1 Thinking التفكير

CHAPTER ONE · READ IN ORDER

الفصل هذا هو الأساس.
كل اللي بعده يبني عليه.
This chapter is the foundation.
Everything after builds on it.

How science reasons — and how not to fool yourself

Before any biology, data or code, we start with the habits of mind the rest of the curriculum depends on. This chapter covers how a claim earns belief, how to read a result honestly, and how one result leads to the next question.

ABOUT 55 MIN · 13 SECTIONS · 2 SESSIONS

IN YOUR PROGRAMME

SEP 3 — SESSION 1 · THU, 3 SEPT · 5–7 PM
What research is · the claim ladder
Before it: Crash Course Scientific Thinking, full series

SEP 5 — SESSION 2 · SAT, 5 SEPT · 5–7 PM
Reading a result · the four traps
Before it: Feynman, Cargo Cult Science

SEP 10 — ASSIGNMENT 1 · DUE
The Claim Audit
Set at Session 2 · Sat 5 Sep. Uses sections 1.3, 1.5 and 1.7.

SEP 8 — YOUR PROJECT · STAGE 0
Set up
Do during this chapter. Zotero, OSF and GitHub accounts, before Session 3.

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BY THE END YOU SHOULD BE ABLE TO

All seven of these. Tick where you are now, and again when you finish the chapter.

		NOT YET	A BIT	YES
1	Place any claim on the ladder from guess to hypothesis to finding, and that includes your own claims.	☐	☐	☐
2	List the rival explanations for a result, and say what test would eliminate each.	☐	☐	☐
3	Explain why a false positive costs a discovery science more than a false negative.	☐	☐	☐
4	Distinguish correlation from causation, and reproducibility from replication, in your own words.	☐	☐	☐
5	Read a result together with its caveats, and name the traps that catch people out when they interpret it.	☐	☐	☐
6	Turn a result into a hypothesis that is testable, specific, falsifiable and consequential.	☐	☐	☐
7	Choose language that matches the strength of your evidence, so you claim no more and no less than it supports.	☐	☐	☐

مو لازم أي معرفة الحين. هذا عشان يبان الفرق في الآخر.

You don't need to know any of this yet. It's so you can see how far you've come.

KEY TERMS · 19

ENGLISH	SAY IT	العربية	بالعربي البسيط	WHAT IT MEANS
Finding	FYN · ding	نتيجة مُثبَتة	ادعاء انختبر فعلًا، ومعاه حدود الدليل اللي وراه.	A claim that a specific test has evaluated, reported together with the limits of the evidence behind it.
Guess	GES	تخمين	كلام بلا دليل. ينفع بداية، وما ينفع خلاصة.	A claim with no evidence behind it. A legitimate starting point and an illegitimate conclusion.
Hypothesis	hy · POTH · uh · sis	فرضية	توقّع مكتوب بوضوح، بحيث نتيجة معيّنة تقدر تثبته أو تنفيه.	A claim stated precisely enough that a defined observation could support or contradict it.
False positive (Type I)	fawls · POZ · ih · tiv	النتيجة الموجبة الكاذبة (الخطأ من النوع الأول)	الحكم قال فيه أثر، وهو مو موجود. والناس بنوا عليه.	Concluding an effect is real when it is not. The costlier error in a discovery science, because others build on it.
False negative (Type II)	fawls · NEG · uh · tiv	النتيجة السالبة الكاذبة (الخطأ من النوع الثاني)	الأثر موجود، والحكم قال ما فيه. فيضيع.	Concluding an effect is absent when it is real. The effect stays buried.

ENGLISH	SAY IT	العربية	بالعربي البسيط	WHAT IT MEANS
Reproducibility	ree · pro · doo · suh · BIL · ih · tee	قابلية إعادة الإنتاج	نفس البيانات ونفس التحليل يطلّعوا نفس النتيجة. هذا أقل شي.	Obtaining the same result from the same data and the same analysis. A minimum standard; a reproducible result can still be wrong.
Strong inference	STRONG · IN · fer · uns	الاستدلال القوي	التفسيرات المنافسة تنكتب كلها، ولكل وحدة اختبار يطيّحها.	Enumerating the rival explanations for a result and designing the test that eliminates each.
Confounder	kon · FOWN · der	عامل مُربِك		A third variable that influences both of two things that appear associated, producing a real correlation with no causal link between them.
Signal	SIG · nul	الإشارة	الجزء من القياس اللي فيه المعلومة المطلوبة.	The part of a measurement that carries the information you are after.
Noise	NOYZ	التشويش	كل اللي في القياس غير الشي المقصود قياسه.	Everything in a measurement that is not the thing you are trying to measure.
Controls (positive / negative)	kon · TROHLZ	الشواهد (الموجبة والسالبة)	الموجب: الطريقة تلقى شي معروف؟ السالب: تسكت لما ما فيه شي؟	A positive control checks that a method recovers something known to be true. A negative control checks that it stays silent where there is nothing.
Replication	rep · lih · KAY · shun	إعادة الإثبات	نفس الخلاصة في بيانات جديدة ومستقلة. دليل أقوى بمراحل.	Reaching the same conclusion in new, independent data. Far stronger evidence than reproducibility.
Confirmation bias	kon · fer · MAY · shun · BY · us	انحياز التأكيد	الواحد يدوّر على اللي يأيد رأيه، ويطنّش اللي يخالفه.	The tendency to weigh evidence supporting a belief you already hold more heavily than evidence against it.
HARKing	HAR · king	صياغة الفرضية بعد معرفة النتائج	النمط انشاف بعد النتائج، وانعرض كأنه كان متوقّع من البداية.	Hypothesising After the Results are Known: presenting a pattern found after the fact as though it had been predicted in advance.
Calibration	kal · ih · BRAY · shun	المعايرة	الكلام والاقتناع يكونوا على قد الدليل، لا أكثر ولا أقل.	Matching the strength of your language, and your belief, to the strength of your evidence.
Abduction	ab · DUK · shun	الاستدلال الاستنباطي الأفضل تفسيراً	من ملاحظة وحدة للتفسير اللي يشرحها أحسن. يطلّع فرضيات، وما يحكم بينها.	Reasoning from an observation to the explanation that would best account for it. Generates candidate hypotheses; does not decide between them.
Pre-specification	pree · spes · ih · fih · KAY · shun	التحديد المسبق	القرارات المهمة تنكتب قبل ما تبان أي نتيجة.	Fixing the decisions that matter – thresholds, comparisons, what counts as a hit – before results are seen.
Provenance	PROV · uh · nuns	سلسلة الإسناد	كل رقم يرجع للبيانات والكود اللي طلّعوه.	The traceability of every reported number back to the data and code that produced it.

ENGLISH	SAY IT	العربية	بالعربي البسيط	WHAT IT MEANS
Falsifiability	fawl · sih · fy · uh · BIL · ih · tee	قابلية التكذيب	لازم يكون فيه نتيجة ممكنة تبيّن إن الادعاء غلط.	The property of a claim that some possible observation would show it to be false. A claim nothing could refute is not a scientific claim.

THE CASE · BEFORE YOU START

Would you sign this?

A lab contacts your group. They tested twelve genes against how patients responded to treatment, in one dataset. One gene came out significant. Their draft abstract is below, and they want you as co-authors by Friday.

> **Draft abstract, line 1:** Our analysis proves that gene X causes resistance to treatment.

Would you put your name on it? Say why, in a sentence or two.

How sure? ☐ Guessing ☐ Fairly sure ☐ Certain

You come back to this at the end of section 1.8.

الرأي الأول يتكتب الحين، حتى بدون تأكد. بنرجع له في الآخر.

Write what you think now, even if you're unsure. We come back to it at the end.

CHAPTER 1 · SECTION 1.0

Before you begin

~3 min · Before Session 1

This is the first chapter for a reason. Everything that follows (the biology, the datasets, the statistics, the code) is machinery, and machinery is only as good as the reasoning that decides what to point it at and what to believe once it has run. Someone who can run a pipeline but can't tell a lead from a finding isn't a researcher yet.

You don't need any biology, statistics or programming to read this chapter. What you do need is a willingness to be wrong in public, because that is what science actually asks of anyone who wants to take part.

