure for a population and has no units



Says nothing fixed about one person

People differ in more than ability. **One analysis was "an extensive meta-analysis of personality-intellectual ability correlations"**, which grouped traits into four clusters, called trait complexes, including an "intellectual/cultural" one (Ackerman & Heggestad, 1997). A meta-analysis pools many studies into one answer. Ability, personality and interests tend to come in bundles.

> **Science Says:**
>
> In 1.1.2 I mentioned learning styles, the idea that each person learns best through one sense. **The new point is the verdict of a major review.** Several studies "found results that flatly contradict the popular meshing hypothesis", and "there is no adequate evidence base to justify incorporating learning-styles assessments into general educational practice" (Pashler et al., 2008). Many versions "have simply not been tested".

The meshing hypothesis is the claim that **matching teaching to a person's preferred style improves learning**. Pashler's team found no good evidence for it in the studies they reviewed. People do have preferences, and the review found no case for building lessons around them. **Preference and benefit are separate questions.**

Another review lists learning styles among several legends in education. **The legends include "learners as digital natives", "specific learning styles" and the idea that learners "should be given maximum control over what they are learning"** (Kirschner & van Merriënboer, 2013). Digital natives means young people assumed to learn differently because they grew up with technology.

Legends in education



What does fit practice to the person is what they already know. **Ana's trouble with the video has a name, the expertise reversal effect.** Prior knowledge is everything you already know about a subject before a lesson starts. A beginner and an expert can sit through the same lesson and take away very different things.

Ana knew every shortcut the video explained, so **each step it spelled out was a step she had to read past**. Her mind was busy checking things she already knew, and the new features slipped by. She told me afterwards that she had felt slow at her own job. That is the clash Kalyuga's team describe below.

> **Key Concept:**
>
> The expertise reversal effect. **"Instructional techniques that are highly effective with inexperienced learners can lose their effectiveness and even have negative consequences when used with more experienced learners"** (Kalyuga et al., 2003).
> Step-by-step guidance helps a beginner build understanding. For an expert, the same steps add work that gets in the way.

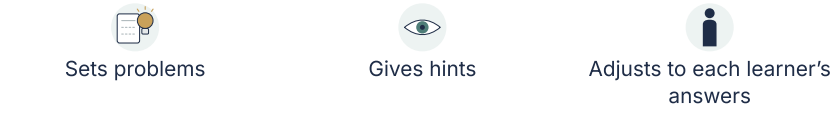
A sat-nav reading out every turn helps a stranger in town and irritates a local taxi driver. **The help has to shrink as the learner grows**, and that analogy is my own. My advice is to start new topics with worked examples and full steps, then take the steps away as you get better.

A sat-nav reading out every turn



Computer tutors are one way to adjust practice to each learner. **An intelligent tutoring system (ITS) is a computer program that sets problems, gives hints and adjusts to each learner's answers.** The reviews below date from 2013 to 2014, before generative AI chatbots, and they should not be applied to AI tools.

An intelligent tutoring system



> **Science Says:**
> A review of 107 effect sizes and 14,321 participants found that ITS beat teacher-led large-group teaching, with an effect size of 0.42 (Ma et al., 2014). **An effect size of 0.42 means a gap of about four tenths of a standard deviation**, the typical spread of scores. The review found "no significant difference between learning from ITS and learning from individualized human tutoring".

A second review, of 39 studies, found that **"ITS had a moderate positive effect on college students' academic learning"**, with effect sizes from 0.32 to 0.37 (Steenbergen-Hu & Cooper, 2014). It found that "ITS were less effective than human tutoring". One review found no gap with human tutors, and the other found human tutors ahead.



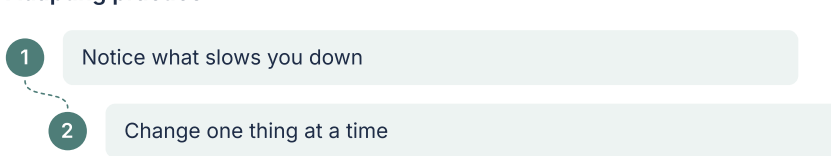
I cannot say which review is right on the evidence here. They pooled different sets of studies and learners. Both found real gains from computer tutors over the comparisons they used. Neither settles the question for every subject or kind of learner.

For schoolchildren the picture was weaker. **A review of 34 samples from 1997 to 2010 found that "ITS had no negative and perhaps a small positive effect on K-12 students' mathematical learning"** (Steenbergen-Hu & Cooper, 2013). The review covered maths only. K-12 means the school years from kindergarten to the final year of secondary school.

Taken together, the tutoring reviews suggest that **computer tutors of that era helped more than large classes and were no better than a good human tutor**. Module 8 looks at what modern AI tutors can and cannot do. None of these older figures can be carried over to them.

Some differences need a specialist. **If you suspect dyslexia, a lasting difficulty with reading and spelling, or ADHD, attention deficit hyperactivity disorder, talk to a doctor or a qualified assessor.** This book cannot judge whether someone has either, and an assessment is the way to find out.

Adapting practice can help anyone, with or without a diagnosis. **My suggestion is to notice what slows you down, such as long blocks of text, noise or a fast pace, and change one thing at a time.** Larger print, shorter sessions or a quieter room are easy to try, and none of them replaces an assessment.



Topic	What was found	Kind of study
Stability of ability	Low in preschool children, high from late adolescence	Review of long-term studies
Heritability	A population figure with no units	Methods paper
Learning styles	No adequate evidence for matching teaching to styles	Review
Expertise reversal	Beginner methods can harm experienced learners	Review of experiments
Computer tutors (2014)	Beat large-group teaching, no gap with human tutors	Review

Topic	What was found	Kind of study
Computer tutors (college)	Moderate gains, behind human tutors	Review
Computer tutors (school maths)	No harm and perhaps a small gain	Review

The next time the office ran training, **Ana skipped the video and took a short test of the new features instead**. She found two gaps and learned those in ten minutes from the help pages. Ben watched the video twice, and both came out knowing what they needed. **Neither of them wasted the afternoon.**

Exercise:

Fit the practice to you.

1. Pick one skill you want to improve.
2. Rate your knowledge of it from 1 for complete beginner to 5 for expert.
3. If you scored 1 or 2, find a worked example and copy each step. If you scored 4 or 5, try a problem first and check the solution after.
4. **After a week, rate yourself again and adjust the help you use.**

Key idea:

Fit practice to what a learner already knows, and give no weight to learning-style labels.

Quick check:

An experienced cook follows a beginner's step-by-step recipe video and makes more mistakes than usual. What effect could explain this? Answer: the expertise reversal effect, where guidance that helps beginners can hinder experienced learners.



Module

8

Technology, AI and Cleverini Games

8.1 Using Tools Well

8.1.1 Notes, Diagrams, Calculators and Search

You want to make pancakes, so you look up the recipe on your phone. It is the fifth time this year, and you still cannot say how much flour goes in. Perhaps the phone makes you forgetful, or perhaps it frees your mind. **The honest answer is both**, and the difference lies in how you use it.



A fridge door crowded with sticky notes and a shopping list, the household memory kept on the outside.

People have always kept knowledge outside their heads. A shopping list, a diary and a map in the glovebox each do a job your mind could do more slowly. Scientists call this **offloading**, handing part of a task to the world around you so your head has less to carry.

Offloading



A shopping list



A diary



A map in the glovebox

> **Key Concept:**
>
> Offloading. Two researchers describe cognitive offloading as using a physical action to change what a task asks of your mind, so it takes less mental effort (Risko & Gilbert, 2016). Writing a number on your hand is offloading, and a phone reminder is another case. In their review, **offloading can help or harm**, depending on the task and what you want from it.

A backpack works the same way. On a long walk it carries the tent, so your hands stay free. **That is a real help.** If you never learn to put the tent up, though, the backpack cannot do it for you on a windy hill. The tool carries the weight, and the skill has to live in you.

The backpack

The backpack		The skill
Carries the tent	≈	Has to live in you
Your hands stay free	≈	Put the tent up on a windy hill

Offloading is a fine choice when you will **never need the thing again**. A phone number you dial once can live in the phone. A plan with ten steps can live on paper, so your working memory is free for the hard step.

The trouble starts when **the thing you hand over is the skill** you are trying to build. A child who copies the answers from the back of the book finishes the homework fast. The homework is done, and the learning it was meant to bring has gone to the book.

When to hand it over

Offloading is a fine choice	The trouble starts
⊕ When you will never need the thing again	⊖ When the thing you hand over is the skill

Search engines are the biggest backpack most of us own. In 2011 a study in the journal Science suggested that when people expect to look something up later, they **remember where it is stored more than the fact itself** (Sparrow et al., 2011). The idea sounds right to anyone who reaches for a phone at dinner.

One study is only a first step. Scientists then try a **replication**, running the same study again with new people to see if the result holds. A large project re-ran 21 experiments from two top journals, and 13 of them replicated (Camerer et al., 2018). Sparrow's first experiment was one of the 21.

> **Science Says:**
>
> When Sparrow's first experiment was run again, **the effect came out at about 13.5% of its original size**, and the result was no longer clear (Camerer et al., 2018). A second team tested the same idea with 89 people and found "no conclusive evidence" for it (Hesselmann, 2020). Sparrow's team raised objections to how the repeat was designed, and the part about remembering where facts are kept was not part of the repeat.

I leave Sparrow's search finding out of my advice for that reason. **Other findings about search are better tested**, and they point somewhere useful. They are about how search makes you feel and what it does to your habits.

The search study



Searching can make you feel you know more than you do. Across nine experiments, people who searched the internet for explanations rated their own knowledge higher afterwards, because **they mistook "access to information for their own personal understanding of the information"** (M. Fisher et al., 2015). What rose was how much they believed they knew, which the authors call "self-assessed knowledge".

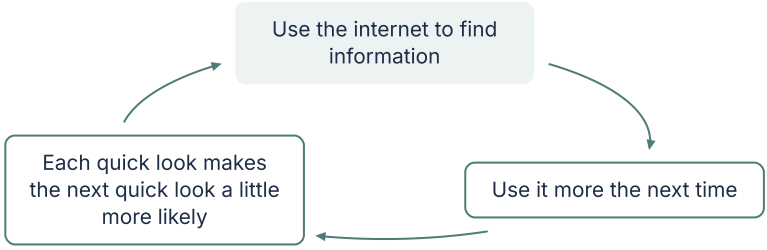
The feeling is the risk. **When you feel you know something, you stop studying it.** A student who has just searched a topic can walk into a test sure of an answer that was never stored. A quick check, saying the answer aloud with the screen off, shows which kind of knowing you have.

The feeling is the risk



Search can **become a habit that feeds itself**. In small lab studies, people who used the internet to find information went on to use it more the next time (Storm et al., 2017). Each quick look makes the next quick look a little more likely.

A habit that feeds itself



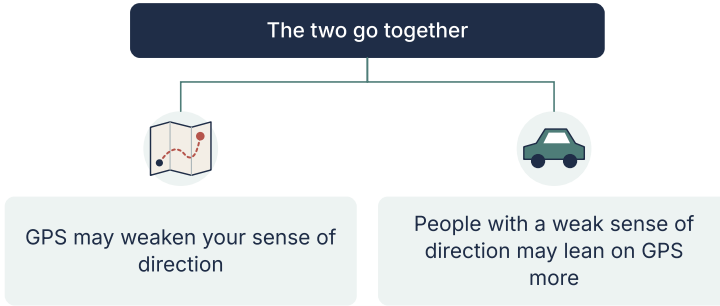
Cameras play a similar trick. In a museum study, people who photographed objects **remembered those objects less well** than when they only looked at them (Henkel, 2014). The samples were small, so I treat it as a hint. The camera held the picture, and the mind relaxed.

Sat-navs are the clearest everyday case. A study of 50 drivers found that **people who used GPS more had worse spatial memory**, the memory you use to find your way around (Dahmani & Bohbot, 2020). Thirteen of the drivers were tested again about three years later.

The study shows a correlation (see 1.1.1), so it tells us that the two go together. **It cannot say which came first.** GPS may weaken your sense of direction, or people with a weak sense of direction may lean on GPS more. Most of the data came from one moment in time, with only a small group followed up.

Since the cause is unclear, **a small test of your own** costs nothing. Walk or drive a route you know once a week with the screen off, and notice whether the turns come to you. If they do, the sat-nav is a backpack. If they do not, you have learned something about how you use it.

GPS and spatial memory



Calculators raise the same question in maths, and here the studies are kinder to the tool. A study that combined 79 research reports found that, except in grade four, **calculators used alongside normal maths teaching improved** average pupils' basic skills with pencil and paper (Hembree & Dessart, 1986).



A pupil's maths test on a desk, with a calculator lying beside the answer sheet.

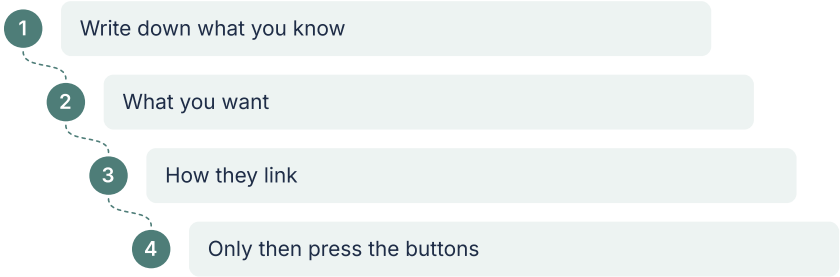
Later reviews found the same pattern. Across 54 studies, skills at working sums and solving problems **improved when calculators were a normal part of testing and teaching**, and "in all cases, calculator use did not hinder the development of mathematical skills" (Ellington,

2003). A review of 42 studies of graphing calculators found gains under the same condition (Ellington, 2006).

Those results come from school maths lessons that planned the calculator in, and they leave one job to you. A calculator is **good at the sum and no help with the setup**. Choosing which numbers count and what to do with them is where the variables get identified, and that part is intellect at work.

Let the calculator do the sum **once you have done the setup** yourself. Write down what you know, what you want and how they link, and only then press the buttons. If the answer looks odd, your setup will show you where to look.

Setup first



Note-taking had its own big claim. A 2014 study found that students who typed notes on laptops **did worse on questions about ideas** than students who wrote by hand (P. A. Mueller & Oppenheimer, 2014). It gave a simple rule, put the laptop away.

> **Science Says:**
>
> A later team ran the comparison again and found that "performance did not consistently differ between any groups" (Morehead et al., 2019). When they pooled the studies, the effects favouring longhand were **small and could have been chance**. Their verdict was that "concluding which method is superior ... seems premature".

My advice is to pick **whichever method you will really use**, and spend your effort on what you write. A page of copied sentences, in ink or on screen, gives your mind little to do.

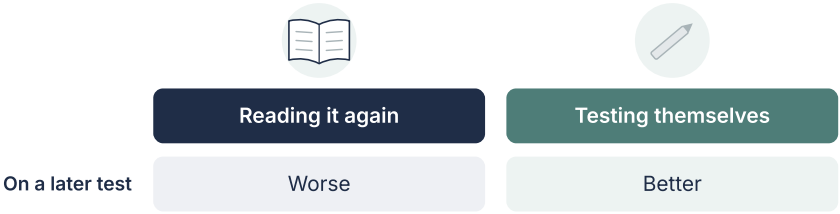
Diagrams are a different kind of note. A concept map puts ideas in boxes and joins them with short labelled lines, like **a small map of a topic**. Even a recipe can be mapped this way.

The maps have a good record. A review of 55 studies with 5,818 learners found that **concept maps went with better retention**, keeping what you learned for longer (Nesbit & Adesope, 2006).

Drawing the map makes you decide **how the ideas connect**. You cannot draw a line between two boxes without asking what the link is. Copying a list asks for none of that.

The most useful finding about notes has nothing to do with the tool. Students who **tested themselves on the material** did better on a later test than students who read it again (Roediger & Karpicke, 2006). This is called the testing effect.

Two ways to study



> **Key Concept:**
>
> The testing effect. Recalling something from memory, with the book closed, **beats reading it again** when you are tested later (Roediger & Karpicke, 2006). A path across a field gets easier to follow each time you walk it, and recall works a little like that path.

Search fits neatly with the testing effect. **Try to answer first**, even with a rough guess, and look it up second. The search then checks your memory and stops standing in for it. You get the speed of the tool and the learning in your head.

> **Exercise:**
>
> Try first, then look.
>
> 1. Pick three things you looked up this week, such as a recipe, a word or a date.
> 2. Before you search again, write your best answer from memory (Kornell et al., 2009).
> 3. Look it up, and mark what you got right.
> 4. Repeat next week, and count **how many you no longer need to look up**.

A simple rule sums up the section. Before you hand a job to a tool, ask whether you will need the skill again. If you will, **practise it first and use the tool to check**. If you will not, let the tool carry it and spend your effort elsewhere.

Back in the kitchen, try saying the amounts out loud before you open the recipe. You may get the flour wrong the first time. After a few rounds, **the recipe will live in your head**, and the phone will be there only to check.

Key idea:

A tool should carry the load you have already learned to lift, and leave the new learning to you.

Quick check:

You search for a fact and then feel you knew it all along. What might be going on? Answer: searching can give an illusion that the knowledge was in your own head.

8.2 Training Intellect with AI and Chatbots

8.2.1 What AI Can and Cannot Do for Your Intellect

Two children sit down to the same maths homework on the same evening. One types the question into a chatbot and copies the answer. The other asks it for a hint, gets stuck, asks for another and solves the sum alone. **Both hand in a correct sheet.**

The sheet cannot tell you which child got cleverer that night. **Only one of them did the learning**, and the chatbot was used in two opposite ways.

Two children, one sheet

Copies the answer	Asks it for a hint
A correct sheet	A correct sheet
No learning	Solves the sum alone

Most talk about AI and the mind asks whether AI is good or bad for us. **The more useful question is how you used it.** The same tool can build a skill on Monday and stand in for it on Tuesday.

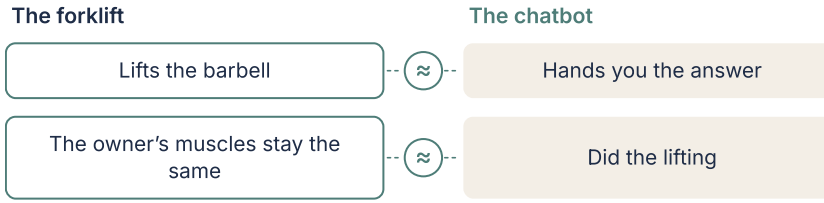
A forklift in a gym makes the point. It can lift a heavy barbell with no trouble, and the bar goes up and down all day. **The owner's muscles stay the same**, because the forklift did the lifting. A chatbot that hands you the answer is a forklift for your mind.



A forklift raising a barbell in an empty gym while its owner stands by with folded arms.

Chatbots are the strongest forklifts ever built for school work. They write essays, solve equations and sum up whole books in seconds. **That speed is the gift and the risk in one.** Whether the speed helps you depends on who holds the bar.

A forklift for your mind



The research on AI and learning falls along that line. When the AI makes you do the work, results look good. When it does the work for you, **the gains can vanish once the tool is gone**. Two recent trials show both sides, and both used the same kind of study.

> **Key Concept:**
> Controlled trial. A controlled trial splits people into groups **by chance**, like drawing names from a hat, and gives each group a different treatment. Because chance did the sorting, a difference at the end most likely comes from the treatment.

At Harvard, 194 physics students took part in a trial of an AI tutor. The authors report that **"students learn significantly more in less time when using the AI tutor"** (Kestin et al., 2025). The research team built that tutor on teaching research, and the trial ran inside one course.

The Harvard trial



194 physics students



An AI tutor



Learn significantly more in less time

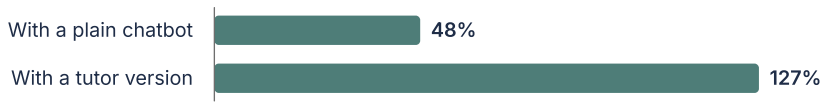
A good result from one careful build tells you **what AI can do when it is set up to teach**. It tells you less about the chatbot on your phone, which nobody set up to teach you anything.

A custom tutor and **an everyday chatbot are different tools**. The second trial looked at what happens when students use a chatbot with no guardrails, meaning no special limits on how it helps.

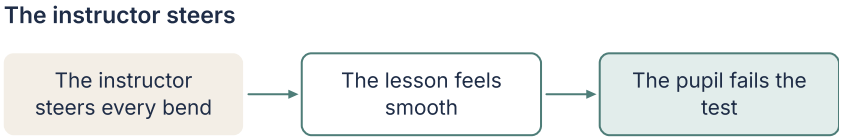
> **Science Says:**
>
> A study titled "Generative AI without guardrails can harm learning" followed nearly a thousand high school maths students (Bastani et al., 2025). With access during practice, **grades rose by 48%** with a plain chatbot and by 127% with a tutor version. Once access was taken away, the plain-chatbot group did 17% worse than students who had never had access at all.

The plain chatbot behaved like the forklift. **Practice scores went up while it did the lifting**, and the skill was missing when it left. Students leaned on it like a walking stick, and a stick does nothing to make your own legs stronger.

Grades during practice



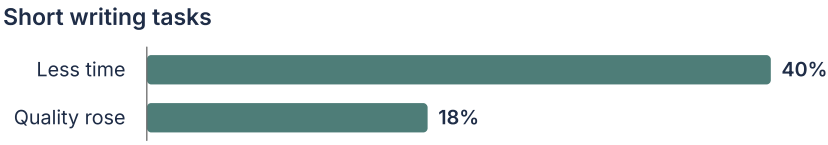
A driving lesson shows the same trap. Some instructors have a second set of pedals and can grab the wheel. **If the instructor steers every bend, the lesson feels smooth** and the pupil fails the test, because the pupil never steered.



Studies of AI at work tell a brighter story, and they measure something else. They count **how much people get done**, and what they produce in an hour. Learning is what you can still do the next day without the tool.

> **Key Concept:**
> Output and learning. Output is **what you produce with the tool in your hand**. Learning is what stays in you when the tool is put down. The work studies below measure output, so they say a lot about speed and quality and very little about your intellect. A spellchecker lifts the output of a letter at once, and your own spelling may stay the same for years.

In one experiment, 453 professionals did short writing tasks. With a chatbot they **took 40% less time**, and the quality of their writing rose by 18% (Noy & Zhang, 2023). The tasks were short, and the study measured productivity.



At a call centre with 5,172 agents, an AI helper raised productivity by about 15% (Brynjolfsson et al., 2025). **Less experienced agents gained the most.** The top agents saw small declines in quality.

For a beginner at work, that is good news. For your intellect, **the open question is the day the helper is switched off**. Whether those newer agents could then do the job better was outside what the study measured.

The most telling work study gave 758 consultants 18 tasks (Dell'Acqua et al., 2026). On tasks the AI handled well, an early version of the paper reports that consultants with AI **finished 12.2% more tasks**, worked 25.1% faster and turned in work of over 40% higher quality.

> **Science Says:**
>
> The same study set one task that lay outside what the AI could do well. There, consultants with AI were **"19% less likely"** to reach the right answer than those working alone (Dell'Acqua et al., 2026). The authors call the edge of what AI does well a jagged frontier, a line with sharp ins and outs.

The frontier is **a coastline you cannot see**. Inside it, AI made people faster and better. A step outside, taken without noticing, led people with AI to the wrong answer more often than people working on their own.

The jagged frontier



Spotting the frontier from the outside is hard. **Test the chatbot on questions you can already answer** in a subject, and see where it slips. Those slips mark the coast for you, and 8.2.4 shows how to check its answers.

Leaning on AI every day may change the effort you put in yourself. A survey of 319 knowledge workers, with 936 examples of their AI use, found that **"higher confidence in GenAI is associated with less critical thinking"** (Lee et al., 2025).

Gerlich asked 666 people about their use of AI tools. **Heavier use went with lower critical-thinking scores**, with offloading (see 8.1.1) sitting between the two (Gerlich, 2025).

Trust and checking



Both studies are correlations (see 1.1.1), built on what people said about themselves. **They show that the two go together** and cannot say

which causes which. Trust in AI may lead people to check less, or people who prefer to check less may lean on AI more.

With a chatbot, **what you hand over decides the result.** Giving a chatbot the spelling check on a long report frees you for the argument. Giving it the argument leaves you with nothing to practise.

Coach or forklift



A simple test follows for every use of AI. Ask **who did the hard part**. If the chatbot made you produce, explain or check something, it was a coach. If it produced the thing for you, it was a forklift.

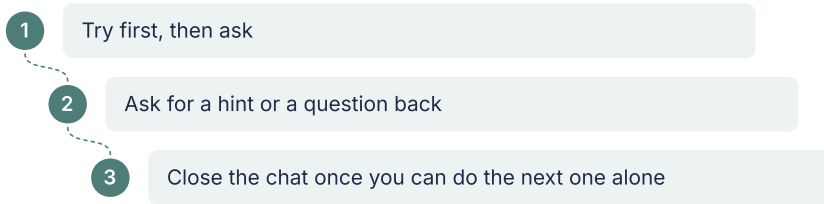
Used as a coach, a chatbot has real strengths. **It never runs out of patience.** It can explain one idea five ways, invent a fresh practice question at midnight, argue the other side of your view, or point to the step where your working went wrong. The next three sections take those uses one at a time.

Some jobs stay with you whatever the tool. **A chatbot cannot do your practice for you**, any more than a friend can do your press-ups. It can sound just as sure outside its frontier as inside. It cannot tell what you have learned, because only a try without it shows that.

Two habits keep the chatbot on the coach side. **Try first, then ask**, so the tool meets your attempt and not a blank page. Ask for a hint or a

question back before you ask for an answer, and close the chat once you can do the next one alone.

Keep the chatbot a coach



> **Exercise:**
>
> Coach or crutch.
>
> 1. For one week, note each time you use a chatbot.
> 2. Mark each use “did it for me” or “made me do it”, and count each kind.
> 3. Pick one “did it for me” task and **redo it with the chatbot as a coach**, asking only for hints.
> 4. A week later, try that kind of task alone and **see what stayed with you**.

Back at the kitchen table, the second child spent longer on the homework. **The extra minutes were the learning.** A chatbot can explain, quiz, argue and check, and it will do any of those for you all day.

Your intellect grows only from the part you did yourself. The next time a chatbot offers you the whole answer, **ask it for the next step instead**, and keep the last step for you.

Key idea:

AI helps your intellect when it makes you do the work, and harms it when it does the work for you.

Quick check:

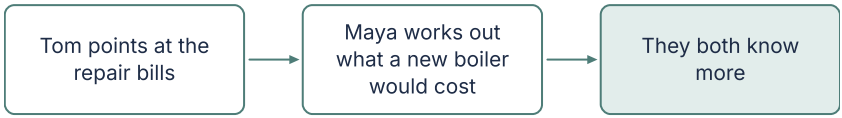
In one trial, students who practised with a plain chatbot got higher grades. What happened when the chatbot was taken away? Answer: they did 17% worse than students who never had the chatbot.

8.2.2 Sparring with a Chatbot: Debate, Devil's Advocate and Defending Your Answer

YOU ARE SURE YOU are right about something, and **the hard part is finding out if you are wrong**. Your own head is a poor place to look, because it keeps agreeing with you. A friend who pushes back does better, since **a partner can find the hole before life does**.

Two friends sit over coffee, arguing about whether to buy a flat or keep renting. Maya likes buying. Tom points at the repair bills, so Maya works out what a new boiler would cost. **Each push from Tom makes her case sharper**, and by the second cup they both know more than when they sat down.

Each push from Tom



Boxing has a word for this. A sparring partner throws real punches, softly, with padded gloves and headgear. **You learn to block before the real fight**, where a mistake costs more. A chatbot can be that partner for your arguments, if you set it up to hit back.

Sparring has rules that make it useful. **Your partner hits hard enough to teach and never hard enough to injure.** You can stop the round, ask what went wrong and try the move again. A real fight gives you none of that.



Two boxers in padded headgear trading light punches in a small, bright gym.

Two scientists, Hugo Mercier and Dan Sperber, have a theory about why a push from outside helps so much. When we argue, they say, we

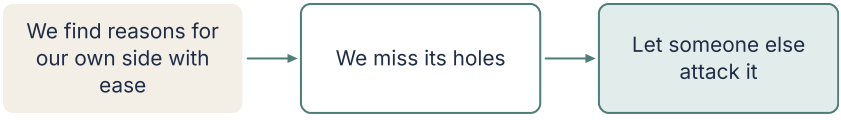
are **"skilled arguers"** who are "not after the truth" (Mercier & Sperber, 2011). We find reasons for our own side with ease and miss its holes.

Rules of sparring



Their idea is a hypothesis, a proposal still being tested, and the paper came out alongside replies from other scientists. **Its advice is useful either way.** If we are poor judges of our own reasoning, we should let someone else attack it. A good arguer on the other side does the hole-spotting we skip.

Let someone else attack it



Practice at arguing builds skill. In a study that ran over several years, young teenagers argued with each other in dialogue. **Their skill carried over into essays they wrote alone**, and beat a group that practised essay writing (Kuhn & Crowell, 2011). The study took place in one school, with a modest number of students.

Arguing out loud with another person is slow, and a willing partner is hard to find at eleven at night. **A chatbot is always free to spar**, and it never takes the argument personally. Those two things make it worth learning to use well.

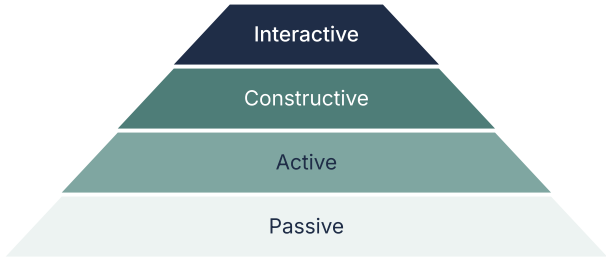
> **Science Says:**
> A review of ways to teach reasoning pooled 341 effect sizes and found an average of 0.30 (Abrami et al., 2015). **Dialogue was one of the methods that helped**, alongside real-world problems and mentoring.

Two learning scientists explain why talking with someone can do more than working alone. **Learning grows as you do more with the material**, and doing it with a partner sits at the top of their scale. Sitting through a talk and taking nothing down sits near the bottom.

> **Key Concept:**
> Interactive learning. Chi and Wylie rank four ways of learning, from passive (listening), to active (underlining), to constructive (explaining in your own words), to interactive (building on a partner's ideas). **Interactive comes out on top** (Chi & Wylie, 2014). Parts of the scale are still a hypothesis.

A chatbot counts as a partner only when you **make it answer back**. Ask it to tidy your argument, and it does the work while you watch. Ask it to argue the other side, and you are in the ring.

Four ways of learning



Setting up the ring takes one message. Tell the chatbot its role, the rules and when to stop. **Clear rules turn a chat into a drill**, and the drill keeps the hard part with you.

> Exercise:
>
> Debate.
>
> 1. Pick a question with two sides, such as "Should our town ban cars from the high street?"
> 2. Tell the chatbot, "You argue against. I argue for. Give me one point at a time and wait for my reply."
> 3. Answer each point in your own words before you read the next.
> 4. After five rounds, **swap sides** and argue the case you just fought.

A round might start like this. Maya argues for buying, and the chatbot opens with a cost she forgot, the fees paid when a flat changes hands. **She has to answer in her own words**, so she looks up the fees and finds a figure for her town.

The chatbot's next point is about moving for a new job. Maya has no answer, and says so. **A point you cannot answer is the best thing a round can give you.** It shows where your case needs work before a bank manager finds the gap.

A round



Before any of these drills, **answer from your own memory first**. The testing effect from 8.1.1 explains why, and a chatbot that speaks first does the recalling for you, so the practice is gone before the round begins.

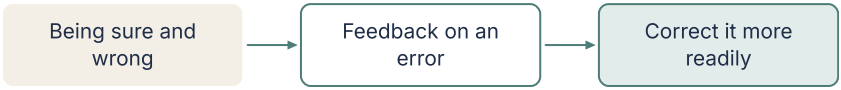
Devil's advocate is an old job. **Someone is given the task of attacking an idea everyone likes**, so its weak points show up while they are cheap to fix. A chatbot will take that job without hurt feelings, and without getting tired of it.

> Exercise:
>
> Devil's advocate.
>
> 1. Write down a view you hold firmly, in one sentence.
> 2. Ask, "Give me the three strongest arguments against this view. Do not soften them."
> 3. For each one, write whether it **changes your view, sharpens it or fails**, and why.
> 4. Rewrite your sentence so it survives the best attack.

Being wrong with confidence sounds like the worst case. **Confident mistakes are often the easiest to fix**, and scientists have a name for that.

Say you were sure that a spider is an insect, and you rated that a 5. Learning it has eight legs and sits with the scorpions is a jolt. **Being sure and wrong is nothing to dread**, since those are the errors people are likeliest to fix.

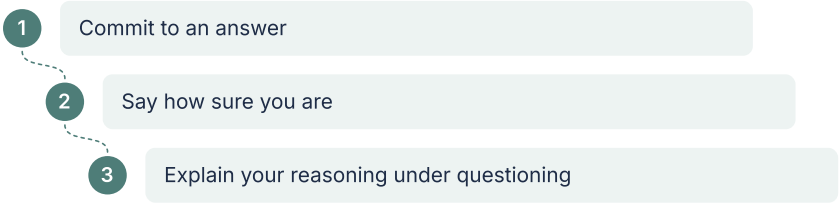
Sure and wrong



> **Key Concept:**
> Hypercorrection. When people get feedback on an error they felt sure about, they correct it more readily than errors they guessed at (Butterfield & Metcalfe, 2001). More broadly, **making errors and then getting the right answer helps learning** (Metcalfe, 2017).

The self-explaining from 3.2.1 shapes the third drill, and it has a measured size. A review of 69 effect sizes found an average effect of 0.55 when learners were prompted to explain to themselves (Bisra et al., 2018). You commit to an answer, say how sure you are, and **explain your reasoning under questioning**. Only then do you check.

Defend your answer



The drill works best on questions you can check later, so the verdict means something. **Maths problems, dates and science facts make good material.** Opinions suit the first two drills better.

> Exercise:
>
> Defend your answer.
>
> 1. Take a question with a clear answer, such as a maths problem.
> 2. Write your answer and rate how sure you are, from 1 to 5.
> 3. Ask the chatbot, "My answer is below. Do not say if it is right. Question my reasoning."
> 4. Answer its questions, then ask for the verdict, and **look hardest at answers you rated 4 or 5**.

Answering before you see the AI's view has a name, cognitive forcing. In an online study of 199 people, **forcing designs cut overreliance on AI**, the habit of accepting its suggestion even when it is wrong (Buçinca et al., 2021). People liked those designs less. Expect the drills to feel slower than asking for the answer.

The slowness has a purpose. **The seconds spent committing to an answer are the seconds you practise in.** Skip them, and the round turns into reading someone else's work.

> Science Says:
>
> In a study of 2,190 people, conversations with a chatbot (GPT-4 Turbo) reduced belief in a conspiracy theory by about 20%, and the effect lasted two months (Costello et al., 2024). **A chatbot can argue well enough to change minds.**

The finding cuts both ways. **A partner strong enough to move a false belief can move a true one.** After a sparring round, check any new fact it gave you before you change your view. Chatbots change fast, so a partner that is weak today may be strong next year, and the reverse.

The finding cuts both ways

A strong partner	The risk
⊕ Can move a false belief	⊖ Can move a true one

A partner can fail the other way, by **giving in at the first push**. Scientists call this sycophancy, when a chatbot tells you what you want to hear, like a sparring partner who drops their guard whenever you frown.

> **Science Says:**
>
> Five AI assistants **kept telling users what they wanted to hear** across four kinds of writing task. When users said they doubted an answer, the assistants changed it between 32% (GPT-4) and 86% (Claude 1.3) of the time, and Claude 1.3 wrongly admitted mistakes on 98% of questions (Sharma et al., 2024). These are older models from 2023.

Giving in does most harm with health. In a study published in 2025, five leading chatbots of the time, sent requests built on a false claim about medicines, at first went along with them in up to 100% of cases (S. Chen et al., 2025). **Never use a chatbot for medical advice**; ask a doctor or a pharmacist.

Two habits keep you safe in the ring. **Ask for sources on any new fact**, and check them yourself. Ask the chatbot to argue your own side at full strength, so you hear both cases before you decide.



Two sparring partners resting on the ropes after a round, gloves off, with no winner named.

Back at the cafe, Maya did not win by being right at the start. **She got better by being tested**, and Tom's pushes did that for her. Pick one view you care about this week, and put it in the ring with a chatbot before you put it in front of a person.

Key idea:

A good sparring partner pushes back, and you grow by defending your answer before you check it.

Quick check:

Why write your answer and rate your confidence before you ask a chatbot?
Answer: recalling it yourself makes it stick, and the errors you felt sure about are the easiest to fix once you see the feedback.

8.2.3 The Chatbot as Socratic Tutor and Problem-Setter

A GOOD TEACHER SELDOM TELLS you the answer straight away, and a chatbot that always tells you is a worse teacher, odd as that sounds. **The reason lies in who does the work**, and a bicycle shows it best. Most of us have met both kinds of teacher, and we learned more from the one who made us try.

Remember learning to ride a bike. An adult runs alongside, holding the saddle tight at first. **Bit by bit they let go**, and one day you look round and see them far behind. If they had never let go, you would still need them.

Teachers call that holding and letting go scaffolding, after the frame builders put up around a new wall and later take down. **Help shrinks as skill grows.** A chatbot can give you that kind of help if you ask for it. Left to its own habits, it tends to hand over the finished wall.

Scaffolding



A piano teacher works the same way. When you stumble on one bar, a good teacher points at it and asks you to play it again. **Playing the piece for you would sound nicer and teach you nothing.** Your fingers have to find the notes.



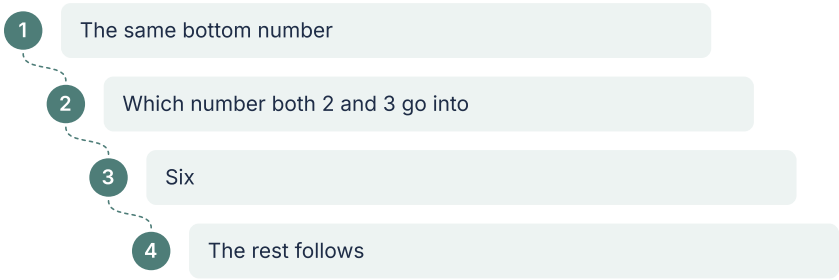
A piano teacher pointing at one bar of music while the pupil's hands rest on the keys.

> **Key Concept:**
>
> Socratic questioning. The name comes from Socrates, a teacher in ancient Athens who taught mostly by asking questions. A Socratic tutor answers your question with a question of its own, **one small step at a time**, until you reach the answer yourself. A good Socratic question is small enough to answer and big enough to make you work.

A Socratic exchange on fractions might go like this. You ask what a half plus a third makes. The tutor asks what the two fractions would need in common before you can add them. **You have to find the step yourself**, and the tutor waits.

You answer that they need the same bottom number. The tutor asks which number both 2 and 3 go into. Six, you say, and the rest follows. **A few small questions did what one answer could not**, because each step came from you.

A Socratic exchange



Tutoring of this kind has a long record. Long before chatbots, scientists built computer tutors that guided students through problems step by step. **Those older systems give the best evidence we have**, because they were tested over many years and in many subjects.

> **Science Says:**
>
> A review compared human tutors with computer tutors that work step by step (VanLehn, 2011). Human tutoring gave an effect size (see 1.2.2) of 0.79, and **step-based computer tutors came close at 0.76**. A later review of 50 evaluations found a median effect size of 0.66, with smaller gains on standard tests (Kulik & Fletcher, 2016).

The gap between the two tutoring results was small. **A patient computer came close to a human tutor**, at least in the subjects those systems covered. Those were good tutors on narrow ground.

Human and computer tutors



Those systems were built before chatbots, each for one subject. **A chatbot is a far looser tool.** The old results show what good tutoring can do, and say much less about what a chatbot will do on its own. A tool that can talk about anything has no built-in plan for teaching you one thing.

The closest test with a modern AI is the Harvard physics trial in 8.2.1 (Kestin et al., 2025), and its design adds something here. **The tutor gave hints and steps and held back direct answers.** Students worked in groups of two or three, and the groups were split by chance between the AI tutor and active lessons in class.

The Harvard tutor



Hints and steps



Held back direct answers



Groups of two or three

An everyday chatbot will not behave this way unless you ask it to. The good news is that asking takes one message.

In Nigeria, a six-week programme had students use a chatbot, Copilot running on GPT-4, with teachers guiding the sessions. **Their scores rose by 0.31 standard deviations** across the tests, and by 0.23 in English (De Simone et al., 2025). The report is a working paper, which means other experts have not yet checked it for a journal.

One more trial used AI tips to coach 900 human tutors, never their 1,800 school pupils. **For every 100 pupils, about 4 more mastered a topic**, and about 9 more for pupils of lower-rated tutors (Wang et al., 2024). The tutors asked more guiding questions and gave fewer answers away. Other scientists have not yet reviewed this preprint.



Questions run both ways in good tutoring. With a tutor, students asked **about 240 times as many questions** as in class (Graesser & Person, 1994). How many they asked did not go with how well they did. How good their questions were did, after some time in tutoring. It is only a correlation, so it cannot show cause.

> **Science Says:**
>
> A review of studies that taught students to **write their own questions** about a text found a median effect of 0.36 on standard tests and 0.86 on tests the researchers made themselves (Rosenshine et al., 1996). All the studies tested reading, and the gain was smaller on the standard tests.



A teenager reading a textbook page aloud to herself, one finger resting on the line she is explaining.

Writing your own question is one way to turn an idea over yourself. Explaining it out loud is another, though it feels slow and a little silly. **Putting it into your own words shows you the gaps**, since a step you cannot explain is a step you do not yet understand. A tutor who keeps asking why finds them sooner.

Explaining out loud



With a Socratic chatbot, the explaining gains a partner. **Each question makes you explain**, and each reply builds on what you just said, so the gaps show up one at a time.

> **Exercise:**
>
> Socratic tutor.
>
> 1. Pick a topic you are learning, such as fractions.
> 2. Type, "Be my Socratic tutor. Ask me one question at a time. Never give me the answer. If I am stuck, give the smallest hint you can."
> 3. Answer each question in your own words.
> 4. At the end, **explain the topic back** in three sentences.
> 5. The next day, ask one fresh question on it.

If the chatbot slips and gives you the answer, say so and ask it to go back to questions. **You are in charge of the rules**, and you can restate them as often as you like. A short reminder at the top of each new chat saves trouble later.

The second job is setting problems. **A chatbot can write fresh questions all day**, on any topic, at any level.

> **Key Concept:**
> Problem-setter. A problem-setter writes practice tasks for you, **a little harder each time**, and keeps the answers hidden until you have tried. Getting some wrong is part of the plan, and nothing to hide from.

Tasks you can do half asleep teach little, and tasks far above you just stop you. **Aim for tasks that make you work** and that you sometimes get wrong. I aim for about four out of five on a set, and when I score five every time, I ask the chatbot for harder ones.