Finding

نتيجة مُثبَتة

Where This Sits

CHAPTER	WHAT IT ANSWERS
▶ 1 · Thinking	How does science reason, and how do I avoid fooling myself?
2 · Practice	How do we behave? Integrity, collaboration and communication.
3 · The Science	What is cancer, and how does a cell power itself?
4 · Data & Tools	What data exists, and how do we handle it without breaking it?
5 · The Toolkit	The statistics and code, as a reference you return to.
6 · Build Your Own	Now go find a question of your own and run it.

How To Read The Coloured Boxes

These six appear throughout every chapter and always mean the same thing. Each one has a word and a symbol as well as a colour, so they still work in black and white.

BOX	USE IT TO
◆ KEY IDEA	The thing to remember if you remember nothing else from the section.
■ DEFINITION	A term given a precise meaning, used precisely from then on.
▲ CAUTION	A trap that catches careful people. Read these twice.
● WORKED EXAMPLE	The abstract idea worked through on a real case.
? CHECKPOINT	Stop and answer before you carry on. These come mid-chapter, not only at the end.
▸ GO DEEPER	Videos, articles and papers if you want more than the chapter gives.

CHAPTER 1 · SECTION 1.1

What research actually is

~6 min | Before Session 1

التخمين قبل القراية،
والغلط هنا عادي.

Guess before you read. Getting it wrong here is fine.

GUESS FIRST · BEFORE YOU READ

You believe an idea is right. Which does more to earn it credibility?

- ☐ (A) Collecting many more examples that fit it.
- ☐ (B) Surviving serious attempts to prove it wrong.
- ☐ (C) Getting someone senior to agree with it.

How sure? ☐ Guessing ☐ Fairly sure ☐ Certain

A wrong guess costs nothing. Guessing first, even wrong, helps you remember the answer.

Research is disciplined truth-seeking under uncertainty, and each part of that phrase is there for a reason.

It is **truth-seeking** because the aim is to find out how things really are, rather than to win an argument or confirm what we hoped. It happens **under uncertainty** because if the answer were already known we wouldn't be doing research. And it has to be **disciplined** because the human mind is very good at seeing what it wants to see, and most of what we call method exists to protect us from that.

Ordinary speech blurs three things together, so it helps to pin them down. A guess is a claim with no evidence behind it. A hypothesis is a claim stated precisely enough that evidence could count for or against it. A finding is a claim that evidence has actually tested and, for now, supported. The daily work of research is moving statements up that ladder, and the most common failure of honesty in science is pretending a statement sits higher than it does.

مثل إيش؟
Like what?

Guess
تخمين

Hypothesis
فرضية

Finding
نتيجة مُثبَتة

● THE RED QUESTION

What does it look like, in practice, to report a claim one rung higher than it earned? Give one example.

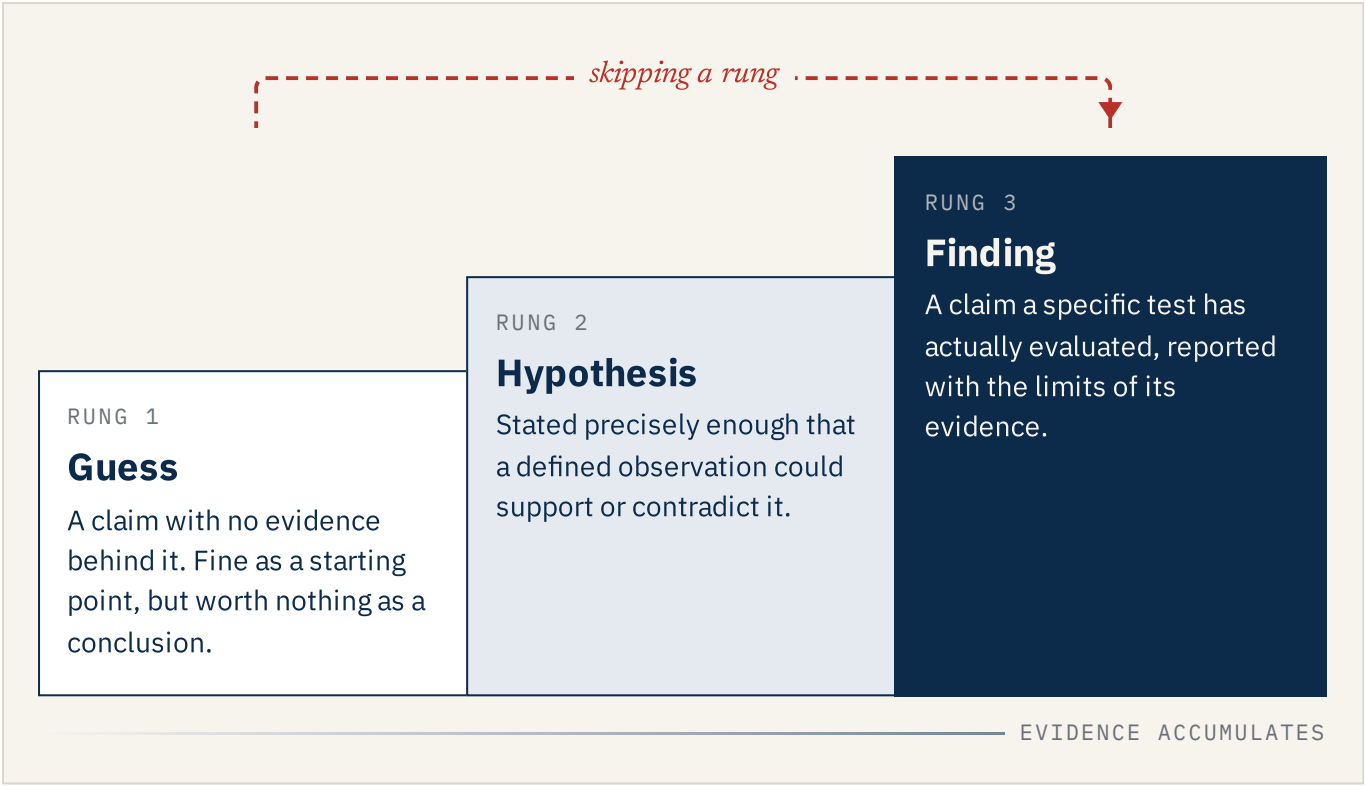


FIGURE 1.1 The ladder every claim climbs. Most of what goes wrong in science is a claim reported one rung higher than it earned.

الغلط الشائع: النطّ من التخمين للنتيجة على طول.

The usual mistake: jumping from guess straight to finding.

TRY THIS ON THE SITE

Put each claim on its rung

researchbasira.com/chapters.html#s1.1

التجربة باليد أحسن.

Try it with your own hands.

KEY IDEA

The lopsidedness of evidence

It is easy to find support for a belief you already hold. Go looking for confirmation and you will always find some. Science asks you to do the opposite and try hard to break your own idea.

A hypothesis earns credibility by surviving serious attempts to refute it, and piling up confirmations adds very little. So as a researcher you keep the possibility that you are wrong in view the whole time.

GUESS AGAIN · SAME QUESTION

You believe an idea is right. Which does more to earn it credibility?

☐ **A** ☐ **B** ☐ **C** | ☐ Guessing ☐ Fairly sure ☐ Certain

هل اتغيّر الرأي؟ وقد إيش التأكد الحين؟

See whether your answer changed, and how sure you are now.

CHAPTER 1 · SECTION 1.2

The method, as it is actually practised

~2 min | Before Session 1

The version of the scientific method taught in school, where you observe, hypothesise, test and conclude in a tidy line, is a cartoon. Real research goes round in loops and is messy. Hypotheses get revised halfway through, analyses fail and have to be redesigned, dead ends are common, and the clean story only gets put together afterwards.

Hypothesis

فرضية

That messiness is normal, but it doesn't excuse sloppiness. One part of the cartoon survives and we don't bend on it. A claim has to be exposed to a real chance of being wrong, and the competing explanations for a result have to be actively ruled out.

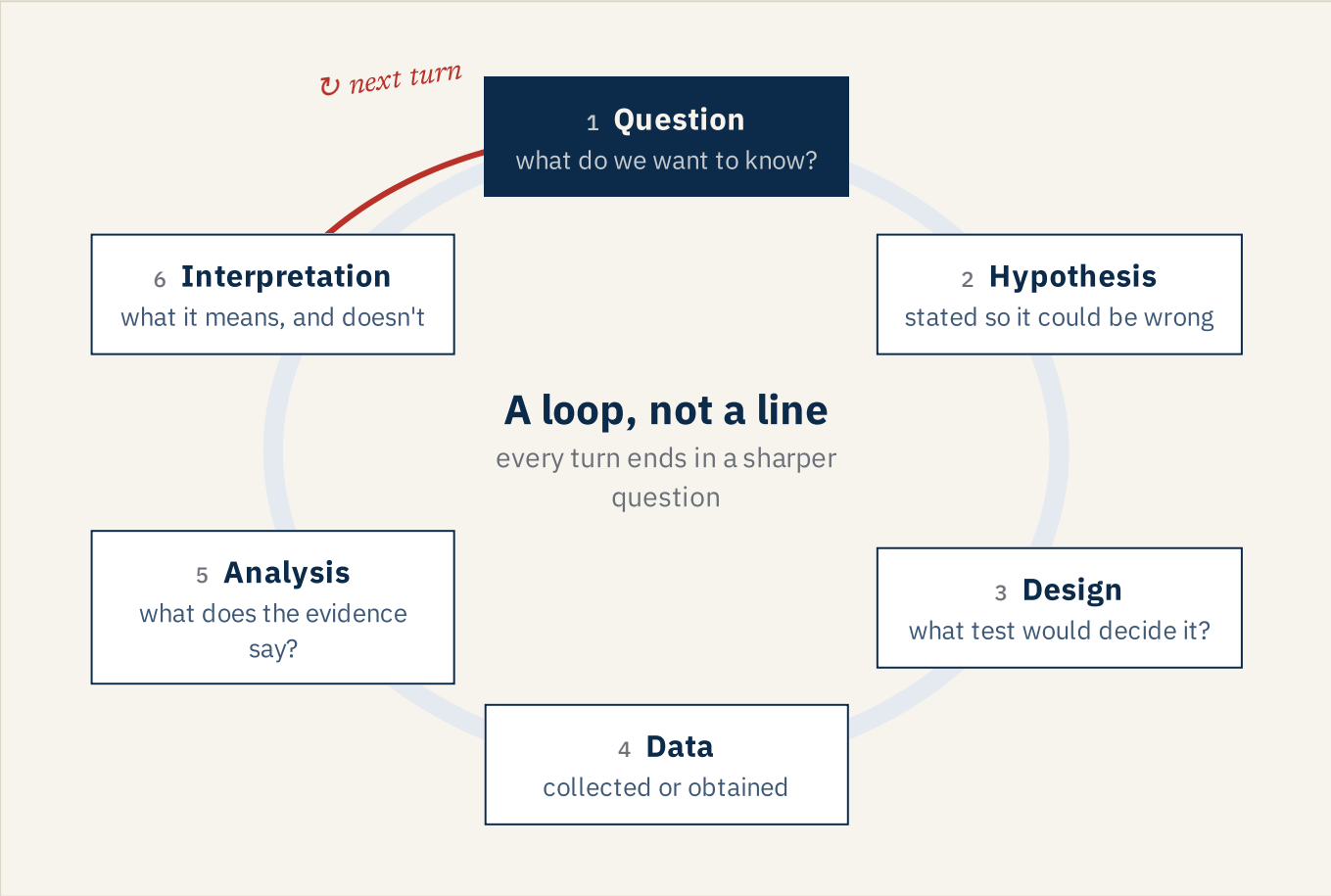


FIGURE 1.2 Research runs in a loop. The end of one turn is the start of the next, and that step is what section 1.9 is about.

آخر اللفّة هو أول اللفّة الجاية.

The end of one turn is the start of the next.

Research also never starts from nothing. Other people have worked on your question, or on the ones next to it. You need to know that earlier work for two reasons. It saves you time, since there is no point spending a year rediscovering what is already known. It is also a matter of integrity, because

building on someone's work means acknowledging it. Reading the literature critically rather than credulously is a core research skill, and you will practise it from your first week.

CHAPTER 1 · SECTION 1.3

Strong inference

~6 min | Before Session 1

التخمين قبل القراية،
والغلط هنا عادي.
Guess before you read. Getting it wrong here is fine.

GUESS FIRST · BEFORE YOU READ

Tumour samples show more of gene X than normal samples. How many different explanations could produce exactly this observation?

- ☐ A. One. The tumour cells make more of gene X.
- ☐ B. Two. A real change, or chance.
- ☐ C. Several. A real change, a different mix of cells, a batch effect, or chance.

How sure? ☐ Guessing ☐ Fairly sure ☐ Certain

A wrong guess costs nothing. Guessing first, even wrong, helps you remember the answer.

Strong inference
الاستدلال القوي

Ruling out alternatives matters so much to good work that it has its own name, strong inference. For any result you are excited about, you deliberately list the other explanations that could produce the same observation, and then you design the analysis that tells them apart.

طيب، ليش؟
Why, though?

A result is only as strong as the alternatives you have eliminated. If three plausible rival explanations are still standing, what you have is a hypothesis that happens to look like a finding.

THE RED QUESTION

Why is a result with rival explanations still standing only a hypothesis?

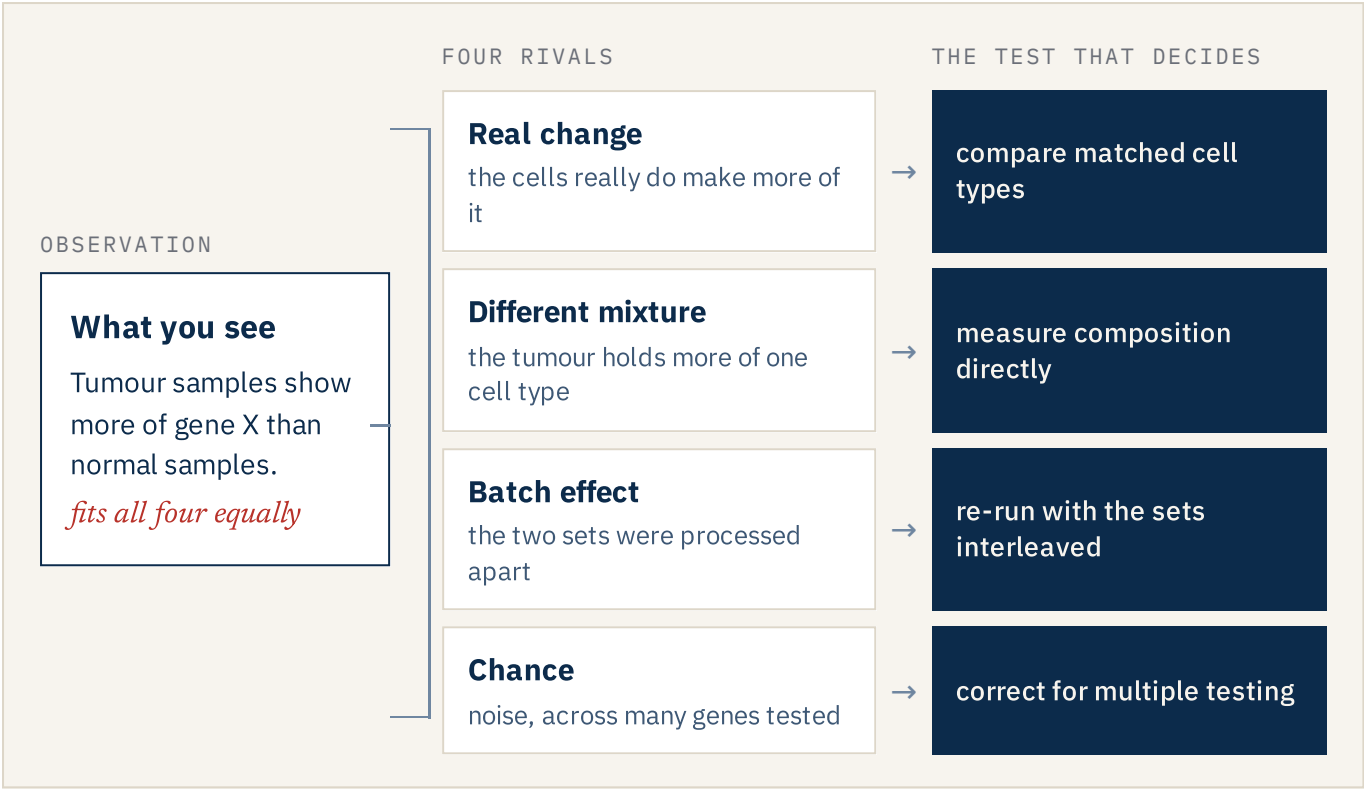


FIGURE 1.3 One observation, four rivals, four tests. The observation on its own doesn't favour any of them.