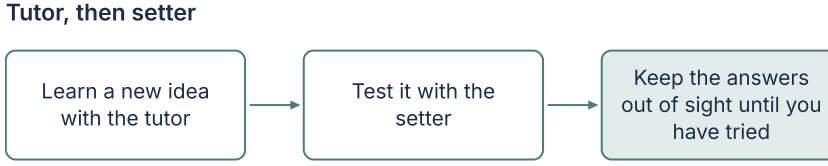
> **Science Says:**
> In algebra, beginners took far less time over worked examples, problems already solved step by step, than over plain problems. Afterwards they solved similar problems faster and with fewer errors, but **only problems with the same structure** (Sweller & Cooper, 1985).

Problem sets work best when they climb like a staircase. **Each step is only a little higher than the last**, so you can always reach it with some stretch. If one step is out of reach, ask for a smaller one in

between, or for a worked example first. When examples feel easy, ask for a new kind of problem.

> **Exercise:**
>
> Problem-setter.
>
> 1. Type, "Set me five practice problems on fractions, each a little harder than the last. Show one at a time. Do not show answers until I ask."
> 2. Try each one on paper first.
> 3. Compare with its answer and **write one line on any mistake**.
> 4. Ask for two more problems aimed at that mistake.

The two jobs work well together. **Learn a new idea with the tutor, then test it with the setter**, and keep the answers out of sight until you have tried. One chat can do both if you tell it when to switch.



A chatbot can get its own answer key wrong. **Check any answer that disagrees with yours**, by working it again or looking it up, before you accept that you were wrong. Mark any answer you are still unsure of and ask a teacher or a textbook. The next section is about that kind of checking.

The adult on the bike path knew when to let go. **A chatbot will hold the saddle for ever unless you tell it to step back.** Set the rules at the

start of each chat, ask for questions and hints, and keep the last step for yourself.

The chat will take longer than asking for the answer. **That extra time is the price of learning**, and it is cheap. What you learn in it will still be yours when the screen is off, and the bike will stay upright without anyone holding the saddle.

Key idea:

Ask the chatbot for questions and hints, and keep the answers for yourself to find.

Quick check:

You ask a chatbot to be your Socratic tutor, and it gives you the whole answer. What should you do? Answer: remind it of the rules, ask for one question at a time, and try the step yourself.

8.2.4 Spot the Error: Checking and Correcting AI Answers

A CHATBOT GIVES YOU A neat answer with three references at the bottom, each with authors, a year and a journal. **Any of those references could be made up**, and you cannot tell by looking. All three may be real, or none, and the page looks the same either way. This section is about finding out which.

Say you buy milk, bread and eggs, and the receipt looks fine at a glance. At home you read it line by line and find the milk charged twice. **The till did not mean to cheat you.** It made a slip and printed it as neatly as every other line, so the neat print told you nothing.



A shop receipt held up under a kitchen lamp, with one line circled in pencil.

Chatbots make the same kind of slip. **A confident answer can be made up**, and it arrives in the same tidy sentences as a true one. People who build and study language programs treat this as a known problem, with its own name and a whole survey of the field (Ji et al., 2023).

The receipt

The till		The chatbot
Made a slip	≈	A confident answer can be made up
Printed it as neatly as every other line	≈	The same tidy sentences as a true one

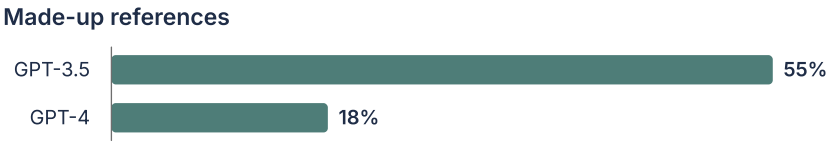
> **Key Concept:**
>
> Hallucination. When an AI states something false or made up as if it were true, the error is called a hallucination. **The answer sounds just as sure as a correct one**, which is why it is hard to spot. The word borrows from people seeing things that are not there.

One plain way to picture the cause is this. A chatbot writes text that fits the pattern of what you asked for. **A made-up reference fits the pattern perfectly**, with real-sounding authors, a likely journal and a sensible year, and still points to nothing.

References are the easiest place to catch a hallucination, because you can look them up. Two research teams did that with older versions of ChatGPT and Bard, and **many of the references did not exist**. Others were real papers with the wrong year, the wrong journal or the wrong authors attached.

> Science Says:
>
> In a study published in 2023, 55% of the references written by GPT-3.5 and 18% of those by GPT-4 were made up (Walters & Wilder, 2023). Among the real ones, 43% and 24% had errors of substance. In tests run in 2023, **hallucination rates were 39.6% for GPT-3.5, 28.6% for GPT-4 and 91.4% for Bard** when each was asked for references for research reviews (Chelli et al., 2024).

Those figures are old. **They describe chatbots that have since been replaced**, and the drop from GPT-3.5 to GPT-4 shows how fast the numbers move. Do not quote them as today's rates. What they still show is the shape of the problem, an answer that looks like real research and is partly invented.

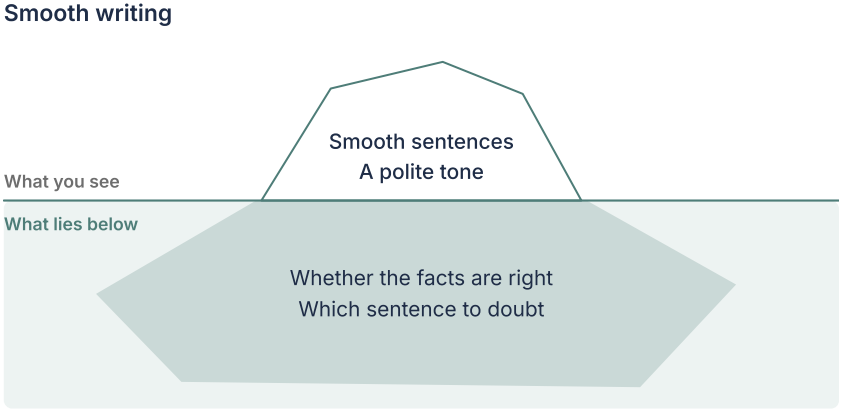


One public ranking tests how often models invent details when they sum up a document. In early November 2026 it listed 111 models, last updated on 22 October 2026 (Vectara, 2026). **The rates differed a great deal from model to model**, and they shift with every update. Even the best model on the list made some errors.

The lesson holds whatever the year. **Every chatbot makes some errors, and the errors do not come labelled.** You are the checker, and a few habits make the job quick. None of them needs special training, only a search box and a little patience.

Checking is cheaper than it sounds. **A single check usually takes a minute or two** with a search engine or a book. Compared with handing in a wrong answer, or repeating a false fact to a room of people, that minute is a bargain.

A spell-checker draws a red line under words that look wrong to it, which is handy. **When no red line appears, it is easy to stop reading closely.** A wrong word that happens to be spelled right, like "form" for "from", then slips through. The tool's silence starts to feel like a promise.



Chatbots invite the same trust. **Their answers come with no red lines at all**, in smooth sentences and a polite tone. Nothing on the screen tells you which sentence to doubt, so the doubting is your job. Smooth writing is a sign of a good writer, and tells you little about whether the facts are right.

> **Key Concept:**
> Automation bias. Automation bias is the habit of trusting a machine's output over your own judgement, **so you miss its mistakes or follow its wrong advice**. A review gathered 74 studies of it in tools that help people make decisions (Goddard et al., 2012).

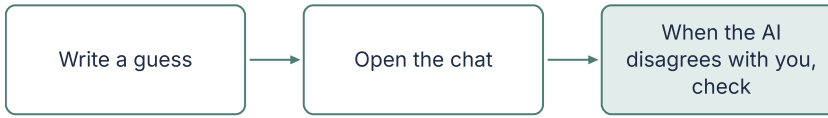
Knowing about the bias is a start, and on its own it falls short. Two researchers, reviewing older kinds of automation from before chatbots, concluded that automation bias **"cannot be prevented by training or instructions"** (Parasuraman & Manzey, 2010). You need a habit that builds the check into the task.

> **Science Says:**
> Skill is no shield on its own. In the consultant study from 8.2.1, one task lay outside what the AI did well. **84.5% of consultants working alone got it right**, and consultants with AI were "19% less likely" to be correct (Dell'Acqua et al., 2026). The AI's answer led skilled people astray.

The habit is the one from the sparring section, cognitive forcing (see 8.2.2). **Commit to your own answer before you read the AI's.**

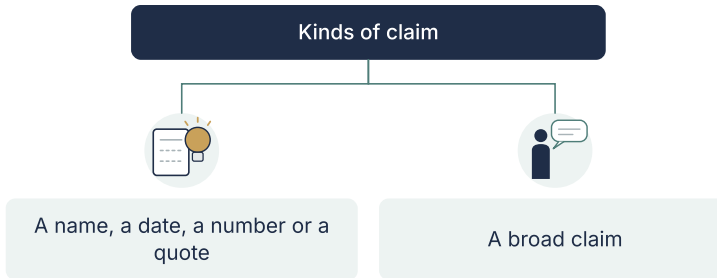
In practice, write a guess, even a rough one, before you open the chat. **The guess gives you something to compare against**, and a guess on paper is harder to let go of than one in your head. When the AI disagrees with you, treat that as your cue to check before you give in.

Commit first



Checking starts with sorting. **A few kinds of claim are quick to test.** A name, a date, a number or a quote can be looked up in a minute. A broad claim, such as "most experts agree", needs a source you can open and read yourself.

Checking starts with sorting



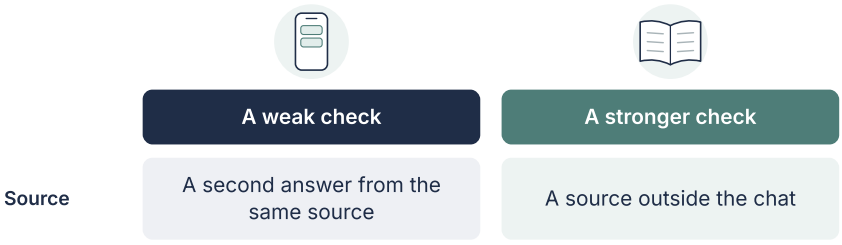
For references, search the exact title. **If you cannot find the paper, treat it as made up** until you can. If you do find it, open it and check that it says what the chatbot claims, since a real paper can still be quoted wrongly.

For numbers, ask where they came from, then go there. The original study or an official statistics office is the best place to land. **A figure with no source is a guess in a suit.** For steps in maths or logic, work

the problem yourself and compare the two at the first point where you differ.

You can ask the chatbot to check its own answer, and sometimes it catches its slip. **A second answer from the same source is a weak check.** Ask it for the source, then open the source yourself. A source outside the chat, such as a textbook, an official site or a person who knows, is stronger.

Weak and strong checks



You cannot check everything, and you do not need to. **Check what you will repeat, act on or hand in.** A fun fact you will forget by tomorrow can pass. A figure in your homework, or a claim you will pass on to friends, deserves a look.

Check what you will



Finding errors does more than protect you. **I find that hunting for a slip teaches me more** than reading a clean answer. An AI answer with a hidden slip is a ready-made puzzle, and you get the feedback the

moment you check. Each slip you catch teaches you the topic and the tool at once.

> Exercise:
>
> Error hunt.
>
> 1. Pick a topic you know well, such as your town's history or a hobby.
> 2. Ask a chatbot for three facts and three sources on it.
> 3. Check each one, and mark it right, wrong or not found.
> 4. For each wrong one, **write the correction in your own words**, with where you found it.
> 5. A month later, hunt again on a new topic.

A harder version suits anyone learning maths. Ask the chatbot to solve a problem with one deliberate mistake hidden in the working, and to keep the mistake secret. **Find the step, fix it and explain why it was wrong.** Then ask it to reveal the mistake and compare.

The first error hunt takes a while. **Later hunts go faster**, because you learn what to look up first, the names, numbers, dates and quotes. Checking turns from a chore into a quick routine, like glancing at a receipt before you leave the shop.

You would not stop shopping because a till once charged you twice. **You would read the receipt.** Treat every AI answer the same way, as a useful draft that still needs checking, line by line where it counts. The

chatbot saves you time on the draft, and the minute you spend checking keeps the result yours to trust.

Key idea:

Treat every AI answer as a draft, and check it before you trust it.

Quick check:

A chatbot gives you a reference you cannot find anywhere. What should you assume? Answer: that it may be made up, until you find the paper and see that it says what the chatbot claims.

8.3 Practising with Cleverini

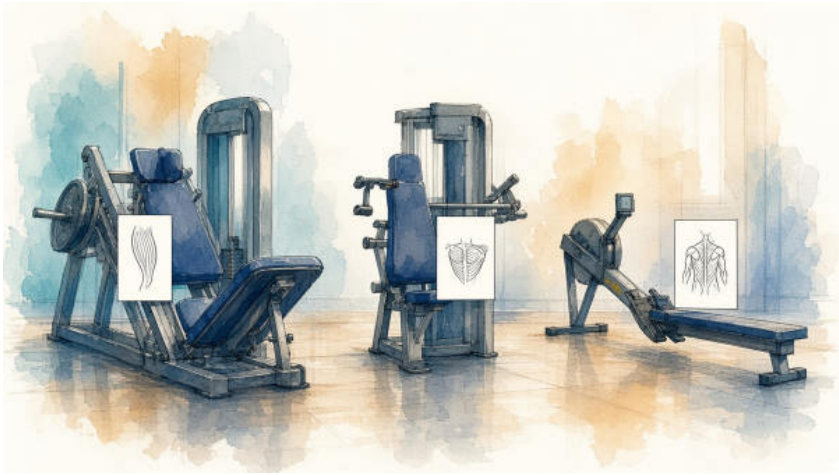
8.3.1 What Each Game Practises and What Its Score Means

YOU BEAT YOUR SUDOKU time three days running, and the clock says you are faster each morning. **Something got better, and it may be your Sudoku more than you.** Which of the two improved decides how you should read every game score in this section, and how you should pick the games you play.

Say your best time drops from twelve minutes to nine. You have learned where to look first, which numbers to pencil in and which rows to fill early. **Those tricks are real skill, and they belong mostly to Sudoku.** A brand-new kind of puzzle on Monday would not start at nine minutes.

A gym works the same way. The leg press makes your legs strong on the leg press. **It does not teach you to swim**, even though swimming uses

your legs. Each machine trains one movement, and you get good at that movement first and most.



A row of gym machines, each with a small card showing the one muscle it works.

Games behave like gym machines, and the idea has been **tested on very large groups**. The best-known test ran online for six weeks, with people playing reasoning and memory games at home and taking other tests before and after.

Games and gym machines

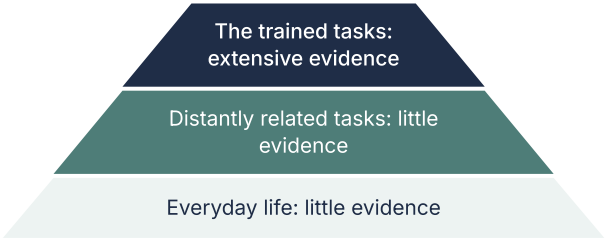
A gym machine		A game
Trains one movement	≈	Good practice for the skill it targets

> **Science Says:**
> In a study of 11,430 people, players improved on every task they trained. The researchers reported that "no evidence was found for transfer effects to untrained tasks, even when those tasks were cognitively closely related" (Owen et al., 2010). **Practice made people better at the practice.**

A smaller online study of 72 people found the same pattern. **Trained tasks improved, and untrained tests did not** (Stojanoski et al., 2018). The players got faster at the games, and the gain stayed inside the games. Brief, cheerful practice on a phone did what practice usually does.

A review by a large group of scientists pulled the evidence together. It found "extensive evidence" that brain-training programs improve the trained tasks, and "little evidence" for distantly related tasks or everyday life (Simons et al., 2016). **This is near and far transfer again** (see 1.2.2), with plenty of the first and very little of the second.

Near and far transfer



None of this makes games useless. **A game is good practice for the skill it targets**, and practice is easier to keep up when it comes as a game. The useful question is which skill each game practises. The table

lists the ten Cleverini games that fit this book, with one line on why each is here.

Read the last column as the reason to play. **Each game earns its place by practising one skill you can name**, and you will get better at that skill inside the game first. The evidence for each type comes next, game by game.

Game	What you do	Why it is here
Echo Match	Say if each card matches the one before, then the one two back, in a 60-second run	Practises holding and updating facts in working memory
Shape Spin	Decide if shape B is shape A turned, or its mirror image, in a 60-second run	Practises turning shapes in your mind
Chess Puzzles	Solve mate in 1, mate in 2 and tactics rated about 600 to 2000, in three minutes with three strikes	Practises calculation, spotting patterns and logic under time
Robot Route	Read a short program of moves, turns and loops, then tap where the robot stops, over eight levels	Practises following steps in order
Sudoku	Fill a 9×9 grid so every row, column and 3×3 box holds 1 to 9	Practises deduction from fixed rules
Wordy	Find a hidden five-letter word from green and yellow letter clues	Practises deduction with words
Logic Challenge	Solve number sequences, brick pyramids and shape rules	Practises finding rules in several forms
Brainy Digits	Find the rule in a row of seven numbers and pick the missing one from six options	Practises finding the rule in a sequence
Math Matrix	Find the rule that turns the corner numbers into the centre number	Practises finding a number rule
Pyramid	Find the pattern that runs through the bricks	Practises finding a pattern

Brainy Digits, Math Matrix, Pyramid and Logic Challenge all ask you to **find the rule hidden in the items**. The numbers are on the page, and

the link between them is missing, which is the heart of intellect in this book. No study has tested these four games themselves.

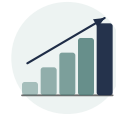
Find the rule



Brainy Digits



Math Matrix



Pyramid



Logic Challenge

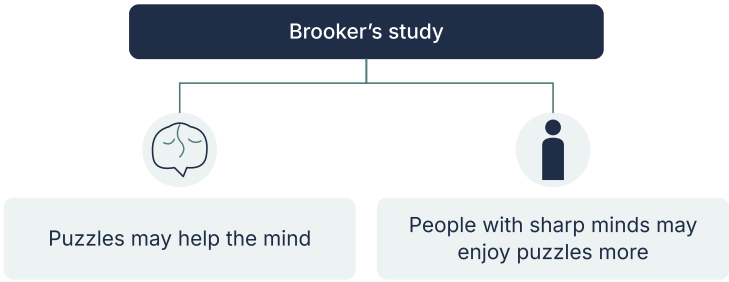
Puzzles like these look like the matrix items on some intelligence tests. **Play them for the practice**, and never read a better score as a higher IQ.

> **Science Says:**
>
> Gains on IQ tests behave the same way. Across 64 studies of 26,990 people taking IQ tests again, **the gains from a second try were not gains in g**, the general ability shared across many tests (te Nijenhuis et al., 2007). Training on Raven's matrices, a puzzle-style IQ test, gave gains that did not carry over to other tests. No puzzle games were tested, so the review only hints at what these four can do.

Sudoku practises **deduction from fixed rules**. Each number you place narrows the choices in its row, column and box. In 19,078 adults aged 50 to 93, those who did number puzzles more often scored better on all 14 tests of mental skill (Brooker, Wesnes, Ballard, Hampshire, Aarsland, Khan, Stenton, Megalogeni, & Corbett, 2019). That study asked about number puzzles in general and never named Sudoku.

Brooker's study took one snapshot in time. **It shows a link and cannot show a cause.** Puzzles may help the mind, or people with sharp minds may enjoy puzzles more, and the study cannot tell which.

Puzzles and sharp minds



Shape Spin practises turning shapes in your mind. **Spatial skills respond well to training.** A review found an average effect of 0.47, with gains that lasted and carried over to other spatial tasks (Uttal et al., 2013). Of all the games here, this type has the strongest research behind it.

Robot Route asks you to follow a short program step by step. Across 105 studies, **programming courses carried over to other skills**, with an average effect of 0.49, 0.75 for close skills and 0.47 for distant ones (Scherer et al., 2019). Those were full courses, and an eight-level game is a taste of one.

Programming courses



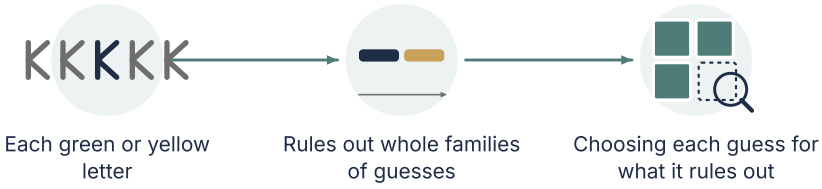
Chess Puzzles practise calculation and spotting patterns against the clock. **Chess skill and fluid reasoning go together**, at r = .24 (Burgoyne et al., 2016). A link like that cannot show that chess builds ability.

> **Key Concept:**
>
> N-back. In an n-back task (Kirchner, 1958), you watch a stream of items and say whether each one matches the item one back, then two back, and so on. **It loads working memory**, the small space where you hold and update facts while you work.

Echo Match is an n-back game. A review of 87 publications found that working memory training gives **near transfer and no far transfer** (Melby-Lervåg et al., 2016). That is why I count Echo Match as working-memory practice, with no promise beyond that.

Wordy practises deduction with words. **Each green or yellow letter rules out whole families of guesses**, much like a number in Sudoku. No study has tested Wordy itself, so play it for fun and for practice at using clues. Choosing each guess for what it rules out is the deduction at work.

Wordy



Word puzzles have a matching study from the same team. Among 19,078 healthy adults aged 50 to 93, those who did word puzzles more

often also scored better on all 14 tests (Brooker, Wesnes, Ballard, Hampshire, Aarsland, Khan, Stenton, McCambridge, & Corbett, 2019). **It is again a link found only in older adults**, so it cannot show that puzzles caused the better scores.

The score at the end of a game needs the same care. One careful study looked at games and intelligence tests side by side, and **its result is easy to misread**.