قبل تصديق أول تفسير، الثلاثة الباقيين لازم ينكتبوا.

Before you believe the first explanation, write down the other three.

KEY IDEA

Strong inference, as a habit you can actually practise

For every result, write down the rival explanations (confounders, artefacts, coincidences) and ask what test would separate the real explanation from each one. Then run that test.

A result with one obvious explanation and no proposed test goes nowhere. A result with three competing explanations and a plan to tell them apart gives you a research programme.

Confounder

عامل مُرِبك

? CHECKPOINT 1 · FROM MEMORY

Answer without looking back. A guess counts.

1 State the difference between a guess, a hypothesis and a finding, and give an example of each from anything you know about. section 1.1

من الذاكرة، بدون الرجوع لفوق.

From memory. Don't look back.

2 Why is trying to break your own idea more informative than trying to support it? section 1.1

3 A friend says “the scientific method is: observe, hypothesise, test, conclude.” What is right and what is misleading about that? section 1.2

4 You observe that students who attend more lectures get better grades. List three rival explanations, and one test for each. section 1.3

GUESS AGAIN · SAME QUESTION

Tumour samples show more of gene X than normal samples. How many different explanations could produce exactly this observation?

☐ A ☐ B ☐ C | ☐ Guessing ☐ Fairly sure ☐ Certain

هل اتغيّر الرأي؟ وقد إيش التأكد الحين؟

See whether your answer changed, and how sure you are now.

CHAPTER 1 · SECTION 1.4

Signal, noise, and two ways to be wrong

~6 min | Before Session 1

GUESS FIRST · BEFORE YOU READ

A study reports “we did not detect an effect.” What does that tell you?

- ☐ (A) The effect is not there.
- ☐ (B) Either the effect is not there, or the test could not have seen it.
- ☐ (C) The effect is there, but small.

How sure? ☐ Guessing ☐ Fairly sure ☐ Certain

A wrong guess costs nothing. Guessing first, even wrong, helps you remember the answer.

التخمين قبل القراية، والغلط هنا عادي.

Guess before you read. Getting it wrong here is fine.

Every measurement contains signal, which is the thing you want to know, and noise, which is everything else. The hard part of research is that you never see the two separately. You only see their sum, and you have to reason about which is which. Statistics is mostly the discipline of not fooling yourself about that. It puts a number on how much of an apparent pattern could be noise, so you don't mistake a coincidence for a discovery.

Signal
الإشارة

Noise
التشويش

Because you are reasoning under uncertainty, you can be wrong in two different ways, and they trade off against each other.

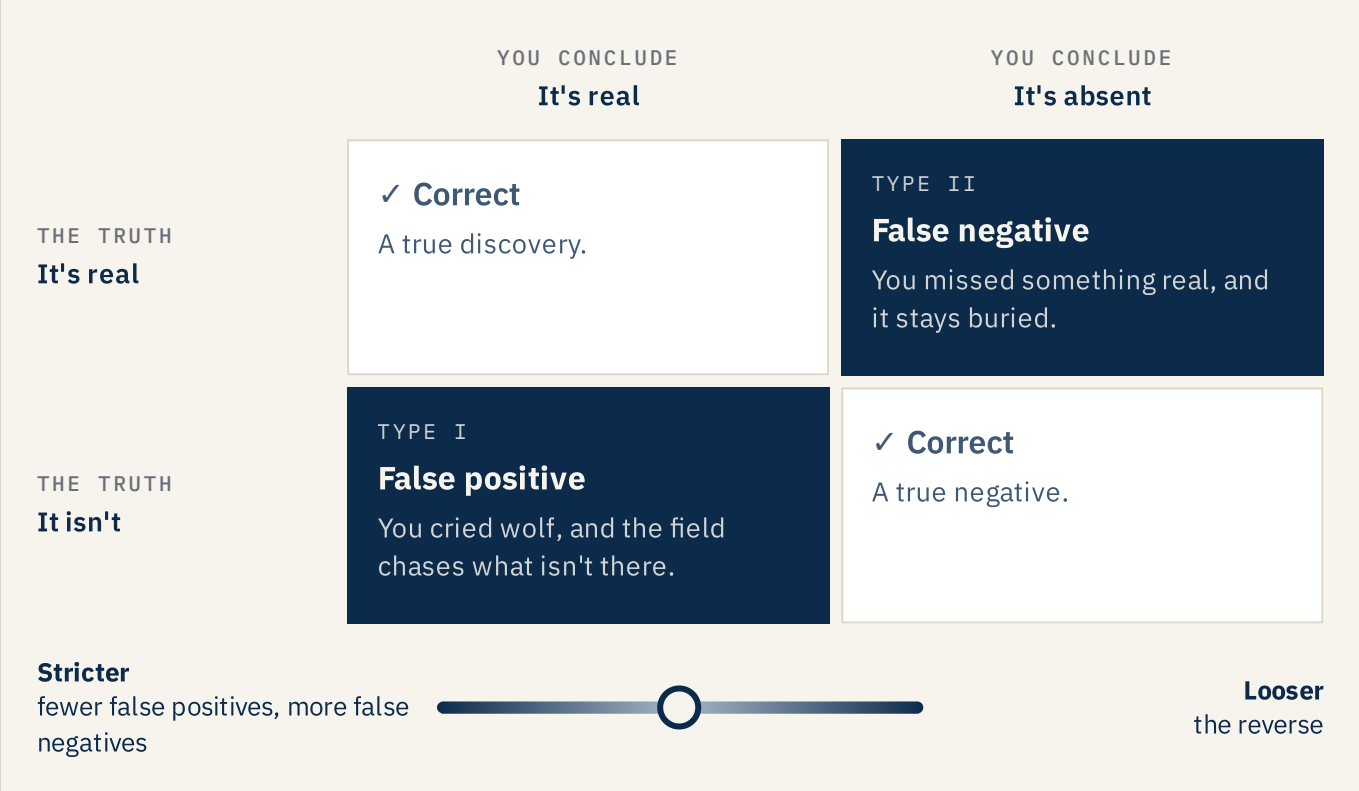


FIGURE 1.4 The two errors. Tightening against one loosens you against the other, and no setting avoids both.

ما في إعداد يمنع الغلطتين. لازم نختار أي وحدة نتحمّل.

No setting avoids both. Choose which one you can live with.

TRY THIS ON THE SITE
Slide the bar for calling something real
researchbasira.com/chapters.html#s1.4

الشريط يتحرّك، والنتيجة تتغيّر.

Move the slider and watch what happens.

A false positive sends a whole field chasing something that isn't there, wasting years and money that were not yours to waste. A false negative quietly buries something real. Both are costly, but in a discovery science the false positive does more damage because it spreads. Other people build on it, cite it and design new work around it. Much of the machinery you will meet later

False positive (Type I)
النتيجة الموجبة الكاذبة (الخطأ من النوع الأول)

False negative (Type II)
النتيجة السالبة الكاذبة (الخطأ من النوع الثاني)

(multiple-testing correction, effect-size thresholds, positive and negative controls) is there to hold the false-positive rate down without leaving us unable to see anything at all.

Controls (positive / negative)
الشواهد (الموجبة والسالبة)

> CAUTION
> **Absence of evidence is not evidence of absence**
>
> "We did not detect an effect" can mean two very different things. Either the effect is not there, or our test could not have seen it even if it were. These must never be reported as the same thing.
>
> In Al Basira we keep them apart in the words we use. "Tested and null" is a result. "Not testable" is a gap, and we report it as a gap.

GUESS AGAIN · SAME QUESTION

A study reports "we did not detect an effect." What does that tell you?

☐ A ☐ B ☐ C | ☐ Guessing ☐ Fairly sure ☐ Certain

هل اتغيّر الرأي؟ وقد إيش التأكد الحين؟

See whether your answer changed, and how sure you are now.