> Science Says:
>
> Researchers tested 188 undergraduates on 12 commercial video games and 11 intelligence tests, under "strict supervision in the laboratory" (Quiroga et al., 2015). The latent factor (see 1.1.1) behind the games and the one behind the tests correlated at r = .93. **Across many games, played with care, the shared skill looked almost the same.**

> Key Concept:
>
> What a game score means. A single score from one game, played at home, measures **how good you are at that game today**. It mixes ability with practice, tiredness and luck. It is a game score, never an IQ.

The .93 came from 12 games and 11 tests, carefully supervised, with the scores of each pooled into one factor. **A single online game score is a long way from that.** Your Echo Match best on a Tuesday evening tells you about your Echo Match, and about how much you have practised it.

> Exercise:
>
> Name the skill.
>
> 1. Pick one game from the table.
> 2. Before you play, write the one skill it practises, in your own words.
> 3. Play it for a week and note your scores.
> 4. Try that skill on a task outside the game, such as a new kind of puzzle, and **notice how much of the gain came with you**.

Your nine-minute Sudoku is a real achievement, and **it tells you that you got better at Sudoku**. Choose each game for the one skill it practises, and read its score for what it is. Every so often, take the skill out of the game, to a new puzzle or a real plan, and see how far it travels.

Key idea:

Each game mainly trains the game itself, so choose it for the one skill it practises and read its score as a game score.

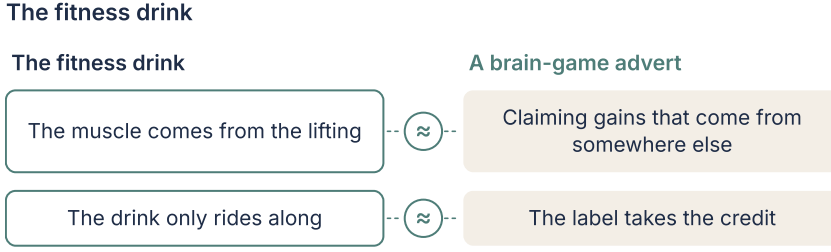
Quick check:

Your Echo Match score doubles in a month. Has your IQ gone up? Answer: the score cannot tell you; it mainly shows that you got better at Echo Match.

8.3.2 Choosing Games, Difficulty, Apps and Offline Alternatives

An advert on the train promises that ten minutes a day of brain games will make you sharper at work. The people in the photo look rested and alert, and the promise sounds easy. **Mostly it does not hold up**, and the reasons will help you choose games that do earn their place in your week.

The advert is not false in every word. **Ten minutes of games a day will make you better at those games.** The leap comes after that, from better at the game to sharper at work, and that leap is where the evidence runs thin. Adverts tend to skip it.



Picture a fitness drink whose label says it builds muscle. The muscle comes from the lifting. **The drink only rides along**, and the label takes the credit. A brain-game advert can work the same way, claiming gains that come from somewhere else, or that never come at all.

> **Science Says:**
> In 2016, Lumos Labs, "the company behind Lumosity", agreed to settle charges from the US Federal Trade Commission. The Commission alleged **"unfounded claims that Lumosity games can help users perform better at work and in school"**, and claims that they could reduce or delay mental decline linked to ageing and other serious health conditions (Federal Trade Commission, 2016). The company would pay $2 million, and a $50 million judgment was suspended.

The phrase "unfounded claims" is worth remembering. **A claim is unfounded when no good study backs it**, however confident the advert sounds. Ask for the study before you believe the promise, and ask what the study measured. A study of the game itself only tells you the game improves.

The Lumosity settlement



The settlement fits the research. **Practice on a game makes you better at that game**, and the gains seldom travel far (see 8.3.1). The large review there warned about the studies themselves, since many of them had weak designs (Simons et al., 2016). Another review points the same way.

> Science Says:
> A review from 2019 found a **"minimal effect on domain-general cognitive skills"**, the broad skills used across many tasks (Sala & Gobet, 2019).

None of that is a reason to stop playing. **Games are good practice for the skill they target**, and fun keeps you coming back. A game turns practice that might feel like homework into play. The trick is to choose them with open eyes and to carry the skill out of the game on purpose.

A board game night is not wasted because it fails to raise anyone's IQ. **Enjoyment is a fine reason to play.** A game that sharpens one skill on top of the fun is a bonus, and you can choose games so that the bonus is one you want.

Some training gains do last, and **they show what to aim for**. In the study below, the gains that lasted were in the skills people trained, which fits everything else in this chapter. Solid practice on one skill is the thing that lasts.

> Key Concept:
> What lasts. In a trial of 2,832 older adults given 10 training sessions, **gains in reasoning and speed were still there ten years later**, with effect sizes of 0.23 and 0.66. Memory gains did not last (Rebok et al., 2014).

The same trial looked at daily life, and about 60% of trained people, against about 50% of the untrained group, were still at or above their starting level in everyday tasks (Rebok et al., 2014). **Everyone in the trial was an older adult.**

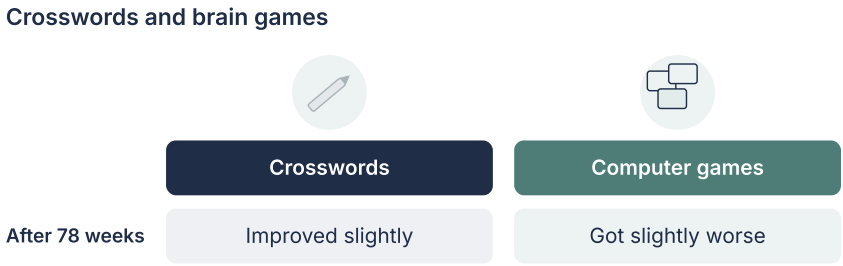


The training in that trial was taught in person, over ten sessions, on named skills. **A phone game is a different kind of training**, so the ten-year result tells you what solid practice of one skill can do, and little about any app.

Crosswords have one interesting study behind them. **It was small, and it was about people with memory problems**, so read it with care. It compared crosswords with computer games over a year and a half, which is a long time for a study of this kind.

> Science Says:
>
> In 107 people with mild memory problems, 78 weeks of web-based crosswords beat computer games on a standard test of mental skills (Devanand et al., 2022). **The crossword group improved slightly, and the games group got slightly worse.** The result covers older people with mild memory problems only. If you are worried about your memory, see a doctor.

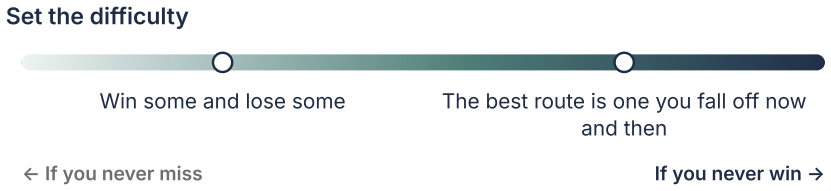
In that group, plain crosswords did better than a set of modern brain games, even though both ran on a computer. **A plain puzzle can hold its own.** And you do not need a screen for one. Paper puzzles are cheap, quiet and easy to share, and a newspaper brings a fresh one every day.



Chess sits between a game and a pastime. **Play chess because you enjoy it**, for the pleasure of planning against an opponent, and count any wider gain as a bonus. Cleverini's Chess vs Computer has five levels, from Beginner to Master, and a board at a cafe or a club is the offline version.

Choosing starts with the skill. **Pick the skill first and the game second.** If you want practice at finding rules, Brainy Digits or Math Matrix fit. For calculation and spotting patterns, Chess Puzzles fit, Chess vs Computer adds planning, and Echo Match suits holding facts in mind. The table in 8.3.1 matches each game to one skill.

What follows on difficulty and apps is my own practical advice. Set the difficulty so you win some and lose some. **If you never miss, the game has stopped teaching you.** If you never win, you will soon stop playing. I could find no study that names the best level, so treat this as my rule of thumb.



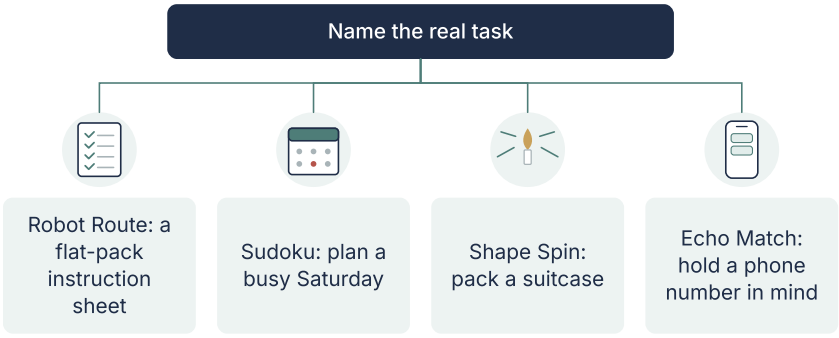
A climbing wall shows the idea well. Routes you can climb half asleep build nothing new, and routes you cannot start build only frustration. **The best route is one you fall off now and then**, and a good game level works the same way.

I play in short sessions of ten to fifteen minutes and stop while I still want more. **Short and regular beats long and rare** for keeping a habit going, at least for me. Two or three games a week, each with a clear purpose, is plenty.

Plan the move from game to real task. **The skill will not travel by itself**, so take it there. After a week of Robot Route, follow a flat-pack instruction sheet step by step and notice the order. After a week of Sudoku, plan a busy Saturday with fixed limits.

Each game can work like this. **Name the real task before you start the week**, so the practice has somewhere to go. After Shape Spin, pack a suitcase by turning each bag in your head first. After Echo Match, hold a phone number in mind while you find a pen.

Name the real task



Apps differ a great deal. **Be wary of any app that promises a higher IQ**, better grades or a younger brain. Check whether it shows adverts

between rounds, which in my experience break up the practice, and whether it lets you set the level. The Cleverini games run in the browser with no ads.

Every game on the list has an offline cousin. **Paper puzzles practise the same moves** without a screen. Sudoku and crosswords come in newspapers and puzzle books, and chess needs only a board and a friend. A friend can write a number sequence on the back of an envelope for you to crack.

Offline cousins



Sudoku and crosswords



A board and a friend



A number sequence on the back of an envelope

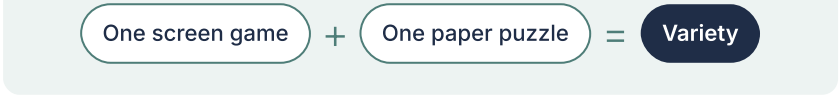


A chessboard and a half-done newspaper crossword on a cafe table, with a phone lying face down beside them.

Paper and board games bring something screens lack. **A friend across the board answers back**, and a paper puzzle has no adverts and no streaks to chase. For memory practice, try saying a shopping list backwards on the way to the shop.

Mixing the two works well. **One screen game and one paper puzzle a week** gives you variety, and it shows you whether a skill holds up outside one format. If it only works on the screen, it is still a game skill.

A week of games



Exercise:

Claim check and game plan.

1. Find a brain-game advert and write down its biggest promise.
2. Ask whether it names a study, and whether that study tested skills outside the games.
3. Pick two games for the week, each for one skill, at a level where you sometimes miss.
4. Swap one session for an offline version, and **try the skill once on a real task**, then note if it showed up.

Back on the train, the advert is still smiling. **You now know what ten minutes of games can buy**, better play at those games and a skill you

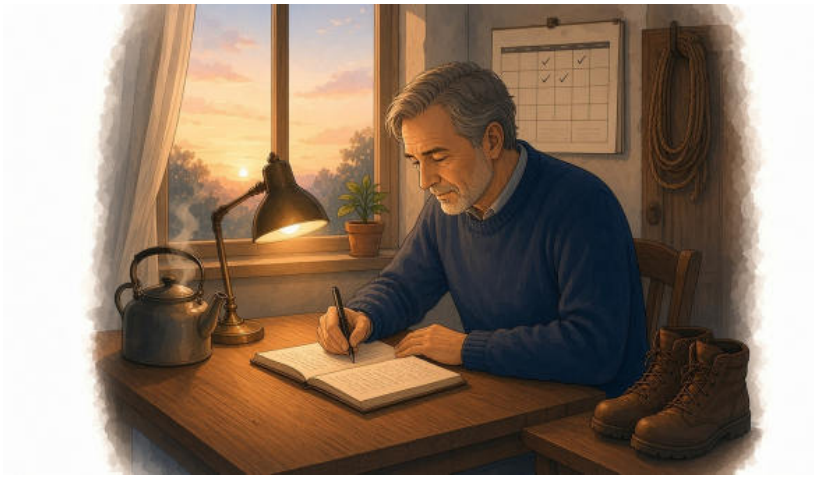
can practise on purpose. The rest depends on what you do with the skill after the game ends, on the train, at work and at home.

Key idea:

Choose a game for the skill you want, keep it hard enough to make you work, and carry the skill into real tasks.

Quick check:

An app says its games will raise your IQ in a month. What should you ask?
Answer: which study backs the claim, and whether that study measured skills outside the games.



Module

9

Your Practice Plan and Practitioner Levels

9.1 Establishing Your Starting Point

9.1.1 Choosing Goals and Recording a Baseline

On Monday you decide to get better at working things out, at home and at work. A wish like that feels strong on the first evening, and by Friday it has nothing to hold on to. **A plan needs a target and a starting mark.**

My friend Anna took up running last spring. She bought new shoes, ran hard for three days and gave up, because **she had no idea whether she was getting faster**. In the autumn she tried again. She timed one easy lap of the park first, wrote it down and picked one goal, a lap two minutes quicker by Christmas.

Anna's two tries

Last spring	In the autumn
Ran hard for three days and gave up	Timed one easy lap of the park first
She had no idea whether she was getting faster	A lap two minutes quicker by Christmas



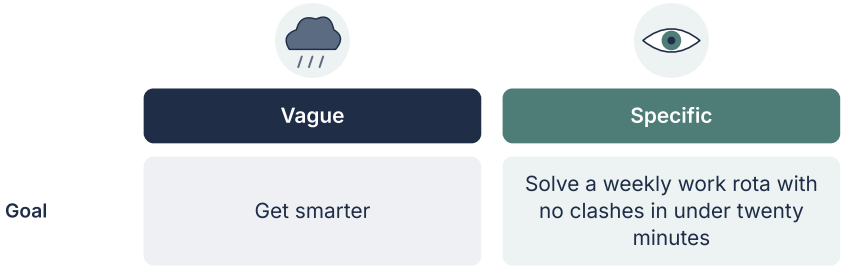
A walker at a trailhead signboard, pressing a finger on the red dot that marks the start of the path.

Anna's second try worked because **she knew where she started and where she was going.** Better than what, and better at which tasks? Practice for intellect needs the same two marks. In this book, intellect means solving tasks where the variables are identified, so your goal should name the kind of task you want to solve better.

Goals do help, by a smaller amount than many posters promise. A review of 141 papers, covering 16,523 people, found **"a small positive unique effect of goal setting"**, an average effect of .34 (Epton et al., 2017). Most of the studies were about health habits, such as eating and exercise.

A goal works better when it is clear. Goal-setting theory grew out of 35 years of research, much of it on workplace tasks, and holds that **specific, hard goals beat a vague "do your best"** (Locke & Latham, 2002). "Get smarter" is vague. "Solve a weekly work rota with no clashes in under twenty minutes" is specific.

Vague and specific goals



My advice is to choose the task area with care. **Practise the kind of task you want to improve**, and expect the gain to stay mostly there. If your goal is planning rotas, practise rotas, and if it is a monthly budget, practise budgets.

Keep the list short. **One or two goals are plenty for a first plan**, because each goal needs its own practice time and its own baseline. A third goal usually steals time from the first two, and none of them gets enough attention to change. Save the third for your second plan.

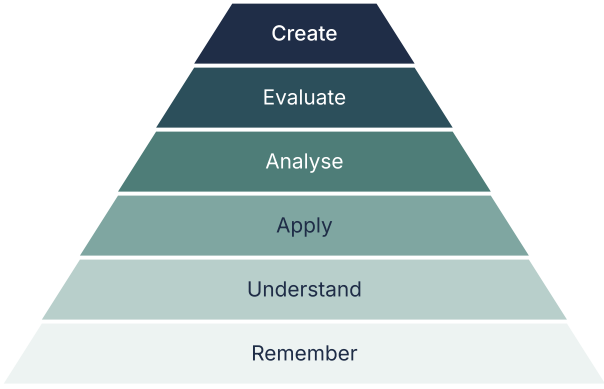
Keep the list short



> **Key Concept:**
> Levels of a goal. One common way to sort learning goals runs from remember and understand up to apply, analyse, evaluate and create (Krathwohl, 2002). **A goal can sit at any of these levels.** "Remember the steps of a budget" is lower down, and "plan next month's budget from scratch" is higher. The ladder is a way of sorting goals, and no study shows it causes better learning.

Use the ladder to aim your goal. **Aim for applying or higher**, using a method on your own tasks. A good goal names the level along with the area, for example "apply a checklist to spot errors in my team's reports". A goal at the remember level is fine for a start, as long as you know where it sits.

Levels of a goal



Once you have a goal, decide when and where you will practise. **A plan that links a cue to an action, "if X, then Y", is called an if-then plan.** It ties the action to a cue you will meet anyway, such as "if I sit down with my morning tea, then I will do one practice task".

> **Science Says:**
> A review of 94 independent tests with 8,461 people found that if-then plans had a **medium to large effect** on reaching goals, d = .65 (Gollwitzer & Sheeran, 2006). People who planned when, where and how they would act did better than people who only held the goal.

Write one if-then plan for your goal today. **Choose a cue you meet every day**, one that comes before a quiet moment. A cue like "after lunch" is loose, and "when I close my laptop at lunch" is clear enough to notice.

An if-then plan



Write the goal in task terms. **Name what you will be given and what you must find**, since intellect works on tasks where the variables are identified. "Given the bills and the income, find a monthly plan with no overspend" tells you what a practice task looks like, and what a solved one looks like.

Write the goal in task terms



The starting mark comes after that. **A baseline is a record of how well you do a task before you begin to practise.** Without one, you cannot tell later whether anything changed, and memory is a poor judge of where you used to be. A baseline turns "I was probably worse" into a line you can read.

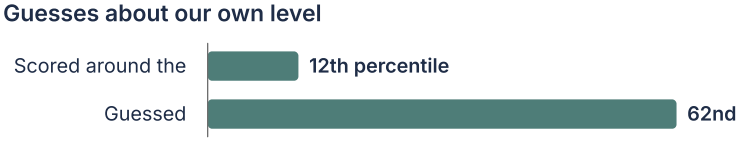


Pencil marks on a kitchen door frame, each one a child's height with a date beside it.

> **Key Concept:**
>
> Baseline. Your baseline is **a small set of tasks, scored and dated on three days** in the week before the plan starts. Like the pencil marks on a door frame, it only works if you measure the same way each time. Use real tasks from your goal area, on paper, with a time limit and a clear way to mark them.

Your record has to be honest, and our guesses about our own level are often wrong. In one set of studies, people who scored around the 12th percentile **guessed that they were around the 62nd** (Kruger &

Dunning, 1999). A written score beats a feeling, every time you look back.



If you can, **ask someone else to mark one or two of your tasks**. A colleague, a friend or a family member will not share your hopes for the result. Their marks give you a check on your own, and any gap between the two goes in the journal.

Spread the baseline over one week. On three different days, do five or six fresh tasks in a half-hour sitting, and **mark them, note the time and add one line on how hard they felt.** Your starting mark is the median, the middle score of the three, and the gap between the highest and lowest is your wobble.



Make spare sets at the same time. **Write three more batches of tasks of the same kind and level, and put them away unseen.** The retest at week twelve uses them, because the very same tasks come back easier the second time, and fresh sets measure skill instead of memory for the answers.

Expect the second try to look better whatever you do. **Scores rise on a retest because the format is familiar** (see 1.3.1), and an unusually bad first day tends to be followed by a more ordinary one. Both effects can fool you, so treat any small early jump with care. The fresh sets in week twelve tell you more.

Scores rise on a retest



Checking how you are doing helps in its own right. **Keeping track of progress helps people reach their goals**, and the record you keep is the tool that does it. The evidence comes from a large review of studies that set out to get people checking their progress.

> **Science Says:**
>
> Across 138 studies with 19,951 people, interventions that helped people **monitor their progress** made them more likely to reach their goals, d+ = 0.40 (Harkin et al., 2016). A baseline week is the first step of that monitoring.

Monitoring needs **something to compare with**, and the dated sheet gives you that. Each later score means more when it sits next to the first one. Without the first sheet, a good week and a bad week look the same in memory, and both fade. A glance at the sheet once a week is enough.

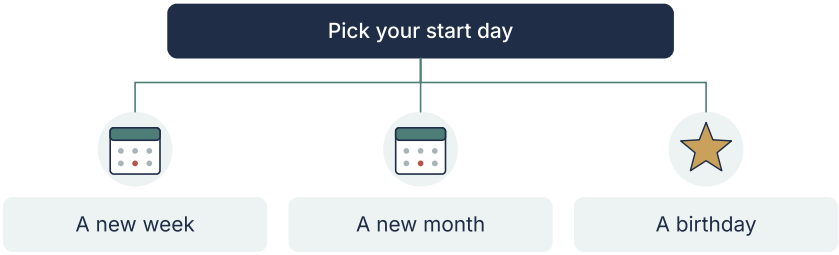
Pick your start day with some thought. **People search for diets, visit gyms and commit to goals more often after "landmark" dates**, such as a new week, a new month or a birthday (Dai et al., 2014). That study tracked what people did and cannot show the date caused it, so choose a start date that feels fresh to you.

Home measures of intellect have limits. **No standard test of everyday intellect exists outside clinical settings**, so your baseline is a personal mark, useful only for comparing you with yourself. It is no diagnosis and no IQ, and it does not rank you against anyone. Compare this month's you with last month's you, and nobody else.