CHAPTER 1 · SECTION 1.5

Two confusions that ruin conclusions

~3 min | Before Session 1

1.5.1 Correlation is not causation

Two things moving together does not mean one causes the other. A third variable, called a confounder, may be driving both. This is the most common error people make when reasoning from data, and it's common because the causal story is so much more satisfying than the boring one.

Confounder
عامل مُربِك

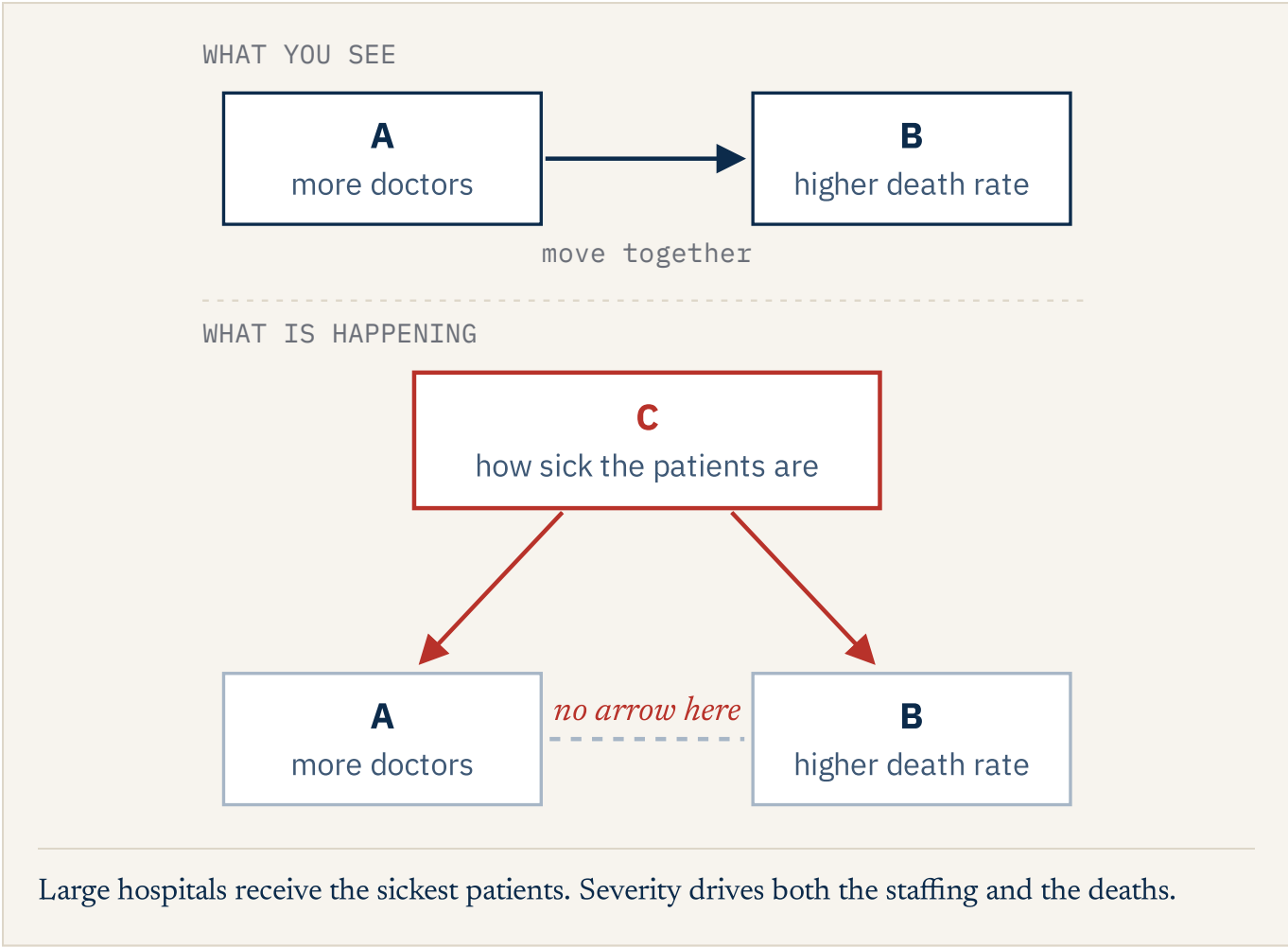


FIGURE 1.5 A confounder produces a real, reproducible association with no causal link between the two things you measured.

لما A و B يمشوا سوا، الدور على C.

Whenever A and B move together, look for C.

TRY THIS ON THE SITE

Find the hidden third thing

researchbasira.com/chapters.html#s1.5

التجربة باليد أحسن.

Try it with your own hands.

WORKED EXAMPLE · STEP BY STEP

Why the association is real and the conclusion is wrong

Hospitals with more doctors per patient record higher death rates. Taken at face value, that suggests doctors are dangerous.

> STOP AND THINK
>
> Before you read on: is the association real? If it is, what else could produce it?

The association is real and will replicate in fresh data. But the large, well-staffed hospitals are the ones that receive the sickest and most complex patients, while stable patients are treated in smaller places. Severity drives both the staffing and the deaths.

التفكير قبل الخطوة الجاية.

Think before you read the next step.

STOP AND THINK

So what does the association tell you, and what does it not?

The data are fine here. The mistake is reading a cause into them, because an association narrows down what can be true without telling you which of the remaining stories is the right one.

1.5.2 Reproducibility is not replication

People use these two words interchangeably in conversation. In a claim, you must never do that.

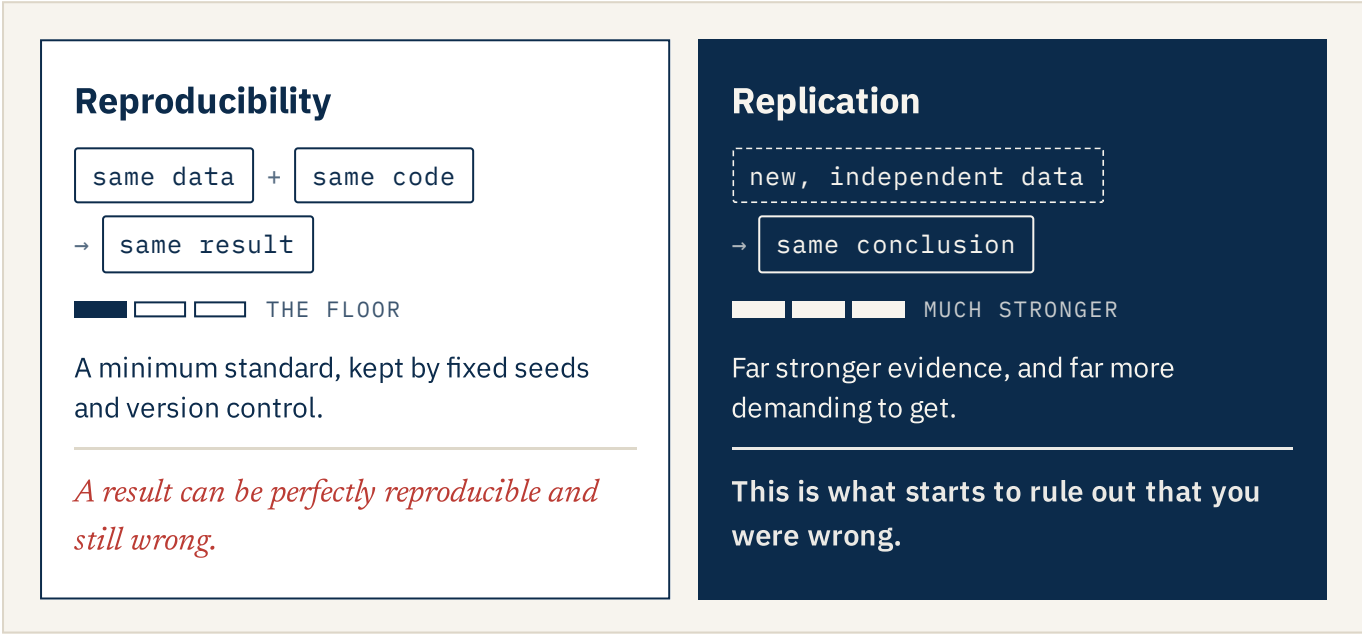


FIGURE 1.6 Reproducibility is the minimum. It shows your analysis is honest, and says nothing about whether your conclusion is right.

تكرار التحليل بنفس النتيجة أقل شي مطلوب، مو دليل كافي.

Rerunning and getting the same result is only the minimum.

? CHECKPOINT 2 · FROM MEMORY

Answer without looking back. A guess counts.

من الذاكرة، بدون الرجوع لفوق.

From memory. Don't look back.

1 In your own words: why is a false positive more damaging than a false negative in a discovery science? section 1.4

2 A study reports “no significant difference between groups.” What is the one question you must ask before believing the effect is absent?
section 1.4

3 Give an example of a correlation from everyday life that you are confident is not causal, and name the confounder. section 1.5.1

4 A colleague says “I reran your code and got the same numbers, so the finding is solid.” What have they established, and what have they not?
section 1.5.2

CHAPTER 1 · SECTION 1.6

Reading a result

~5 min | Before Session 2

GUESS FIRST · BEFORE YOU READ

An analysis hands you a ranked list of hits. What do you have?

- ☐ (A) A discovery.
- ☐ (B) A lead: a hypothesis with some evidence behind it, pointing where to look next.
- ☐ (C) Nothing, until it is published.

How sure? ☐ Guessing ☐ Fairly sure ☐ Certain

A wrong guess costs nothing. Guessing first, even wrong, helps you remember the answer.

التخمين قبل القراية،
والغلط هنا عادي.

Guess before you read. Getting it wrong here is fine.

This is the biggest change of view we ask for in this chapter, and it is also the simplest. When an analysis hands you a number, a ranked list or a hit, it is tempting to feel the work is finished and the discovery made. It isn't. A result is a lead, meaning a hypothesis with some evidence behind it that points at where to look next.

Hypothesis
فرضية

We don't say that out of modesty. A well-motivated lead is valuable, because it gives you a specific reason to look at one thing rather than a thousand others. But its value is as a direction, and treating it as settled skips every step that would actually establish it.

مثل إيش؟
Like what?

● THE RED QUESTION

Which steps? Name two that would actually establish a result.

Every result comes with caveats, and interpreting it responsibly means keeping those caveats attached to it. A result measured in one population may not hold in another. A borderline call may flip under a slightly different choice of method. An under-powered comparison needs replication before it counts as more than a lead. If you interpret a result without its caveats, you are really interpreting a different, more certain result than the one you have.

Replication

إعادة الإثبات

GUESS AGAIN · SAME QUESTION

An analysis hands you a ranked list of hits. What do you have?

☐ **A** ☐ **B** ☐ **C** | ☐ Guessing ☐ Fairly sure ☐ Certain

هل اتغيّر الرأي؟ وقد إيش التأكد الحين؟

See whether your answer changed, and how sure you are now.

CHAPTER 1 · SECTION 1.7

The traps

~6 min | Before Session 2

GUESS FIRST · BEFORE YOU READ

When is your judgement about your own result least reliable?

- ☐ (A) When the result is null.
- ☐ (B) When the result confirms what you hoped.
- ☐ (C) When the sample is small.

How sure? ☐ Guessing ☐ Fairly sure ☐ Certain

A wrong guess costs nothing. Guessing first, even wrong, helps you remember the answer.

التخمين قبل القراية، والغلط هنا عادي.

Guess before you read. Getting it wrong here is fine.

Your judgement is least reliable at the moment a result confirms what you hoped, or looks as if it might be important, because now you want it to be true. Four traps do most of the damage.

- **Confirmation bias.** Giving more weight to evidence for the exciting result than to evidence against it. You don't decide to do this. It is a drift you fail to notice.
- **Narrative seduction.** A clean, compelling story feels true. The world has no reason to be tidy, though, and a good story is not evidence. Be suspicious of results that are unusually satisfying.
- **HARKing.** Hypothesising After the Results are Known. You build a hypothesis around a pattern you have already seen, then present it as though you had predicted it. A prediction that survives testing is strong evidence and a story fitted to the data afterwards is not, so HARKing passes off the second as the first.
- **Patterns in noise.** Test enough things and striking patterns turn up by chance alone. Your eyes don't correct for this. If anything they are built to do the opposite and find patterns everywhere.

Confirmation bias
انحياز التأكيد

HARKing
صياغة الفرضية بعد معرفة النتائج

Hypothesis
فرضية

Noise
التشويش

CAUTION

The exciting result is the dangerous one

Nobody can reliably catch themselves in the moment, so the defence is to lean on process. Fix thresholds before you look, run controls before you make claims, and label exploratory work as exploratory.

A result you are thrilled by deserves more scrutiny than one you don't care about. If you notice yourself arguing for a result instead of testing it, stop.

GUESS AGAIN · SAME QUESTION

When is your judgement about your own result least reliable?

☐ A ☐ B ☐ C | ☐ Guessing ☐ Fairly sure ☐ Certain

هل اتغيّر الرأي؟ وقد إيش التأكد الحين؟

See whether your answer changed, and how sure you are now.

CHAPTER 1 · SECTION 1.8

Saying exactly what the evidence supports

~6 min | Before Session 2

التخمين قبل القراية، والغلط هنا عادي.

Guess before you read. Getting it wrong here is fine.

GUESS FIRST · BEFORE YOU READ

You found a striking pattern after looking through the data. Which is the honest way to report it?

- ☐ (A) "Our analysis shows X."
- ☐ (B) "X is consistent with our data. This is exploratory and needs testing in new data."
- ☐ (C) Leave it out; it was not planned.

How sure? ☐ Guessing ☐ Fairly sure ☐ Certain

A wrong guess costs nothing. Guessing first, even wrong, helps you remember the answer.

طيب، ليش؟

Why, though?

What matters most when you communicate science is calibration, which means claiming no more and no less than the evidence warrants. Over-claiming is the familiar mistake, and it leads people to act on a certainty that isn't there. But false modesty is also a failure, because burying a solid result in hedging wastes it. You want your language to track your confidence so closely that a careful reader can tell from the words alone how much to trust each sentence.

Calibration

المعايرة

● THE RED QUESTION

Why is under-claiming a failure too, and not just the safe choice?

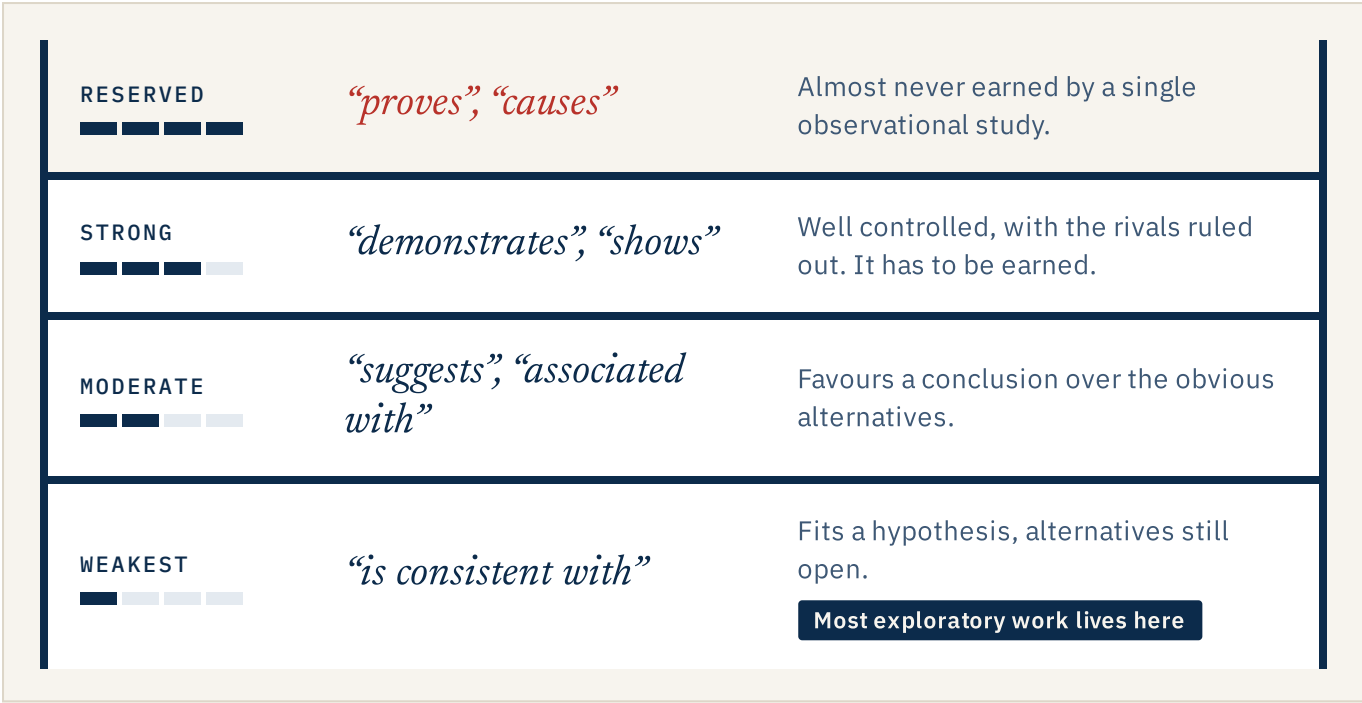


FIGURE 1.7 Climb this ladder deliberately. Most exploratory work belongs on the bottom rung, and there's nothing wrong with saying so.