If your reason for a baseline is worry about real decline, such as forgetting how to do familiar tasks or getting lost in a known place, **a home baseline is the wrong tool**. Please speak to a doctor or another clinician (see 6.3.2), and keep this plan for practice.

> Exercise:
>
> Write your goal and baseline.
>
> 1. Name one task area and one level from the ladder, for example "apply budgeting rules to my own month".
> 2. Write one if-then plan with a daily cue.
> 3. On three days this week, do five or six fresh paper tasks from that area in a timed sitting.
> 4. **Mark and date each sheet**, then circle the median and note the wobble.

Landmark dates



Anna's lap time from that autumn evening is still in her notebook. **It turned a vague wish to be fitter into a number she could beat.** Do the same for your intellect this week, with one goal, one if-then plan and three dated sheets of tasks you can return to.

Key idea:

A clear goal and an honest starting mark let you see real progress, and spot the gains that are only familiarity.

Quick check:

You plan to "get sharper". Name the two things to write down before you start. Answer: a specific goal in one task area and a baseline from three dated days of tasks in that area, with its median.

9.1.2 Building a Sustainable Weekly Routine

On Sunday evening the plan looks perfect, an hour of practice every day for the whole week. **By Thursday it has usually vanished.** Most plans fail in the middle of the week, when work runs late and the hour never turns up. A routine that lasts is built for the busy Thursday, never for the calm Sunday.

My neighbour Tom tried the hour-a-day plan to learn spreadsheet formulas. He managed Monday and Tuesday, missed Wednesday and felt so behind that he stopped. **His second plan was twenty minutes, three times a week**, always straight after he had washed up the breakfast things. Six months later he was still going.

Tom's two plans

The hour-a-day plan	His second plan
Managed Monday and Tuesday	Twenty minutes, three times a week
Missed Wednesday and felt so behind that he stopped	Six months later he was still going



A kettle coming to the boil beside an open notebook and a pencil on a windowsill in early light.

What made the second plan last where the first had failed? Tom's second plan had three parts that carry over to any goal. **It was small, it hung on a fixed moment of the day, and it was spread across the week.** The rest of this section takes each part in turn, with the research that sits behind it.

Three parts that carry over



It was small



It hung on a fixed moment of the day



It was spread across the week

The fixed moment comes first. **A practice session tied to something you already do every day** needs no fresh decision each time. You do not ask yourself whether to practise, because the washing-up or the morning tea asks for you. You wrote an if-then plan in your goal sheet (see 9.1.1), and now it gets a daily job.

> **Key Concept:**
> Habit. A habit is **an action that starts almost by itself** when you meet a familiar cue, such as brushing your teeth after breakfast. The more often the action follows the same cue, the less you need to decide. Researchers call that growing ease automaticity.

A new habit takes longer for some people than for others. **The time it takes varies a great deal from person to person**, and one study shows how much.

> **Science Says:**
> In a study of habit forming, 96 volunteers picked one daily behaviour, such as a glass of water with lunch or a short walk, and rated how automatic it felt over 12 weeks (Lally et al., 2010). Reaching 95% of their top level of automaticity **took anywhere from 18 to 254 days**. People who did the behaviour more consistently fitted the habit pattern better.

You may have heard that a habit takes 66 days. **That number has no specific evidence base**, and the range in Lally's study ran from under three weeks to over eight months. The study was small, with fewer than a hundred people, so treat any single number with care.

When you miss a slot, **pick up again at the next cue** without trying to make up the lost time. A double session to catch up turns the routine into a chore. What Lally's data point to is regular repetition over weeks, and one gap in a run of weeks is part of real life.



A path worn across a lawn where people have taken the same short cut day after day.

What the study does support is regular repetition. **The people who acted most consistently** showed the clearest climb towards habit. A worn path across a lawn forms the same way, by the same feet taking the same line again and again, and a path walked once a month never forms at all.

A worn path

The path		Practice
The same feet taking the same line again and again	≈	The people who acted most consistently
A path walked once a month never forms at all	≈	Showed the clearest climb towards habit

Regular does not mean daily for everyone. **Three or four fixed slots a week can work well**, as long as each slot hangs on a cue you meet on those days. Choose cues from your real week, such as the train on Tuesdays and Thursdays and the quiet hour on Saturday morning.

Keep each session small. **Twenty to thirty minutes is enough for one focused session** in my own experience, and short sessions are easier to protect on a busy day. A long session that you skip helps less than a short one you do. Stop while you still have a little energy left, so the next start feels easy.

Spread the sessions across the week. A pot plant does better with a little water every few days than a full bucket once a month. **Practice works in a similar way**, and the research on spacing backs that up.

Spacing and massing



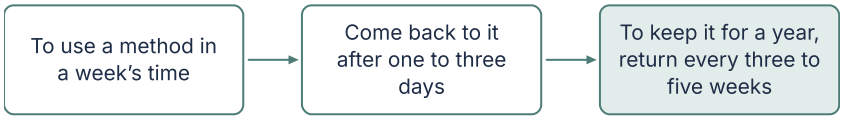
> **Key Concept:**
>
> Spacing. Spacing means **spreading practice over several sessions with gaps between them**, instead of packing it into one long sitting. The packed version is called massing. Each return to the material after a gap forces you to pull it back up, and that effort helps it last.

A large review pooled 839 assessments of spacing from 317 experiments. **Spaced practice beat massed practice**, and the best gap between sessions grew longer as the time you wanted to remember grew longer (Cepeda et al., 2006). Most of these studies asked people to remember words and facts.

> **Science Says:**
>
> A later study tested more than 1,350 people over gaps of up to a year. For a test one week away, the ideal spacing was **about 20 to 40% of that week**, and about 5 to 10% when it came after one year (Cepeda et al., 2008).

Turn those percentages into a week. To use a method in a week's time, **come back to it after one to three days**. To keep it for a year, return every three to five weeks once you know it well. The studies used remembered material, so treat the numbers as a guide for skills.

Turn those percentages into a week

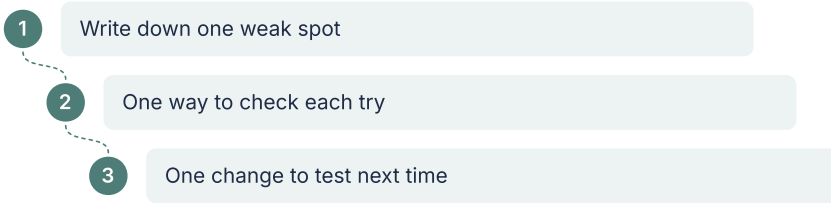


The third part is what you do inside each session. **Repeating what you already do well feels good and changes little.** Practice that improves you is aimed at the part you find hard, with feedback on each try.

> **Key Concept:**
> The session card. Before each session, **write down one weak spot, one way to check each try and one change to test next time.** The card turns an ordinary hour into the kind of practice Ericsson's team studied (Ericsson et al., 1993). A pianist who plays the two hard bars ten times and notes which bar still slips is using it.

The same idea fits any intellect goal. **Find the step where you go wrong most often** and practise that step on its own. If your monthly budget always breaks on irregular bills, spend a session on five irregular-bill problems, check each one and note what tripped you up.

The session card



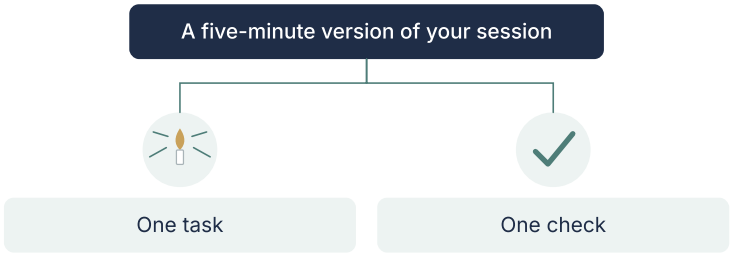
Here are two lessons I keep in mind. First, **practice is worth doing**, because it moves your own skill on the tasks you train. Second, a slow month is no proof that you are doing it wrong, or that you cannot improve. Keep going, and look back over a few months before you judge.

Your routine has to fit around sleep, food and movement, never squeeze them out. **A session that costs you an hour of sleep is a bad trade** (see 5.1.1). Put practice in a slot you already have, and leave the evening wind-down alone. If you are short of sleep, sleep comes first and practice can wait.

Plan for the bad week before it arrives. **Write a five-minute version of your session**, such as one task and one check, for days when the full slot disappears. The five-minute session keeps the cue and the habit alive, and it stops one missed day from turning into a missed month.

A sample week makes the idea concrete. **The table is one way to lay it out**, with three short sessions, one quick review and plenty of space between them.

Plan for the bad week



Day	Cue	What you do	Time
Monday	After breakfast washing-up	One hard task of your goal type, checked	20 minutes
Wednesday	On the train home	Revisit Monday's method on a fresh task	20 minutes
Saturday	With the first coffee	Two mixed tasks, then mark them	30 minutes
Sunday	Before the weekly shop	Read the week's notes and plan next week	5 minutes

Adjust the table to your life. **The days and cues are yours to change**, and the gaps between sessions are the part to keep. If a slot fails two weeks running, move it to a better cue instead of blaming yourself.

Use the Sunday slot well. **Read the notes from the week and pick next week's weak spot**, so each session starts with a clear aim. Five

minutes of planning saves the first ten minutes of every session, which would otherwise go on deciding what to do.

> Exercise:
>
> Build your week.
>
> 1. Write down three moments you meet every week, such as a commute or a meal.
> 2. Attach a 20 to 30 minute session to each with an if-then plan.
> 3. Leave at least a day between sessions on the same method.
> 4. **Write your five-minute version** for busy days, and keep it next to your goal sheet.

Tom still does his twenty minutes after the washing-up. **He never found the perfect hour, and he did not need it.** Build your own week around small, fixed sessions spread across the days, aimed at your weak spot, and protect the cue more than the clock.

Key idea:

A small routine tied to fixed cues and spread across the week lasts longer than a big plan that collapses by Thursday.

Quick check:

You have four hours a week to practise. Choose how to lay them out.
Answer: in several shorter sessions with gaps between them, each tied to a fixed cue, because spaced practice lasts better and short slots are easier to keep.

9.2 Putting the Plan into Action

9.2.1 Your First Twelve Weeks, and Adapting When Life Changes

Week five arrives, work doubles and the family needs you every evening. **Every plan meets a week like that**, and the plans that survive are the ones built to bend. This section lays out a first twelve weeks and shows how to bring them back after a knock.

My friend Priya had a good routine going, three short sessions a week on the train. In week six she moved flat. **The new route to work had no train, and her sessions vanished with it.** She was surprised how fast a habit she had trusted simply stopped, and she blamed herself for a fortnight.

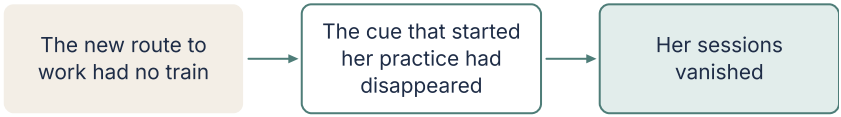


A gardener tying a wind-bent bean plant back to its cane after a stormy night.

Priya had done nothing wrong. Why did a habit she trusted stop so fast? **The cue that started her practice had disappeared**, and a habit

without its cue has nothing to start it. Once she saw that, she found a new cue at her new kitchen table and was back on track within a week.

Priya's lost cue



I picked twelve weeks myself, as a first plan long enough to show change and short enough to see the end. You can make your plan longer or shorter. The number has some history behind it, and no proof. Treat it as a frame you can adjust.

> **Science Says:**
>
> The habit study from 9.1.2 ran "for 12 weeks", with the volunteers repeating one behaviour every day (Lally et al., 2010). **No evidence shows twelve weeks is the best length.**

Twelve weeks breaks neatly into four blocks. **Each block has one job**, and you can see from the table where you are at any point. The weeks are a guide, so stretch a block if life gets in the way, and keep the order of the blocks.

Weeks	Block	What you do
1 to 2	Settle	Finish your goal sheet and baseline, try your cues and fix any that fail
3 to 6	Build	One weak spot each week, three short sessions, one Sunday review
7	Check	Do a few fresh tasks, compare them with the baseline, adjust the plan
8 to 11	Stretch	Harder tasks, mixed types, less help from notes

Weeks	Block	What you do
12	Review	Do the three spare sets on three days, compare, and plan what comes next



Four seed trays on a greenhouse bench, the seedlings taller in each tray from left to right.

The first two weeks are for settling. **Expect some cues to fail**, because the cue that looked good on paper may clash with real mornings. Move a failed session to a new cue in week two, and keep the ones that worked. Treat your first routine as a draft.

Weeks three to six do the building. **Pick one weak spot a week** from your Sunday notes and give it most of the practice time. Keep a short record after every session, with the task, the result and one line on what went wrong. Those lines are what you read back on Sunday.

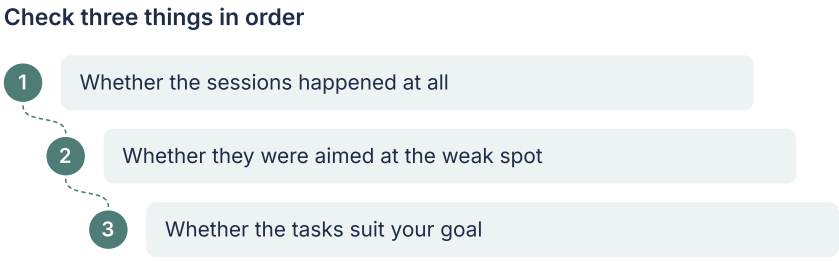
Twelve weeks in four blocks



Week seven is the halfway check. **Do a few fresh tasks of the same kind as your baseline**, mark them and set them beside the first sheet.

Use new tasks, because old ones come back easier. If nothing has moved, the plan needs changing, and the way you read your results decides what to change.

When week seven shows little change, **check three things in order**. First, see whether the sessions happened at all. After that, see whether they were aimed at the weak spot, and last, whether the tasks suit your goal. Fix the first problem you find, and leave the rest of the plan alone.



The way you give yourself feedback decides how much it helps. Feedback is anything that tells you how a try went, from a marked answer to your own note. **Feedback can make performance worse**, and a large review counted how often that happens.

> Science Says:
>
> Across 607 effect sizes, feedback improved performance on average, d = .41. Yet **over one third of feedback interventions lowered performance** (Kluger & DeNisi, 1996). The authors found that the effect of feedback "decreases as attention moves up the hierarchy closer to the self".

> **Key Concept:**
> Task feedback and self feedback. Feedback about the task says **what went wrong in the work**, such as “I missed the bill that comes every quarter”. Feedback about the self says what the result means about you, such as “I am hopeless with numbers”. The first points to a fix. The second points to nothing you can practise.

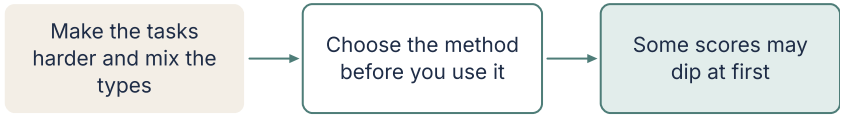
Rewriting a note takes a few seconds, and the task version gives the next session a job. **The table shows three self notes turned into task notes.**

Self note	Task note
I am hopeless with numbers	I added the quarterly bill twice
I always panic on long problems	I started calculating before listing what I was given
I will never get this	I have not yet tried the method on a problem with two unknowns

Another review agreed that the effect of feedback **“can be either positive or negative”**, depending on its type and the way it is given (Hattie & Timperley, 2007). Write your notes about the work. If you catch yourself writing about yourself, rewrite the line as a step you can practise next time.

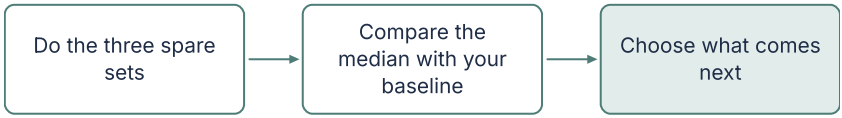
Weeks eight to eleven stretch the skill. **Make the tasks harder and mix the types**, so each session asks you to choose the method before you use it. Lean less on notes and worked examples. Some scores may dip at first, which is normal when tasks get harder.

Make the tasks harder



Week twelve closes the plan. **Do the three spare sets you put away in your baseline week**, one on each of three days, and mark them the same way. Compare the median with your baseline. Then choose what comes next, a new goal, a harder level of the same goal or a lighter plan to keep what you have.

Week twelve closes the plan



Life changes break habits because they remove the cues. A study of students who moved to a new university found the same pattern Priya met when she changed flats and lost her train.

> Science Says:
>
> Students' habits, such as exercise and reading the news, carried on after a move to a new university **"only when aspects of the performance context did not change"** (Wood et al., 2005). When the setting changed, the change "placed behavior under intentional control", so people were back to deciding each time.

Read the second finding as good news. **After a move you are back to deciding**, which is harder work for a while, and it is a chance to build a

better routine. A new job or a new home lets you choose cues on purpose, instead of keeping the ones that happened to work before.

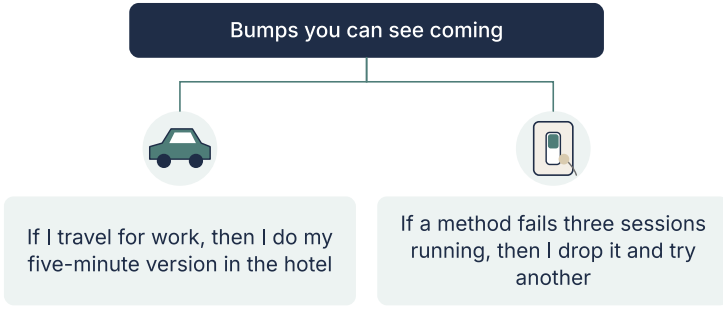
After a move

Before	After a move
The performance context did not change Habits carried on	You are back to deciding Choose cues on purpose

You met if-then plans in 9.1.1 as a way to start each session. **A review of them found a second use, protecting a plan from bumps**, and helping drop a failing plan. It described them as useful for "shielding of ongoing goal pursuit from unwanted influences" and for "disengagement from failing courses of action" (Gollwitzer & Sheeran, 2006).

Write if-then plans for the bumps you can see coming. **"If I travel for work, then I do my five-minute version in the hotel"** is one. "If a method fails three sessions running, then I drop it and try another" is a second, and it saves weeks of stubborn practice on something that does not work.

If-then plans for the bumps



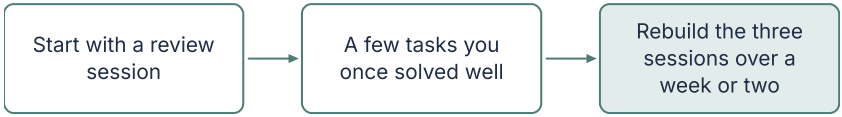
Some breaks are longer, such as illness, a new baby or a hard month at work, and none of them is a failure of will. **Rest when you need to, and plan the return.** Skills fade when they go unused, and the classic picture of that fading is the forgetting curve.

> **Key Concept:**
>
> Forgetting curve. The forgetting curve shows **how memory for something learned fades over time** when you stop reviewing it. A modern replication of Ebbinghaus's classic study, run with a single person, found a curve much like the original (Murre & Dros, 2015).

A one-person study is thin evidence, so take the shape as a reminder. **After a long break, start with a review session**, using a few tasks you once solved well, before you take on anything new. Then rebuild the three sessions over a week or two. Your minimum week keeps the gap small while you recover.

> **Exercise:**
>
> Plan for the bumps.
>
> 1. List three disruptions likely in the next twelve weeks, such as travel, a busy month or illness.
> 2. Write an if-then plan for each one.
> 3. Write your minimum week, the least practice that keeps the cues alive.
> 4. Add one rule for **dropping a method that keeps failing**.

After a long break



Priya's plan ran fourteen weeks in the end, two longer than she meant. **It reached the finish because it could bend.** Run your twelve weeks in four blocks, write your feedback about the work, and when life changes, find a new cue and start again from where you are.

Key idea:

Expect the plan to bend, and use if-then plans and task-focused feedback to bring it back after every knock.

Quick check:

A move breaks your routine in week six. Name the first thing to look for.

Answer: a new cue in the new setting, with an if-then plan that ties your sessions to it.

9.3 Reviewing Progress and Practitioner Levels

9.3.1 Measuring Understanding, Accuracy, Retention and Application

Your score on the week-seven tasks came out higher than your baseline. **A number can rise for several reasons**, and only one of them is real progress. This section shows what to measure and how to measure it fairly, so the number you write down means something.

After a big Sunday lunch I once stepped on the bathroom scales and gained a kilo in an afternoon. **Nothing about my body had changed for good**, of course. The scales measured the lunch, the water and the time of day. A fair weigh-in happens on the same scales, at the same hour, in the same clothes.

A fair weigh-in

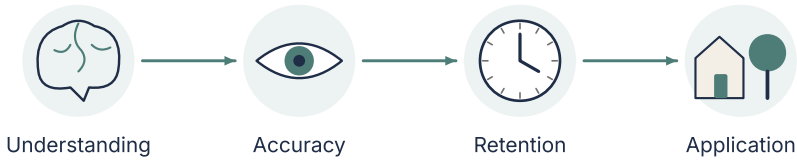
The bathroom scales		Your intellect
Same scales, same hour, same clothes	≈	Keep the conditions the same and the tasks fresh
Measured the lunch	≈	Change only the one thing you want to see, your skill



A tailor's tape measure draped over a half-finished jacket on a cutting table.

Measuring your intellect works the same way. **Keep the conditions the same and the tasks fresh**, and change only the one thing you want to see, your skill. Before you can do that, you need to know which skill you are measuring, because "getting better" has at least four parts.