الكلمة على قد الدليل، مو أعلى.

Pick the word your evidence earns, not one higher.

Two habits follow from this. First, always make clear in your wording whether a result is exploratory or confirmatory. A result you went looking for after seeing the data is a hypothesis for the next study, not a confirmed finding, and it must be described that way. Second, state limitations plainly instead of hoping nobody notices. When you name the weaknesses of your own work, readers trust the rest of what you say more.

Hypothesis
فرضية

Finding
نتيجة مُثبَتة

? CHECKPOINT 3 · FROM MEMORY

Answer without looking back. A guess counts.

من الذاكرة، بدون الرجوع لفوق.

From memory. Don't look back.

1 **Why does a result you are excited about need more scrutiny than one you are indifferent to?** `section 1.7`

2 **Explain HARKing to someone who has never heard the term, and say why it inflates apparent evidence.** `section 1.7`

3 Rewrite this sentence so it is honestly calibrated: “Our analysis proves that gene X causes resistance to treatment.” section 1.8

4 You find a striking pattern after trying twelve different comparisons. What must you say about it when you report it? section 1.7–1.8

GUESS AGAIN · SAME QUESTION

You found a striking pattern after looking through the data. Which is the honest way to report it?

☐ A ☐ B ☐ C | ☐ Guessing ☐ Fairly sure ☐ Certain

هل اتغيّر الرأي؟ وقد إيش التأكد الحين؟

See whether your answer changed, and how sure you are now.

BACK TO THE CASE

Draft abstract, line 1: Our analysis proves that gene X causes resistance to treatment.

What would you say to the lab now?

الجواب الأول جنب جواب الحين.

Put your first answer next to the one you'd give now.

CHAPTER 1 · SECTION 1.9

From result to hypothesis

~2 min | Before Session 2

A result becomes science when it leads to the next question. This is the creative part of research and the hardest to teach, because there is no procedure to follow. You are proposing an explanation.

The move has a shape you can learn to recognise. A result gives you a fact that needs explaining. A hypothesis is a proposed explanation specific enough to be tested. The reasoning that takes you from one to the other is called abduction, or inference to the best explanation. Deduction moves from premises to a guaranteed conclusion, and induction generalises from many observations. Abduction runs the other way, from a single striking observation to the hypothesis that would best account for it.

Hypothesis

فرضية

Abduction

الاستدلال الاستنباطي الأفضل تفسيراً

DEFINITION

Abduction

Reasoning from an observation to the explanation that would best account for it. Abduction gives you candidate explanations but doesn't tell you which is right. That is what the next experiment is for.

التفكير قبل الخطوة الجاية.

Think before you read the next step.

WORKED EXAMPLE · STEP BY STEP

The generative move, performed slowly

Observation: patients taking a particular drug live longer than patients who are not.

> STOP AND THINK
>
> Abduce: before you read on, list what could account for this.

Abduce. What could account for this? (1) The drug works. (2) Healthier patients are the ones well enough to be prescribed it. (3) The patients who tolerate it are those whose disease is less aggressive to begin with. (4) The two groups were followed for different lengths of time.

> STOP AND THINK
>
> For each rival, what observation would tell it apart from the others?

Distinguish. For each pair of rivals, what observation would tell them apart? Comparing patients matched on baseline health deals with (2). Checking who stopped treatment early deals with (3). Lining up the follow-up windows deals with (4). Whatever survives all three is a real candidate for (1).

> STOP AND THINK
>
> Which idea from earlier in the chapter is this?

This is strong inference from section 1.3, run forward. The same method you use to evaluate a result also gives you the research plan.

Strong inference

الاستدلال القوي

CHAPTER 1 · SECTION 1.10

What makes a hypothesis good

~3 min | Before Session 2

Not every question a result suggests makes a good hypothesis. The generative move is only useful if what comes out of it can actually be tested and would actually matter.

Hypothesis

فرضية

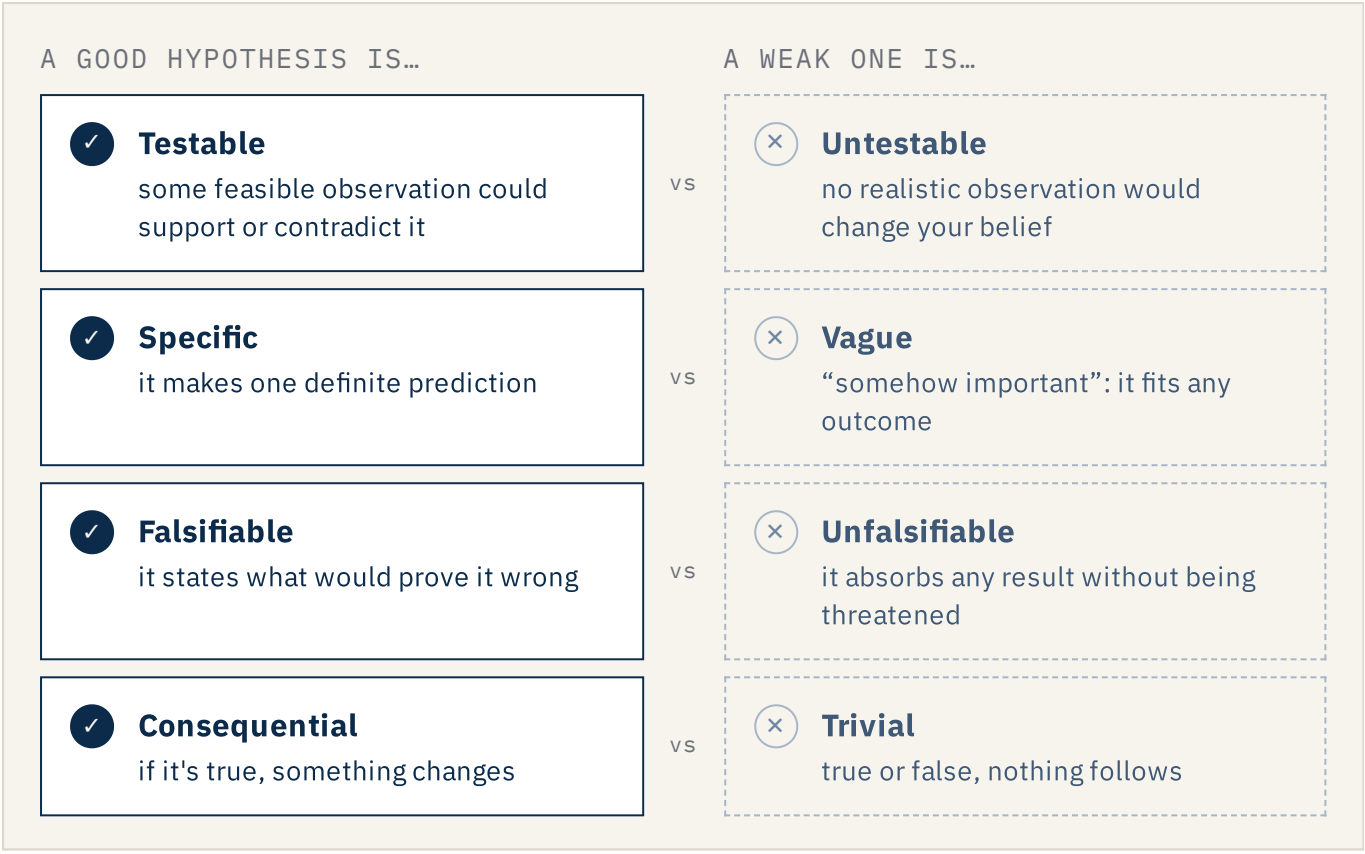


FIGURE 1.8 Four tests. Apply them to your own ideas before you put months into one.