Understanding comes first



What you measure	What it tells you	A fair way to test it
Understanding	Whether you know why a method works	Explain it in your own words, then solve a task that changes one detail
Accuracy	How often you get the right answer	Mark a set of fresh tasks of the same kind and level, under the same time limit
Retention	Whether the skill is still there later	Do fresh tasks after weeks with no review
Application	Whether you use it on real problems	Solve one task from your own life and note the result

The four parts are not equal. **Understanding comes first and application last**, because you can only use a method well on a real problem once you know why it works. A plan that measures only accuracy can miss the fact that you never use the method outside practice.

Understanding is the easiest to fake. **Reading a worked answer and nodding feels like understanding**, and it is often only recognition. Close the book, explain the method aloud or on paper, then try a task where one detail is different. If the changed detail stops you, the understanding is thinner than it felt.

Test your understanding





A child at a kitchen table explaining a drawing to a grandparent, who leans in to listen.

A good test is to explain the method to a friend or a child. **Their puzzled face shows you the gap** faster than any score, and the gaps are where your next practice should go.

Accuracy needs fresh tasks. Did you get better, or did the tasks just feel familiar? **A large review measured how long the gain from familiar tests keeps growing**, and the answer shapes how you plan your checks.

> Science Says:
>
> A review of 122 studies with 153,185 people found **"significant retest effects and no further score gains after the third test administration"** (Scharfen et al., 2018). The size of the effect depended on the content of the test, how alike the forms were, the gap between tests and the age of the people tested.

First, **most of the familiarity gain arrives in the first few retests**, so later checks are less inflated by it. Second, the more alike the forms, the bigger the gain, so write new tasks of the same kind for every check. Keep the spare sets you wrote at the start of your plan for this purpose.

Accuracy needs fresh tasks

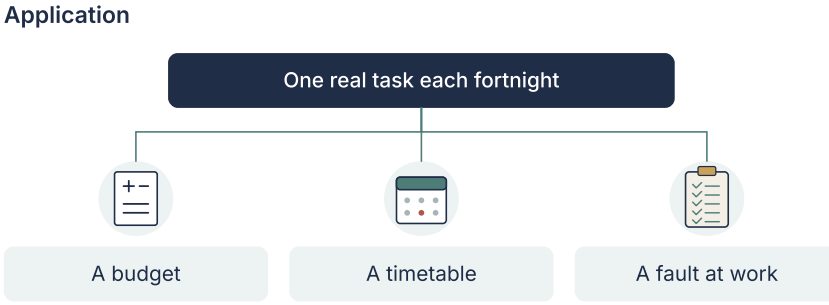


Retention needs a gap. **A skill that works on the day you practise it** may be gone a month later. Test retention with fresh tasks after a few weeks with no review of that method, and mark them the same way as before.

> **Science Says:**
>
> Bahrick tested 733 people on knowledge learned at times spread across 50 years. **Their knowledge fell for the first three to six years, then stayed stable for up to 30 years** (Bahrick, 1984). He called that stable store a permastore.

> **Key Concept:**
>
> Permastore. Permastore is **knowledge that survives the early loss and then stays put** for decades. Much of what you learn fades fast at first. The part that remains after the first years tends to remain for a very long time.

Application is the hardest to measure. **Use the method on one real task each fortnight**, such as a budget, a timetable or a fault at work. Write down the task, what you did and how it turned out. A short note of real use is evidence that no practice score can give you.

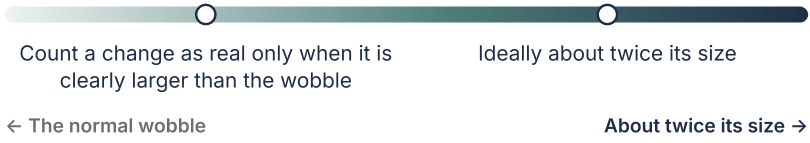


Even a fair test wobbles. **Scores move a little from day to day for no real reason**, like a cheap kitchen scale that reads 498 grams, then 503, for the same bag of flour. Before you trust a change, you need to know how big the wobble is.

> **Key Concept:**
>
> Reliable change. Reliable change is **a change bigger than the normal wobble of the test**. Researchers in psychotherapy built a formula that divides the change by the expected wobble, and said a result above 1.96 "would be unlikely to occur ($p < .05$) without actual change" (Jacobson & Truax, 1991).

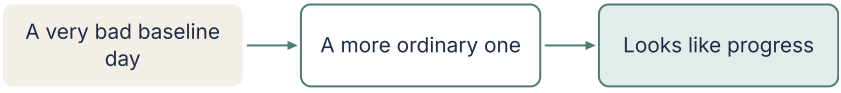
You do not need the formula at home. **Your three baseline days give you the wobble**, the gap between your highest and lowest day. Retest on three days in the same way and compare the two medians. Count a change as real only when it is clearly larger than the wobble, ideally about twice its size.

Reliable change



Extreme first scores need care. **A very bad baseline day tends to be followed by a more ordinary one**, which looks like progress and is only regression to the mean. A paper on the subject warns that it "can make natural variation in repeated data look like real change" (A. G. Barnett et al., 2005).

Regression to the mean



A change smaller than your wobble may still be real. **Keep it in your notes and look again at the next check**, because a real gain keeps growing while a lucky day fades back.

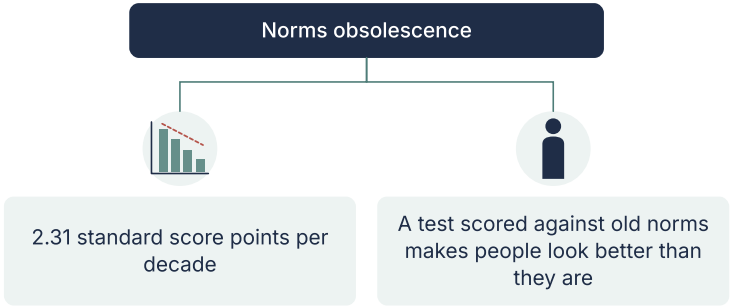
Old measuring sticks bend over time. **Test norms go stale**, because average scores across whole populations have shifted over the decades, the Flynn effect from Module 1. A review found what that means for anyone using an old test.

> Science Says:
>
> A review of 285 studies found average scores rising by **2.31 standard score points per decade**, a trend that "results in norms obsolescence" (Trahan et al., 2014). A test scored against old norms makes people look better than they are.

Norms make little difference to your own plan, since you compare yourself with yourself. **They make a big difference to any online test** that hands you a number against "the average person". Without a date for the norms, the number has no anchor.

Online testing has one point in its favour. **Groups tested on the web gave research data as good as groups tested in the lab**, with no difference in average, spread or internal reliability (Germine et al., 2012). That finding is about research groups. It says nothing about how far to trust one person's score at home.

Test norms go stale



> **Key Concept:**
> Benchmark. A benchmark is **a fixed task, scored the same way every time, with a date**. Its value comes from the sameness, so you can compare one result with another. Change the task or the scoring and the comparison breaks.

Benchmarks are everywhere, including in AI. **AI models are compared on public leaderboards**, and the hallucination leaderboard I dated earlier in the book (see 8.2.4) now adds a spread of results.

> **Science Says:**
> Vectara's hallucination leaderboard, "Last updated on October 22, 2026" and read on 4 November 2026, tested 111 models on summaries. **Their rates of made-up content ranged from 1.8% to 24.2%** (Vectara, 2026). The board is run by a company, it changes often, and it measures summaries only.

The leaderboard teaches two habits for your own benchmarks. **Put a date on every result**, and record what the task was, because results change as the tasks and the people change. For your own checks, keep

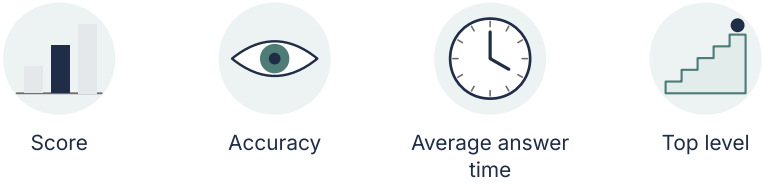
the device, the browser and the time of day the same, and note how you slept. A benchmark without a date is a rumour.

Made-up content on the leaderboard



A Cleverini game can serve as one benchmark among several. **Shape Spin ends each 60-second run with your score, accuracy, average answer time and top level**, and the next section uses that top level as one of its level tests. Play on three days and take the median, as with paper tasks. A game score is never an IQ.

Shape Spin ends each run



Game benchmarks rise with play, like any repeated test. **A higher Shape Spin score after a month** mostly tells you that you got better at Shape Spin. Use it beside your paper tasks and real-life notes, and never as the main measure of your goal.

Exercise:

Four-way check.

1. In your baseline week, do fresh paper tasks on three days, circle the median and note the gap, your wobble.
2. At week seven, explain your main method aloud, then solve a task with one detail changed.
3. Mark a fresh set of tasks under the same time limit as your baseline.
4. **Write one real-life use** from the past fortnight, and compare every result with your wobble.

My bathroom scales still jump after Sunday lunch. **I weigh myself on Friday mornings now, and I ignore the small wiggles.** Measure your intellect the same way, with fresh tasks, fixed conditions and a date, across understanding, accuracy, retention and application.

Key idea:

Measure four things on fresh tasks, the same way each time, and trust only a change bigger than the wobble.

Quick check:

Your accuracy rises from 6 to 7 out of 10, and your wobble is 2. Decide whether you have improved. Answer: you cannot tell yet, because the change is smaller than your normal wobble.

9.3.2 Levels of Practice and Qualification Criteria

My niece came home from the pool with a new badge sewn on her costume. **The badge did not make her swim better.** It marked what she had shown the teacher in front of a witness, on a set length of the pool. Grown-up practice rarely comes with badges, so this section gives you a way to mark your own.

A badge

The badge		A level
Marked what she had shown the teacher	≈	A guide to your practice
Did not make her swim better	≈	Never as a measured rank

The Practitioner Levels are this book's own scheme. No validated scale of levels for intellect exists, and I searched for one. Read the levels as a guide to your practice and never as a measured rank, the way a badge records one swim and says nothing about the swimmer's worth.



A girl in goggles at the edge of a pool, holding up a cloth badge while her teacher ticks a clipboard.

> **Key Concept:**
> Practitioner Levels. The Practitioner Levels are **five steps of practice, from Basic to Master**, each defined by evidence in three strands. The methods strand shows what you can do, the journal strand shows what you did, and the benchmark strand shows your Cleverini results under fixed conditions.

Baseline Week, Practice Block and Retest

How would you show that you had moved up a level, with nobody to hand you a badge? **The answer is a fixed order of steps.** You record a baseline week, work through a practice block, then retest under the same conditions, and only then hold a level review.



The baseline week comes first. On three different days, do a small set of fresh paper tasks from your goal area and play each core game once, on the same device each time. Write every result in the journal. The median of the three days, the middle result, is your starting mark, and the spread is your wobble.



A row of seedlings in pots on a windowsill, each a little taller than the one before.

The practice block follows, twelve weeks in my own plan. Work through the methods for your level and use them on real problems (Table 9.1). The games sit outside the practice block here, because in this module they serve only as tests.

Three strands



The retest repeats the baseline week once the methods and journal strands are complete. Use three fresh paper sets and the same core games on three different days, on the same device. Compare the medians with

your baseline and with Table 9.2, and count only a change larger than your wobble (see 9.3.1).

Table 9.1: Methods and journal evidence for each level

Level	What you can do (methods)	What the journal shows
Basic	Name what is known, unknown and missing, and spot simple rules (3.1), on easy tasks with a worked example nearby	A full baseline week, then short notes on each practice day
Intermediate	Reason, test and compare answers on standard tasks without an example (3.2), and check every answer (3.3.1)	Eight weeks of notes, with one real problem solved each fortnight
Advanced	Choose a strategy for a new kind of task and say why (3.3.1), and carry a method beyond its first exercise (4.2.2)	A full twelve-week plan, with a retention check after weeks without review
Expert	Find your own errors and teach a method to someone else (4.1.2), on real projects (4.3.1)	Several months of notes, with real uses in more than one area
Master	Design your own tasks and checks, and help another person build theirs, without labels (7.1.1)	A year of notes, plus a written record of the person you helped

Cleverini Benchmarks

My rule for this book is that Cleverini games are the level tests. The pages differ in what they show. Two, Chess Puzzles and Echo Match, place a result in a named band. Three, Robot Route, Shape Spin and Chess vs Computer, show levels, and the rest keep a level without a published scale.

Table 9.2 uses the five games that show bands or levels, and I call them the core games. Sudoku, Wordy, Logic Challenge, Brainy Digits, Math Matrix and Pyramid stay out of the table, because their pages give

no level names or numbers to compare against. Write the level they keep in your journal as a record, and nothing more.

Table 9.2: Level-by-game benchmarks

Game (what you record)	Basic	Intermediate	Advanced	Expert	Master
Chess Puzzles (top rating and band)	Record your top rating and band	A band above Rookie	★ A band above Rookie every day	Master tactician, at 1800 and above	★ Master tactician every day
Echo Match (score band)	Record your band	A band above Warming up	★ A band above Warming up every day	Echo master	★ Echo master every day
Robot Route (highest level cleared, of eight)	Clear level 2	Clear level 4	Clear level 6	Clear level 8, which wins the run	★ Win the run every day
Shape Spin (top level, of eight)	Record your top level	Top level 5	Top level 7	Top level 8	★ Top level 8 every day
Chess vs Computer (full game)	Win at Beginner	Win at Casual	Win at Club	Win at Strong	Win at Master

> 🗝 **Key Concept:**
>
> Starred and every-day cells. A ★ marks a cell where the page names no further band or level, so the cell asks for **the same result in each of the three retest sessions**. Every other cell counts once the middle result of the three sessions reaches it. For Chess vs Computer, that means a win on two of the three days.

Which page level goes with which Practitioner Level is my own mapping, and so are the stars. The band names, ratings and level counts come from the game pages. The pages name only the lowest and

highest bands for Chess Puzzles and Echo Match, so the middle cells say "a band above" and name no band.

The games' own labels and the book's levels are separate things. The game's Master level and the book's Master level only share a word. The Shape Spin page says the game "does not predict or grade a formal test result", and the same holds for every cell here. A game score is never an IQ.



A benchmark shows that you reached a band or level in that game, on that device, after practice. It says nothing about everyday problems on its own, which is why the methods and journal strands carry equal weight. Chess vs Computer allows unlimited takebacks on Beginner and Casual, so note in the journal how many you used.

Journal and Level Review

The journal ties the strands together. Each entry records the date and conditions, what you practised, where you used it in real life, and the

result. Table 9.3 gives the headings, and the next section shows how to keep it going.

Table 9.3: Practice-log headings

Day and setting	What I practised	Where I used it	Outcome and note
Hour, device, last night's sleep	Method and minutes	A real task	Score or band, one change

The level review works through Table 9.4, strand by strand. It adds honesty checks for retest gains, the wobble and daily life. Back each tick with evidence you can point to, such as a dated score or a journal entry. A tick with nothing written beside it does not count, however sure you feel.

Table 9.4: Level-review checklist

Area	What to check	Where the evidence is	Met
Methods	I can explain each method for this level in my own words		☐
Methods	The journal dates each time I used a method on tasks		☐
Journal	All three baseline days are logged, with the device and setting		☐
Journal	The real-life uses for this level are logged		☐
Benchmarks	Each core game meets its Table 9.2 cell by the three-day median, on my baseline device		☐
Benchmarks	Starred cells were met in all three sessions		☐
Honesty	My paper tasks were fresh, and my change is bigger than my wobble		☐
Honesty	I have checked whether my gains show up on real problems		☐
Review	Reviewed by myself, a friend or a mentor, with the outcome and date in the journal		☐

A level describes your evidence, and it says nothing about you as a person. Write “my evidence meets Advanced” and never “I am Advanced”. That is my own advice. A note about your evidence tells you which strand to work on next, while a label about yourself gives you nothing to practise.

The outcome goes in the journal as a dated sentence, such as “Advanced, from the week-twelve retest”. If a strand is missing, write “keep practising” and name the strand. Levels say nothing about health, and a worrying change in everyday memory or reasoning calls for a doctor.

> Exercise:
>
> Level review.
>
> 1. Gather the journal, your baseline sheets and the retest results.
> 2. **Work through Table 9.4** and write the evidence beside each tick.
> 3. Ask a second person to check one strand.
> 4. Write the outcome as a dated sentence.

Evidence and labels

A label about yourself	A note about your evidence
I am Advanced	My evidence meets Advanced
Gives you nothing to practise	Tells you which strand to work on next

My niece’s badge is still on her old costume, though she has moved on to longer swims. **A badge marks one moment, and the next length**

of the pool is always ahead. Treat your level the same way, as a dated note about your evidence and a guide to the next step.

Key idea:

A level is the book's own guide to your practice, earned with three strands of evidence under fixed conditions, never a rank or an IQ.

Quick check:

Your Chess Puzzles band rose above Rookie, and your paper tasks stayed flat. Decide whether your level should rise. Answer: no, because every strand must be met, and the paper tasks show no change beyond your wobble.

9.3.3 Your Journal, Level Review and Maintenance Plan

A FRIEND OF MINE SAILS a small boat at weekends, and every trip goes into a battered logbook. **She writes the wind, the route and one thing that went wrong.** She can tell you why she reefs early in a westerly. Your twelve weeks are nearly over, and **the skills you built need something to keep them from drifting**.

Three tools



A short journal



A regular level review



A light maintenance plan

Three tools do most of the work. **A short journal, a regular level review and a light maintenance plan** keep a skill in use long after the first plan ends. Each one takes minutes a week, and together they turn a twelve-week project into a habit you can keep for years.



An open logbook and a pencil on a boat's chart table, with a coil of rope beside them.

> **Key Concept:**
>
> Learning journal. A learning journal is **a short, dated record of what you practised, how it went and what you will change**. It is a working note for you, kept short, and it becomes the evidence for your level reviews.

A good entry is brief. **Four lines written on the day** beat a page written from memory at the weekend. Keep the same headings every time, so a glance down the page shows you patterns that a single entry

would hide. Leave the notebook where you practise, so it is always to hand.

Heading	What to write	Example
Day and setting	When and where you practised, on what device, and how you slept	Tuesday, half past seven in the morning, at the kitchen table, slept well
What I practised	The method, the kind of task and the minutes	Listing every constraint first, three timetable puzzles, 15 minutes
Where I used it	A real task where you used the method, or "not yet"	Planning the school run for the week
Outcome and note	The score or band, one mistake and its cause, and one change	2 of 3 right, missed a constraint in the second puzzle, list constraints before starting

The third row, Where I used it, is the easiest to leave blank, because practice feels like the whole job. Write "not yet" when you have no real use to record, so the gap shows up when you read the page back. The review of progress checks from 9.1.1 also asked how to get people checking at all.

> Science Says:
>
> In the review by Harkin and colleagues, **interventions raised how often people monitored their progress, with an effect of d+ = 1.98** (Harkin et al., 2016). A journal with fixed headings is one simple way to make the checking happen.

Read the journal back once a week, on a fixed day. **Ten minutes on a Sunday is enough to spot an error that keeps coming back**, such as rushing the first step or skipping a check. A repeated error is the best aim for the next week of practice.

The four headings



I found no good study of learning journals in particular. **The evidence is about monitoring progress in general**, and a journal is my suggestion for doing that. If a checklist on the fridge or a note on your phone suits you better, use it, as long as it is dated and kept up.

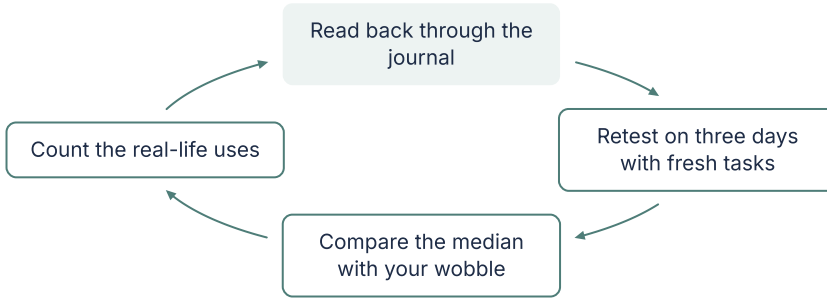


A row of notebooks on a shelf with dates written on their spines in white pen.

A level review checks your evidence against the level-review checklist (see 9.3.2). **Hold one at the end of each plan.** After that, this book's advice is a review every three months, a gap I chose and no study has tested. Read back through the journal first, so the review rests on what you did and not on your mood.

Use the same steps at every review. **Retest on three days with fresh tasks and compare the median with your wobble**, look for a retention check that held, and count the real-life uses. A gain larger than the wobble supports a level, and one strong day does not.

Use the same steps at every review



Level review step	Done
Read back the journal since the last review	
Mark fresh tasks on three days under the usual time limit	
Play the core games on the same device on those days	
Compare each median with your wobble	
Count real-life uses in your notes	
Ask a second person to mark one task	
Write the level as a dated sentence about evidence	

A review ends with a decision. **If the gain held, aim the next plan at your weakest strand**, which is often real-life use. If the scores stayed flat, change one thing, such as harder tasks, a different method or a better time of day, and check again at the next review.

A review ends with a decision

	If the gain held	If the scores stayed flat
Next	Aim the next plan at your weakest strand	Change one thing

Dates make reviews easier to start. **Tie each review to a date you will not forget**, such as the first Sunday of a new month or your birthday. Write it in your diary today, with the time and the place, because a review with no date tends to slip.

> **Key Concept:**
> Maintenance. Maintenance is **the small amount of regular practice that keeps a skill in working order** after the main plan ends. It takes much less time each month than the main plan did.

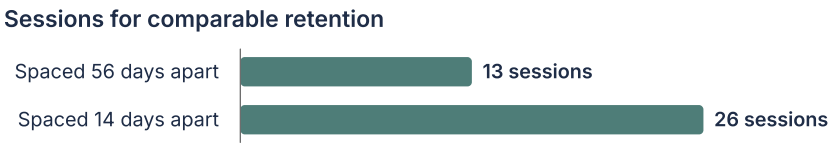
A bike chain needs oil once a month or so. **Skip it for a season and it squeaks and slips**, though the bike still works. Oil it on a schedule and it runs smoothly for years. Skills behave in a similar way, and the evidence suggests the oiling can be spaced well apart.

A bike chain

A bike chain		A skill
Needs oil once a month or so	≈	The oiling can be spaced well apart
Skip it for a season and it squeaks and slips	≈	Keeps a skill in working order

> **Science Says:**
>
> Four people learned foreign language words in a study lasting nine years. **Thirteen sessions spaced 56 days apart gave retention comparable to 26 sessions spaced 14 days apart** (Bahrick et al., 1993). The study had only four people, so read it as a strong hint.

The gaps in the maintenance table below are my own plan, one mixed session every three to five weeks after the first month. Bahrick's study had only four people, so it cannot set an exact gap. If a session at five weeks feels like starting again, move the next one closer, and write the change in the journal.



You cannot keep everything at full strength. Which skills deserve the oil? **Choose two or three methods you use in real life** and maintain those on purpose. The rest can rest, and a short refresher brings them back when you need them, much faster than the first time.

Finish the first plan properly before you cut back. **My advice is to make the method solid first**, because a shaky method has less to keep. If your last retest only just beat your wobble, keep the full plan going for a few more weeks before you switch to maintenance.

Period	What to do	Time
Weeks 13 to 16	One mixed session a week on fresh tasks	About 30 minutes a week
Months 4 to 12	One mixed session every three to five weeks	About 45 minutes a month

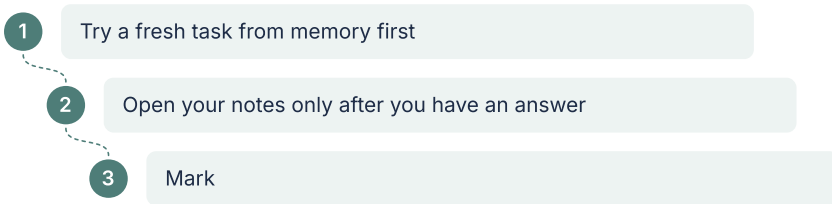
Period	What to do	Time
Every three months (the book's advice)	Level review with a three-day retest and journal read-back	About an hour
Any time	Use a method on a real problem and note it	A few minutes

Make each maintenance session a test. **A short self-test every few weeks does two jobs at once**, keeping the skill in use and showing you whether it has slipped. Try a fresh task from memory first, and open your notes only after you have an answer to mark.

Expect some loss between sessions. A dip at a three-month review is normal. **After a long break, practise for a session or two and repeat the three-day baseline before you judge**, noting how fast the skill came back.

A real decline needs a different response. **If a review shows a drop that does not recover**, or you notice trouble with everyday tasks you used to do easily, please speak to a doctor or another clinician. A journal and a level review are tools for practice, and they cannot tell you why a decline is happening.

Make each maintenance session a test



A Cleverini game can keep its place as one dated record. **Play it on the same device at the same time of day at each review**, write the game's own result in the journal, and read it as a game score. A higher score shows you got better at that game, and it never stands for an IQ.

Exercise:

Set up your maintenance plan.

1. Rule a journal page with the four headings from the table.
2. Put your next three level reviews in your diary, on dates you will not forget.
3. **Book one mixed self-test every three to five weeks** until the first review.
4. Write one real problem where you will use a method this month.

Many people start a second plan after a few months of maintenance. **A new twelve weeks can aim at a new kind of task**, or push one method to the next level. Keep the same journal, so the new plan begins with evidence and not a blank page. Your last level review shows which strand to aim at.

Start a second plan



My friend still writes in her logbook after twenty years of sailing. **She says the notes keep her honest about what she can do in a blow.** Your journal can do the same for your skills, with short notes, spaced

reviews and fresh tasks, so the work of these twelve weeks keeps paying back for years.

Key idea:

Write short notes, review on a spaced schedule with fresh tasks, and keep the skill in use.

Quick check:

Your plan ends in June and you want the skill in a year. Choose a gap between maintenance sessions. Answer: about three to five weeks, as in the maintenance table, with a self-test in each session.

A. A Simple Weekly Practice Planner

On a Sunday evening I sit at the kitchen table with a pencil and one blank sheet. **Five minutes is all the planning my practice week needs.** I write three short sessions into the days ahead, tie each one to a moment I already have and pin the sheet where I will see it on Monday morning.



A cork noticeboard in a narrow hallway, one ruled sheet pinned at its centre and a pencil hanging beside it on a length of string.

> **Key Concept:**
> How to use this planner. **Every sheet in this appendix is a blank copy of a plan from Module 9**, with blank rows for your own plan. The days, cues and minutes in the filled rows are my own advice. The studies behind them are told in 9.1.2 and 9.2.1, and the tables below name the section for each idea. Copy the sheets into a notebook, and use a pencil, because the first version is a draft.

The week rests on three habits. **Keep each session small, tie it to a fixed cue and leave gaps between sessions on the same method.** Twenty to thirty minutes is enough for one focused session in my own experience. To use a method in a week's time, come back to it after one to three days.

A cue is a moment you meet anyway, such as the washing-up after breakfast or the train home. **An if-then plan ties the session to that moment in advance**, in the form "If I finish the breakfast washing-up, then I do one hard task." Write the cue in the second column of the planner, so the plan starts itself.

Table A.1: My weekly planner

Day	Cue (if this happens)	What I do (method and task)	Minutes	Done
Monday				
Tuesday				
Wednesday				
Thursday				
Friday				
Saturday				
Sunday		Read the week's notes and plan next week	5	

The Sunday row is already filled in, because **the weekly read-back is the one slot I never skip**. Five minutes of planning saves the first ten minutes of every session, which would otherwise go on deciding what to do. Pick next week's weak spot from your notes and write it at the top of the sheet.

If you want a starting point, copy my sample week from Module 9. **The days and cues are yours to change**, and the gaps between sessions are the part to keep.

Table A.2: My sample week

Day	Cue	What you do	Time	From
Monday	After breakfast washing-up	One hard task of your goal type, checked	20 minutes	9.1.2
Wednesday	On the train home	Revisit Monday's method on a fresh task	20 minutes	9.1.2
Saturday	With the first coffee	Two mixed tasks, then mark them	30 minutes	9.1.2
Sunday	Before the weekly shop	Read the week's notes and plan next week	5 minutes	9.1.2

Each session starts with a small card. **Before you begin, write down one weak spot, one way to check each try and one change to test next time.** The card turns an ordinary session into aimed practice, and it takes a minute to fill in.

Table A.3: Session card

Date and cue	My weak spot today	How I check each try	One change to test next time

Plan for the bad week before it arrives. **Write a five-minute version of your session**, such as one task and one check, for days when the full

slot disappears. The five-minute version keeps the cue and the habit alive, and it stops one missed day from turning into a missed month.

Your week sits inside a longer plan. **Twelve weeks break into four blocks, and each block has one job.** Twelve weeks is my own choice, and no evidence shows it is the best length. Stretch a block if life gets in the way, and keep the order of the blocks.

Table A.4: Twelve-week tracker

Weeks	Block	What you do	From	Done
1 to 2	Settle	Finish your goal sheet and baseline, try your cues and fix any that fail	9.1.1, 9.2.1	
3 to 6	Build	One weak spot each week, three short sessions, one Sunday review	9.2.1	
7	Check	Do a few fresh tasks, compare them with the baseline, adjust the plan	9.2.1	
8 to 11	Stretch	Harder tasks, mixed types, less help from notes	9.2.1	
12	Review	Do the three spare sets on three days, compare, and plan what comes next	9.2.1, 9.3.1	

Week seven deserves a careful look. **Check first that the sessions happened**, then that they aimed at your weak spot, and last that the tasks suit your goal. Fix the first problem you find before you touch the others.

Week seven check



Bumps come to every plan, and **an if-then plan written in advance brings you back**. Fill in the sheet below for the bumps you can see coming, such as travel, a late shift or a cold. My two favourites are in the first rows.

Table A.5: Plans for bumps

If this happens	Then I will	From
I travel for work	Do my five-minute version in the hotel	9.2.1
A method fails three sessions running	Drop it and try another	9.2.1
A slot fails two weeks running	Move it to a better cue	9.1.2
I am short of sleep	Sleep first, and practice can wait	9.1.2, 5.1.1

Last comes your minimum week. **Write down the least practice that keeps the cues alive**, such as one five-minute session on two days. After a long break, start with a review session on a few tasks you once solved well, then rebuild the three sessions over a week or two.

Your notes after each session feed the Sunday read-back. **Write about the work, never about yourself**, such as "I skipped the check on the second task" in place of "I am hopeless at this." A note about the work points to something you can practise next time.

Exercise:

Fill in your first week.

1. Write three moments you meet every week in the Cue column of Table A.1.
2. Give each one a 20 to 30 minute session, with at least a day between sessions on the same method.
3. Write your five-minute version and your minimum week on the back of the sheet.
4. **Fill in two rows of Table A.5** for the bumps you expect this month.

My Sunday sheet rarely survives the week unchanged. **A crossed-out cue with a better one pencilled beside it is a sign the planner is working.** Keep the old sheets in a folder, and in twelve weeks you will see the pattern of your own practice.

Key idea:

Plan small sessions on fixed cues with gaps between them, and write your bump plans before the bumps arrive.

B. Sleep, Movement and Meal Planning Worksheets

Three small sheets live on a clipboard by my back door. **Each takes a minute a day to fill in.** After a week I can read my own habits in pencil, which is far more honest than my memory of them.



A clipboard hanging on a hook by a back door, three sheets of paper clipped to it and a stub of pencil tucked under the clip.

> **Key Concept:**
> How to use these worksheets. **Each sheet copies the advice in Module 5 and adds nothing stronger.** Fill a sheet in for seven days without changing anything, then pick one change and keep it for a fortnight. Your notes cannot show cause, yet they show your own pattern. If you have a health condition, the doctor line on each sheet comes first.

Sleep

Sleep comes first in my week. **Two sleep medicine bodies say, "Adults should sleep 7 or more hours per night on a regular basis to promote optimal health"** (Watson et al., 2015). An expert panel gave a range of 7 to 9 hours for adults, and said needs "vary across the lifespan and from person to person" (Hirshkowitz et al., 2015).

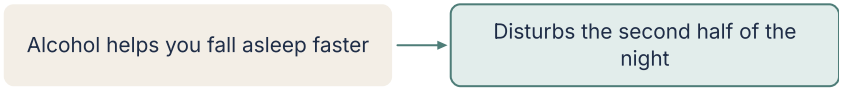
Fill in the sleep notes each morning. **Rate how clear your head felt at ten o'clock, from 1 to 5**, and after seven days look for the nights that came before your clearest mornings. One change, kept for a fortnight, tells you more than five changes made at once.

Table B.1: A week of sleep notes

Night	Went to bed	Woke	Hours	Last caffeine	Alcohol the evening before	Clear head at ten (1 to 5)
1						
2						
3						
4						
5						
6						
7						

People given 400 mg of caffeine six hours before their usual bedtime still slept worse, and the authors advised avoiding it "for a minimum of 6 hours prior to bedtime" (Drake et al., 2013). Alcohol helps you fall asleep faster, then disturbs the second half of the night (Ebrahim et al., 2013).

Alcohol and sleep



The evening routine below is mine, built from the studies in 5.1.1. **Copy the rows you want into the last column**, and change any line to fit your life. The effects of single bedtime tips remain "largely untested in the general population" (Irish et al., 2015), so treat the routine as a habit to try.

Table B.2: My evening routine

Time before bed	What I do	Study behind it	My version
6 hours	Last cup of coffee or tea with caffeine	Drake et al., 2013	
1 hour	Paper book in place of a glowing e-reader	A.-M. Chang et al., 2015	
Most nights	Same bedtime, aiming for 7 hours or more	Watson et al., 2015	
After a bad night	A 10-minute nap in the early afternoon	Brooks & Lack, 2006	

If poor sleep goes on for weeks, please see your doctor and ask about it. For adults with chronic insomnia, a talking and training treatment called CBT-I has strong trial support, and a doctor can point you to it or check for a different cause.

Movement

The movement sheet counts minutes across the week. **The WHO's 2020 guidelines say "All adults should undertake 150 to 300 min of moderate-intensity, or 75 to 150 min of vigorous-intensity physical activity" each week** (Bull et al., 2020). The United States guidelines ask for "muscle-strengthening activities on 2 or more days a week" (Piercy et al., 2018).

If you have a heart, lung or joint condition, please talk to your doctor before you raise your effort. The guidelines add that "some physical activity is better than none" (Bull et al., 2020), so a short walk still goes on the sheet.

Table B.3: A week of movement

Day	Brisk minutes	Strength or balance (tick)	Longest stretch of sitting	Stand-ups on a desk day
Monday				
Tuesday				
Wednesday				
Thursday				
Friday				
Saturday				
Sunday				
Week total	Aim for 150 to 300	Aim for 2 or more		

Five brisk half-hour walks reach 150 minutes, and a strength session at home with a few balance moves fills the second column. My sample week in Module 5 reaches 165 aerobic minutes and two strength days.

On desk days I set a timer for half an hour and stand when it rings. **The trials used breaks of two or three minutes**, and the half hour is my own suggestion. The sitting studies are links that cannot show cause.

Meals

The meal sheet looks at the whole pattern. **A dietary pattern is the whole mix of foods you eat over time**, and no single food has been shown to sharpen your mind (see 5.3.1). The WHO says that "A healthy, balanced diet should be recommended to all adults" (World Health Organization, 2019).

Table B.4: A pattern week

Day	Portions of whole grains	Portions of fruit	Salty foods	Units of alcohol	Note
Monday					
Tuesday					
Wednesday					
Thursday					
Friday					
Saturday					
Sunday					
Week total					
One swap for next week					

The MIND diet is an eating plan from one study, and that study shows only a link (Morris, Tangney, Wang, Sacks, Barnes, et al., 2015). In a later 3-year trial of 604 older adults, changes in cognition and brain scans "did not differ significantly" from a control diet (Barnes et al., 2023). A varied pattern with whole grains, fruit, little salt and little alcohol is good sense for general health.

Count alcohol in units on the sheet. **The NHS says "One unit equals 10ml or 8g of pure alcohol"** (NHS, n.d.). Odds, which come up next, are another way of measuring chance.

In a 30-year study of 550 adults, moderate drinkers (14 to 21 units a week) had three times the odds of shrinking in the right hippocampus, a memory area deep in the brain. It found "no protective effect of light drinking" (Topiwala et al., 2017). **The study is a small link that cannot show cause**, and it gives no reason to start drinking.

> Exercise:
>
> Three sheets, one week.
>
> 1. Fill in Tables B.1, B.3 and B.4 each day for seven days, without changing anything.
> 2. At the end, add up the hours, the brisk minutes and the portions.
> 3. Look for the nights before your clearest mornings.
> 4. **Pick one change on one sheet** and keep it for a fortnight before you try another.

My first week of sheets showed late coffee on my foggiest mornings. **One change, coffee finished by mid-afternoon, was enough to start with.** The other sheets waited their turn, and the clipboard is still by the back door.

Key idea:

Write down a week of sleep, movement and meals before you change anything, then change one thing and keep it for a fortnight.

C. Cleverini Game Guide and Offline Alternatives

On sunny afternoons my family takes a bag of games to the park. **Every Cleverini game in this guide has a paper or table-top partner** you can take anywhere. The guide sets the two side by side, so you can choose a game for the skill it practises and swap to the offline version whenever you like.

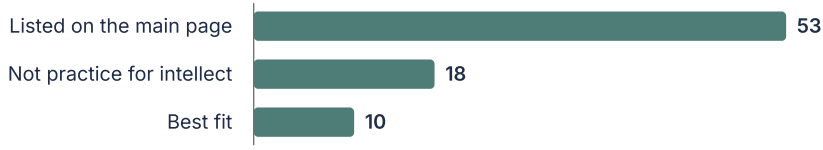


A picnic blanket in a park with a travel chess set, a puzzle book and a pencil laid out on it.

> **Key Concept:**
> How to read this guide. **"What it practises" lists the skills each game's own page names**, as I read them on 4 November 2026. They are the site's own descriptions and carry no independent evidence. The "why this game" line is my own reason for including it.

Cleverini's main page lists 53 games. **I sorted them by the skill each one mainly asks for**, judged 18 not to be practice for intellect and picked 10 as the best fit. The sorting is my own judgement. Chess vs Computer joins as an eleventh, since it adds a full game against an opponent.

Cleverini games

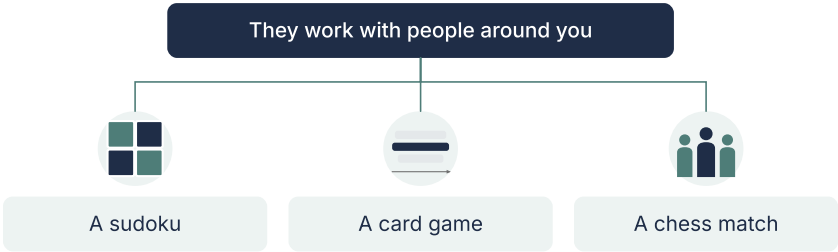


Game	What it practises (game page)	Why this game	Offline alternative
Echo Match	Working memory, attention, decision speed	Holding and updating two items in mind	A friend turns playing cards; say "match" when a card equals the one two back, a spoken n-back task (Kirchner, 1958)
Shape Spin	Spatial reasoning, telling left from right, speed under a clock	Turning a shape in your head	Build two shapes from toy bricks, turn or flip one, and decide which it was
Chess Puzzles	Calculation, pattern recognition, logic under time	Finding the forcing move in a set position	A book of chess puzzles, set up on a real board

Game	What it practises (game page)	Why this game	Offline alternative
Chess vs Computer	Calculation, planning, learning from mistakes	Planning across a whole game	A game across a table at home, a café or a club
Robot Route	Spatial reasoning, sequential logic, memory	Running a short program step by step	Draw a grid, write a list of moves and trace them with a coin
Sudoku	Deduction, pattern recognition, concentration	Ruling out options until one remains	Sudoku from a newspaper or puzzle book
Wordy	Deductive reasoning, vocabulary, strategy	Narrowing a word from letter clues	Two players guess each other's secret five-letter word on paper
Logic Challenge	Pattern recognition, logical reasoning, "Flexible thinking" (switching to a fresh approach as the puzzle type changes)	Switching between kinds of number rule	Puzzle-book sequences, with a friend setting new ones
Brainy Digits	Pattern recognition, mental arithmetic, checking your reasoning	Finding the missing number in a row of seven, from six options	Take turns writing a row of seven numbers with one hidden
Math Matrix	Pattern finding, mental arithmetic, "Flexible thinking" (trying another rule when the first fails)	Finding the rule that joins corner numbers to a centre number	Draw a diamond with four corner numbers and set a rule for a friend
Pyramid	Logic, pattern recognition, attention	Spotting a pattern that wraps across rows	Write a number pattern in a triangle of boxes and hide one

Offline partners have one extra benefit. **They work with people around you**, so a sudoku, a card game or a chess match can become a shared evening. Many of the offline versions need nothing more than paper, a pencil and a friend who likes a puzzle.

Offline partners

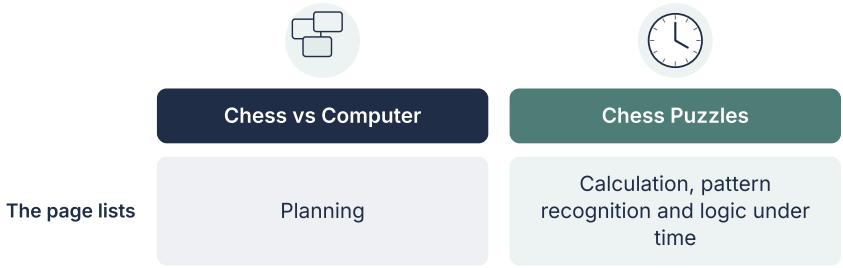


The other games on the site can be good fun. **Most of the 18 I left out ask mainly for attention or memory**, and several are casual sorting and matching games. Relaxation is a fine reason to play them, and this guide sticks to games that ask you to work out an answer.



A pack of playing cards fanned out on a garden table beside a small notebook.

Two of the games are easy to mix up. **Of the two chess games, only the Chess vs Computer page lists planning**, where you play a full game against the engine. Chess Puzzles is a timed sprint of set positions, and its page names calculation, pattern recognition and logic under time.



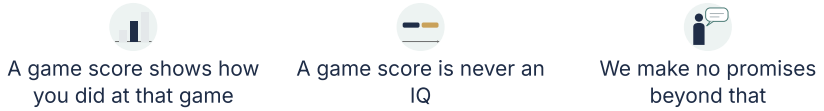
Details about access come from the same pages. **Echo Match, Shape Spin, Chess Puzzles and Robot Route start without a sign-up**, while Sudoku, Wordy, Logic Challenge, Brainy Digits, Math Matrix and Pyramid need a free Cleverini account, which keeps your level. Each page lists the game as free with no ads.

Game	Format and levels on the page
Echo Match	One-minute run, one back for 25 seconds and two back for 35, five score bands
Shape Spin	60-second run, eight levels, from five blocks up to seven
Chess Puzzles	Three-minute sprint with three strikes, puzzles rated about 600 to 2000
Chess vs Computer	Five engine levels, from Beginner to Master
Robot Route	Eight levels with three lives per run, and hidden cards on the last two
Brainy Digits	Up to 60 seconds per puzzle, with a skip
Logic Challenge	15 rounds per game, each with its own timer

The research on games sits in Module 8 (see 8.3.1). **The pages themselves add one new point.** The Shape Spin page says the game "does not predict or grade a formal test result". Read every game the same way. A game score shows how you did at that game, and a game score is never an IQ.

The pages are modest about their own claims. **The Wordy page says it exercises the vocabulary you already have**, and adds "We make no promises beyond that." I like that line, and it is a good rule for reading any game page, on Cleverini or elsewhere.

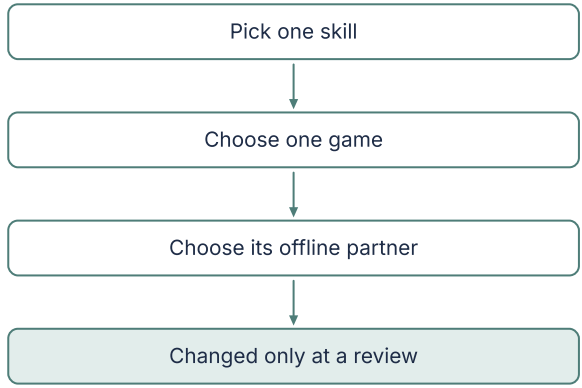
Read every game the same way



Pairing a game with an offline partner works best when the two match. **The Sudoku page says no arithmetic is involved**, so Sudoku and its newspaper cousin practise deduction and not sums. For mental arithmetic, Brainy Digits and Math Matrix are the better picks, and a friend's hand-written rows make a good partner for either.

Module 8 sets out how to choose a game and its difficulty (see 8.3.2). **The new point for this guide is one pair per skill**, a game and its offline partner, changed only at a review. A long list of games spreads your practice thin, and a fixed pair keeps the journal easy to read.

One pair per skill



Exercise:

Choose your pair.

1. Pick one skill from your goal, such as working memory or deduction.
2. Choose one game from the first table that practises it.
3. **Choose its offline partner** and get the paper, cards or board ready.
4. Alternate the two for a fortnight, and note in your journal which one you reached for more.

Our bag of park games changes with the seasons. **The habit of pairing a game with a paper partner stays the same.** Use this guide to choose, keep the screen version for quick sessions, and keep its offline partner for the days the screen is off.

Key idea:

Pick a game for the skill it practises, pair it with an offline partner, and treat its score as a record of that game alone.

D. Practice Tasks with Worked Explanations

A FRIEND ONCE ASKED ME for "a few puzzles to keep sharp". **I gave him six everyday tasks from this book instead**, each with a pencil and a worked explanation on the back of the page. He did them over a fortnight, and the worked steps taught him more than the answers did.

> **Key Concept:**
> How to use these tasks. **Try each task on paper before you read its worked explanation.** Every task comes from Modules 3 and 4, and the method for each one is named in Table D.5 at the end. The numbers are everyday examples, made up for practice. Mark your own answer against the steps, and note any step you skipped.

Task 1, the train. A friend's train leaves at 9.40, the walk to the station takes 25 minutes and she still has to buy a ticket. **Work out when she should leave the house**, and name anything you cannot know yet.

Pólya split the work of solving into four phases. **The first one says "we have to understand the problem; we have to see clearly what is**

required" (Pólya, 1945/1957). Then come making a plan, carrying it out and looking back.

Table D.1: The train, in four phases

Phase	What you do	For the train
Understand	List what is known, wanted and missing	9.40 and 25 minutes are known, the time to leave is wanted and the ticket queue is missing
Plan	Pick a way through	Count back from the train time
Carry out	Do the steps and write them down	9.40 less 25 minutes is 9.15, so she leaves before 9.15 by the time the queue takes
Look back	Check the pieces and the answer	The 25 minutes might be a guess from last summer, so check it

The missing piece is the lesson. **Once the queue has a name, she can deal with it**, by checking the queue on the station website, allowing extra time or buying the ticket on her phone.

Task 2, the bill. A restaurant bill has eight dishes and three drinks. **You add it up line by line and get £86**, and you want to know whether to trust the total.

Table D.2: The bill, checked two ways

Method	Result	What it tells you
Add each line	£86	An exact total, if no line was missed
Round each item to the nearest five pounds	About £95	A rough total, fast
Compare the two	A gap of about £9	Two methods that disagree are a signal to look again
Slower count	A skipped dish	The £86 was wrong

Rounding is fast and rough, and adding line by line is slow and exact. **Start with the rough check, and do the slow count only when the two disagree.** Save your closest look for the answer that feels most certain.

Task 3, the car alarm. Over a year, a thief comes to your street on one night, and the alarm sounds. **On 50 other nights it sounds for a cat, a gust of wind or an owner who pressed the wrong button.** Work out the chance that an alarm means a theft.

The worked answer starts from the base rate, **how often something happens in general**, before the clue in front of you. Out of 51 alarms, one meant a theft. As a percentage, that is about 2 per cent of the nights it sounds, and as a count it is one theft in 51 alarms.

Table D.3: The alarm, two ways

Way of writing it	The alarm	What you see
Percentage	About 2 per cent	A small number that hides the false alarms
Count	One theft in 51 alarms	The 50 false alarms, in plain view

A short paper in Science found that people's difficulties with chance "can be considerably reduced by communicating the information in terms of natural frequencies" (Hoffrage et al., 2000). Natural frequencies are counts of people or cases, such as "10 out of 1,000". The chance of theft is small, and it is worth a look out of the window.

Task 4, rain and a late bus. Decide which is more likely, rain tomorrow or rain tomorrow and a late bus. **The worked answer is rain tomorrow**, because a pair can never be more likely than one part of it. Every day with both is a day with rain.

Task 5, the wet pavement. Take the rule "if it rained, the pavement is wet". **Work out which sight could break the rule**, and what a dry pavement tells you.

Table D.4: Testing the pavement rule

What you see	What it tells you
A wet pavement	Nothing firm, because a burst pipe or a street cleaner could cause it
A dry pavement	It did not rain, the step called the contrapositive
A dry pavement on a day you know it rained	The rule is broken

To check a rule, **look at the cases where the "then" part is false**. No number of wet pavements could prove it. The same habit tests a guess about a phone battery, where deleting a new app for three days is the test that could fail.

Task 6, the double discount. A shop window says "30% off everything, and a further 20% off at the till". **Work out whether the coat is half price.** It looks like half price, but at the till it comes to a little more than half.

Take one discount at a time



Take one discount at a time. **30% off leaves 70% of the price, and a further 20% off leaves 80% of that 70%, which is 56%.** Each

discount takes its share of what is left. A train fare with a railcard and then a group saving has the same outline.

Table D.5: Where each method comes from

Task	Method	From
1, the train	Known, wanted and missing; four phases	3.1.1
2, the bill	Check by a second method	3.3.1
3, the car alarm	Base rate and natural frequencies	3.2.3
4, rain and a late bus	The conjunction rule	3.2.3
5, the wet pavement	A test that could fail; the contrapositive	3.2.2
6, the double discount	Identical elements; comparing two cases	4.2.2

> Exercise:
>
> Do them again.
>
> 1. Two or three days after your first try, cover the worked explanations.
> 2. **Solve each task again from memory** on a blank page.
> 3. Explain one method out loud, step by step, as if to a ten-year-old.
> 4. Write one real task from your week that uses the same method, and solve it.

My friend kept the sheet in his wallet. **The bill check was the one he used most**, on a birthday dinner a month later, and it caught a drink charged twice.

Key idea:

Work each task on paper first, then check every step of the worked explanation, and do the task again from memory a few days later.

E. Progress Journal and Practitioner-Level Rubrics

My father kept a logbook for his old car, with every fill of petrol and every repair written down beside a date. **When the car started using more fuel, the logbook showed it weeks before he noticed.** The pages in this appendix do the same job for your practice, so the record shows a change before your mood decides it.

> **Key Concept:**
> How to use these pages. **The Practitioner Levels are this book's own scheme**, and no validated scale of levels for intellect exists. Each sheet copies the steps, names and numbers from 9.3, with blank rows for your own results. A level describes your evidence, so write "my evidence meets Advanced" and never "I am Advanced".

Every level rests on the same fixed order of steps. **You record a baseline week, work through a practice block, then retest under the same conditions**, and only then hold a level review. The practice block is twelve weeks in my own plan.

Every level rests on the same order



Table E.1: Baseline week

Day	Date	Hour, device, last night's sleep	Tasks done	Score	How hard it felt
1					
2					
3					
Median (the middle score)					
Wobble (highest less lowest)					

On three different days, do five or six fresh tasks in a half-hour sitting. **Mark them, note the time and add one line on how hard they felt.** Your starting mark is the median, the middle score of the three, and the gap between the highest and lowest is your wobble.

Make spare sets at the same time. **Write three more batches of tasks of the same kind and level, and put them away unseen.** The retest

uses them, because the very same tasks come back easier the second time, and fresh sets measure skill in place of memory for the answers.

Table E.2: Retest record

Measure	Baseline median	Retest median	Change	Wobble	Clearly larger than the wobble (yes or no)
Paper tasks					



Two sheets of squared paper side by side on a small balcony table, a mug of tea holding down one corner and a pencil resting between them.

For the retest, use three fresh paper sets on three different days, on the same device. **Count a change as real only when it is clearly larger than the wobble, ideally about twice its size**, a home rule of thumb. A smaller change may still be real, so look again at the next check.

The journal ties the strands together. **A learning journal is a short, dated record of what you practised, how it went and what you**

will change. Keep the same four headings every time, and write four lines on the day in place of a page from memory at the weekend.

Table E.3: Journal page

Day and setting	What I practised	Where I used it	Outcome and note
Tuesday, half past seven in the morning, at the kitchen table, slept well	Listing every constraint first, three timetable puzzles, 15 minutes	Planning the school run for the week	2 of 3 right, missed a constraint in the second puzzle, list constraints before starting

The third column, Where I used it, is the easiest to leave blank. Write "not yet" when you have no real use to record, so the gap shows up when you read the page back. Ten minutes on a Sunday is enough to spot an error that keeps coming back.

Table E.4: Methods and journal evidence for each level

Level	What you can do (methods)	What the journal shows
Basic	Name what is known, unknown and missing, and spot simple rules (3.1), on easy tasks with a worked example nearby	A full baseline week, then short notes on each practice day
Intermediate	Reason, test and compare answers on standard tasks without an example (3.2), and check every answer (3.3.1)	Eight weeks of notes, with one real problem solved each fortnight
Advanced	Choose a strategy for a new kind of task and say why (3.3.1), and carry a method beyond its first exercise (4.2.2)	A full twelve-week plan, with a retention check after weeks without review
Expert	Find your own errors and teach a method to someone else (4.1.2), on real projects (4.3.1)	Several months of notes, with real uses in more than one area
Master	Design your own tasks and checks, and help another person build theirs, without labels (7.1.1)	A year of notes, plus a written record of the person you helped

The levels have three strands, methods, journal and benchmark. **Table E.4 covers the first two**, and the benchmark strand uses the level tests in Table 9.2 (see 9.3.2). Appendix C describes the games behind those tests.

Table E.5: Level-review checklist

Area	What to check	Where the evidence is	Met
Methods	I can explain each method for this level in my own words		
Methods	The journal dates each time I used a method on tasks		
Journal	All three baseline days are logged, with the device and setting		
Journal	The real-life uses for this level are logged		
Benchmarks	Game benchmarks: see 9.3.2, Table 9.2 and Appendix C		
Honesty	My paper tasks were fresh, and my change is bigger than my wobble		
Honesty	I have checked whether my gains show up on real problems		
Review	Reviewed by myself, a friend or a mentor, with the outcome and date in the journal		

Back each tick with evidence you can point to, such as a dated score or a journal entry. Hold a review at the end of each plan, and after that every three months, a gap I chose and no study has tested. The outcome goes in the journal as a dated sentence, such as “Advanced, from the week-twelve retest”.

If a strand is missing, write “keep practising” and name the strand. **Levels say nothing about health**, and a worrying change in everyday memory or reasoning calls for a doctor.

> Exercise:
>
> Start your record.
>
> 1. Copy Tables E.1 and E.3 into a notebook, and fill in the baseline week over the next seven days.
> 2. Write the three spare sets and put them away unseen.
> 3. Keep a journal line after every session for twelve weeks.
> 4. **Fill in Tables E.2 and E.5 at the retest**, and write the outcome as a dated sentence.

The car went to the scrapyard long ago, and the logbook stayed on my father's shelf. **Reading it back, I could see every repair he made and the date he made it.** Your journal will do the same for your practice, one dated line at a time.

Key idea:

Record a baseline, keep a dated journal and retest the same way, and let the evidence, never your mood, decide your level.

Appendix

F. A Short Glossary

WHEN I READ ABOUT a new field, I keep a slip of paper in the back of the book for words I look up twice. **This glossary is that slip for the book you are holding.** Each meaning is a shortened copy of the words the book used the first time.

> **Key Concept:**
> How to use this glossary. **The last column names the section where a term is first explained**, so you can go back and read it in its story. Terms are in alphabetical order across three tables. Game names and game scores are left out, and Appendix C covers those.

Table F.1: Terms from A to F

Term	Plain meaning	First explained in
Absolute risk	The plain chance of something happening in a group, such as 7 in 100	6.2.1
Analogy	Taking a rule found in one place and trying it in another, where the things look different	3.1.2
Automation bias	The habit of trusting a machine's output over your own judgement	8.2.4
Base rate	How often something happens in general, before the clue in front of you	3.2.3

Term	Plain meaning	First explained in
Baseline	A small set of tasks, scored and dated on three days in the week before a plan starts	9.1.1
Benchmark	A fixed task, scored the same way every time, with a date	9.3.1
Chunk	A group of items that the mind treats as one thing	3.1.1
Conjunction rule	Two things joined by “and” can never be more likely than one of them alone	3.2.3
Consolidation	The brain’s way of turning a fresh, fragile memory into a lasting one	5.1.1
Correlation	How strongly two things go together	1.1.1
Cross-sectional study	One snapshot of people at one moment	5.3.1
Crystallised intelligence	What you have learned and can use, such as words and facts	1.1.1
Dietary pattern	The whole mix of foods you eat over time	5.3.1
Effect size	A number that says how big a difference is, so studies can be compared	1.2.2
Far transfer	A skill helping on a very different task	1.2.2
Feedback	Anything that tells you how a try went, from a marked answer to your own note	9.2.1
Fluid intelligence	Solving a new problem you have not met before	1.1.1
Forgetting curve	How memory for something learned fades over time when you stop reviewing it	9.2.1

Some terms come in pairs, and **the pair makes more sense than either word alone**. Near and far transfer and fluid and crystallised intelligence are two of them, so look up both halves.

Table F.2: Terms from G to N

Term	Plain meaning	First explained in
g	General intelligence, the part that is shared across many different tests	1.2.3

Term	Plain meaning	First explained in
Habit	An action that starts almost by itself when you meet a familiar cue	9.1.2
Hallucination	When an AI states something false or made up as if it were true	8.2.4
Hypothesis	A guess about what causes what	3.2.2
Identical elements	The parts two tasks have in common	4.2.2
If-then plan	A plan that links a situation to an action in advance	4.3.1
Incubation	Taking a break from a task you are stuck on	3.3.1
Inference	A gap you fill in yourself, using what you already know	4.1.1
Insight	A sudden new reading of something you already had in front of you	3.3.2
Intellect	Solving tasks where the variables are identified	1.1.2
Interleaving	Mixing different topics or types within one session	4.1.2
Learning journal	A short, dated record of what you practised, how it went and what you will change	9.3.3
Longitudinal study	Research that follows the same people over years	1.3.3
Median	The middle score of three	9.1.1
Meta-analysis	A study of many studies	1.1.1
Metacognition	Your view of your own mind at work	3.3.1
Natural frequencies	Counts of people or cases, such as 10 out of 1,000	3.2.3
Near transfer	A skill helping on a similar task	1.2.2



A small boy on a library step stool reaching for a thick reference book, his mother steadying the stool with one hand.

A few words in the book carry an everyday meaning and a narrower one. **Feedback, risk and odds all mean something precise in the studies**, and the table gives the book's meaning. When a study quote uses one of them, read it with the narrow meaning.

Table F.3: Terms from O to Z

Term	Plain meaning	First explained in
Odds	Another way of measuring chance, comparing how often something happens with how often it does not	5.3.1
Placebo effect	A gain that comes from expecting to improve, with nothing in the treatment causing it	4.2.3
Practitioner Levels	This book's five steps of practice, from Basic to Master, each defined by evidence in three strands	9.3.2
Randomised controlled trial	A trial that splits people into groups by chance, so that the groups can be compared fairly	5.1.1
Regression to the mean	When a score is unusually high or low the first time, the next score tends to sit closer to the average	1.3.1

Term	Plain meaning	First explained in
Reliable change	A change bigger than the normal wobble of the test	9.3.1
Retest effect	The rise in score on a second try	1.3.1
Retrieval practice	Pulling something out of your memory on purpose, with nothing to look at	4.1.2
Reverse causation	The effect may be driving the supposed cause	6.3.1
Risk	The chance that something bad happens over a set time	5.2.2
Schema	A stored outline for a kind of problem	3.1.1
Spacing	Coming back to the same material after a gap	4.1.2
Standard deviation	The usual distance of scores from the average	1.3.3
Testing effect	Recalling something from memory, with the book closed, beats reading it again when you are tested later	8.1.1
Transfer	Whether a skill learned in one place helps in another	1.2.2
Wobble	The gap between your highest and lowest score across the three baseline days	9.1.1
Working memory	The small space where you keep things for a few seconds while you use them	1.1.1

My slip of paper usually ends up with fewer words on it by the last chapter. **A word you can explain in your own words no longer needs the slip.** Cover the middle column now and then, and see how many meanings you can say before you look.

Key idea:

Each term keeps the meaning the book gave it the first time, and the last column takes you back to that page.

G. Further Reading

A FRIEND ONCE ASKED ME which of my sources she should read first, and I had no short answer ready. **This appendix is the short answer.** It lists works the book already cites, chosen because a general reader can follow them without a science degree.

> **Key Concept:**
>
> How to use this list. **Each work appears in the same form as in the book's reference list**, so you can find it in a library or online. The second column gives one plain reason to read it and names the section that uses it. The tables group the works by topic, in alphabetical order within each group.

The first group is about solving problems. **Both books are old, and both are still easy to read**, because they describe the steps of real work in plain language.

Table G.1: Solving problems

Work	Why read it
Pólya, G. (1957). How to solve it: A new aspect of mathematical method (2nd ed.). Princeton University Press. (Original work published 1945)	The four phases of solving a problem, from the author who set them out, used in 3.1.1, 3.3.1 and Appendix D
Wallas, G. (1949). The art of thought (Abridged ed.). Watts & Co. (Original work published 1926). Retrieved November 4, 2026, from https://archive.org/details/dli.ernet.507402	The four stages of creative work, from Preparation to Verification, behind 3.3.2

The second group is about learning and practice. **These works sit behind most of the methods in Modules 4 and 9**, and each one is a review or a single clear study.

Table G.2: Learning and practice

Work	Why read it
Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. Psychological Science in the Public Interest, 14(1), 4-58. https://doi.org/10.1177/1529100612453266	A long review that rates common study methods by how well they work, used in 3.2.1 and 4.1.1
Gollwitzer, P. M. (1999). Implementation intentions: Strong effects of simple plans. American Psychologist, 54(7), 493-503. https://doi.org/10.1037/0003-066X.54.7.493	The paper behind the if-then plan in 4.3.1
Pashler, H., McDaniel, M., Rohrer, D., & Bjork, R. (2008). Learning styles: Concepts and evidence. Psychological Science in the Public Interest, 9(3), 105-119. https://doi.org/10.1111/j.1539-6053.2009.01038.x	Why matching lessons to a "learning style" lacks evidence, used in 1.1.2 and 7.5.1
Roediger, H. L., III, & Karpicke, J. D. (2006). Test-enhanced learning: Taking memory tests improves long-term retention. Psychological Science, 17(3), 249-255. https://doi.org/10.1111/j.1467-9280.2006.01693.x	A short study of the testing effect, used in 8.1.1

The third group comes from health bodies. **These pages are free to read and written for the public**, and they back the sleep, food and alcohol advice in Module 5 and the dementia facts in Module 6.

Table G.3: Health

Work	Why read it
NHS. (n.d.). Calculating alcohol units. Retrieved November 4, 2026, from https://www.nhs.uk/live-well/alcohol-advice/calculating-alcohol-units/	How to count the units in a drink, used in 5.3.1
World Health Organization. (n.d.). Dementia [Fact sheet]. Retrieved November 3, 2026, from https://www.who.int/news-room/fact-sheets/detail/dementia	Plain facts on dementia and its risk factors, used in 6.2.1 and 6.3.2
World Health Organization. (2019). Risk reduction of cognitive decline and dementia: WHO guidelines. World Health Organization. https://www.who.int/publications/i/item/9789241550543	What the WHO does and does not recommend for the ageing mind, used in 5.3.1 and 5.3.2

The last group goes back to the oldest ideas in the book. **One encyclopedia entry and one translated classic** show how people wrote about the mind long before modern tests.

Table G.4: Ideas from history

Work	Why read it
Confucius. (n.d.). The Analects (J. Legge, Trans.). Project Gutenberg. Retrieved November 3, 2026, from https://www.gutenberg.org/ebooks/4094	Short sayings on learning and study, quoted in 1.1.2
Nails, D. (2022). Socrates. In Stanford encyclopedia of philosophy. Retrieved November 3, 2026, from https://plato.stanford.edu/entries/socrates/	The life and method of Socrates, behind the questioning in 1.2.2

Start with one work from the group you care about most. Read it with a notebook open, and note one idea you can try in your next practice week.

Key idea:

Every work here is one the book cites, picked so a general reader can follow it, with a pointer back to the section that uses it.

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