قبل ما نصرف شهور على أي فكرة، لازم تعدّي الأربعة هذي.

Run your own idea through all four before you spend months on it.

These are the same standards we hold any scientific claim to, applied at the moment the claim is first made. A hypothesis that cannot fail is not a scientific hypothesis, however plausible it sounds. A hypothesis whose answer would change nothing isn't worth the cost of testing. Hold your own new ideas to this standard, and do it early, before you are attached to them.

GOES TO YOUR PROJECT · STAGE 1 · ASK

Your first hypothesis

Write one hypothesis about something you would like to answer one day, then hold it to the four tests in Figure 1.8.

My hypothesis, in one sentence

هذي أول فرضية. مو لازم تكون كاملة.

Your first hypothesis. It doesn't have to be perfect.

Testable: what observation could support or contradict it?

Specific: what one definite prediction does it make?

Falsifiable: what result would prove it wrong?

Consequential: if it is true, what changes?

On the site, “Send to my project” puts this on your Project page.

CHAPTER 1 · SECTION 1.11

How a research project is built

~6 min | Before Session 2

GUESS FIRST · BEFORE YOU READ

When should the thresholds for an analysis be chosen?

- ☐ (A) After seeing which results look interesting.
- ☐ (B) Before any result is seen.
- ☐ (C) Whenever a p-value lands close to the line.

How sure? ☐ Guessing ☐ Fairly sure ☐ Certain

A wrong guess costs nothing. Guessing first, even wrong, helps you remember the answer.

التخمين قبل القراية،
والغلط هنا عادي.

Guess before you read. Getting it wrong here is fine.

A project has a shape, and knowing it helps you see where each day's work fits. It runs from a question, to a design that could answer it, to data, to analysis, to interpretation, and then to communication. Weakness at any stage undermines everything after it. A brilliant analysis of the wrong data answers the wrong question, and a flawless result described dishonestly does harm.

طيب، ليش؟

Why, though?

THE RED QUESTION

Why can a brilliant later stage not rescue a weak earlier one?

Three practices hold the whole structure together. You will meet all three again, in Chapter 2 as matters of integrity and in Chapter 5 as lines of code.

- **Pre-specification.** Decide the choices that matter (thresholds, which comparison, what counts as a hit) before you see the results. Choosing afterwards, and tuning until the answer looks good, is one of the easiest ways to fool yourself.
- **Controls.** A positive control asks whether your method recovers something already known to be true. If it can't, you don't trust it on the unknown. A negative control asks whether it correctly stays silent where there is nothing to find. Both run before any new claim is believed.
- **Provenance.** Every number in a final figure or table traces back to the data and code that produced it, and nothing is typed by hand. That means a colleague or a reviewer can check the work, and so can you in six months' time when you have forgotten all of it.

Pre-specification
التحديد المسبق

Controls (positive / negative)
الشواهد (الموجبة والسالبة)

Provenance
سلسلة الإسناد

KEY IDEA

The Al Basira standard, stated plainly

Every number is computed; nothing is typed by hand. Thresholds are fixed before results are seen. Controls run before claims. What could not be tested is reported as untested, not as negative.

If you hold to these four, most of what comes later in the curriculum goes smoothly.

GUESS AGAIN · SAME QUESTION

When should the thresholds for an analysis be chosen?

☐ A ☐ B ☐ C | ☐ Guessing ☐ Fairly sure ☐ Certain

هل اتغيّر الرأي؟ وقد إيش التأكد الحين؟

See whether your answer changed, and how sure you are now.

CHAPTER 1 · SECTION 1.12

End-of-chapter questions

~2 min | Before Session 2

The checkpoints tested recall. These ask you to reason, and several of them have no single right answer. Write a paragraph for each and bring it to the session.

1 Take a claim you have heard recently, in a lecture, in the news or from a friend. Place it on the ladder in Figure 1.1 and justify the placement.

2 Choose any published finding you find interesting. List every rival explanation you can think of, then say which the authors addressed and which they did not.

3 Describe a time you believed something because you wanted it to be true. What would have caught it?

مافي جواب واحد صح.
المهم شرح ليش.

There's no single right answer. What matters is the why.

Finding
نتيجة مُثبَتة

Reproducibility
قابلية إعادة الإنتاج

Hypothesis
فرضية

Falsifiability
قابلية التكذيب

4 "A reproducible result can still be wrong." Explain this, with an example, to someone who thinks the two words mean the same thing.

5 Write one good hypothesis and one weak hypothesis about the same topic. Explain what makes the difference, using all four criteria in Figure 1.8.

6 You run twelve comparisons and one is significant. Write the sentence you would use to report it honestly, and the sentence a careless researcher would write.

7 Pick a question you would like to answer one day. Run it through the funnel: is it testable, specific, falsifiable, consequential? Sharpen it until it passes all four.

CAN YOU DO THIS NOW?

The same seven as the start. Tick again and compare.

		NOT YET	A BIT	YES
1	Place any claim on the ladder from guess to hypothesis to finding, and that includes your own claims.	☐	☐	☐
2	List the rival explanations for a result, and say what test would eliminate each.	☐	☐	☐
3	Explain why a false positive costs a discovery science more than a false negative.	☐	☐	☐
4	Distinguish correlation from causation, and reproducibility from replication, in your own words.	☐	☐	☐
5	Read a result together with its caveats, and name the traps that catch people out when they interpret it.	☐	☐	☐
6	Turn a result into a hypothesis that is testable, specific, falsifiable and consequential.	☐	☐	☐
7	Choose language that matches the strength of your evidence, so you claim no more and no less than it supports.	☐	☐	☐

الفرق من أول الفصل للحين.

See how much has changed since the start of the chapter.

CHAPTER 1 · SECTION 1.13

Go deeper

~2 min | Optional

Every link below is live and goes straight to the resource. [Watch] is video, [Read] is written, [Source] is the original paper or essay.

Crash Course · Scientific Thinking

A seven-episode series that fits this chapter closely. If you watch nothing else, watch this.

VIDEO

The full series, all 7 episodes

Start here. Roughly ninety minutes end to end.

https://www.youtube.com/playlist?list=PL8dPuuaLjXtN6j3y85b7xbJDC8LTgdRJG

VIDEO

#2 Statistical Thinking in Science

Signal, noise, and what a statistic can and cannot tell you. **Goes with section 1.4.**

https://www.youtube.com/watch?v=Lw4oMXTEAkw

VIDEO

#4 Peer Review and the Quest for Truth

How claims get checked before anyone believes them. Sets up Chapter 2.

https://www.youtube.com/watch?v=qsgjKBvxnYA

VIDEO

#5 How Scientists Build Consensus

Why one result is never the answer. **Goes with section 1.6.**

https://www.youtube.com/watch?v=9wSAeV0xX0M

VIDEO

#6 Evaluating Sources & Fact Checking

About the traps in section 1.7. **Goes with section 1.7.**

https://www.youtube.com/watch?v=Fm0MpfKIs5w

VIDEO

#7 When Science Clashes with the Public

Uses the smoking and cancer story. **Goes with section 1.5 and 1.8.**

https://www.youtube.com/watch?v=NaMcw8_10Yg

READ

Crash Course · series homepage

Episode list and teaching notes.

https://thecrashcourse.com/topic/scientificthinking/

Working Through It Yourself

READ

Khan Academy: Statistics & Probability

Free, worked and self-paced. The study-design and confounding sections pair with section 1.5. **Goes with section 1.5.**

https://www.khanacademy.org/math/statistics-probability

READ

Calling Bullshit, by Bergstrom & West, University of Washington

A full university course on spotting bad reasoning with data, free online. The causality lectures are the ones for section 1.5. **Goes with section 1.5.**

https://www.callingbullshit.org/

مو إجباري. بس الحلقة الثانية تستاهل.

Not required. Episode 2 is worth it.

The Originals

ORIGINAL PAPER

Platt (1964), Strong Inference

Where section 1.3 comes from. Short enough to read in one sitting. **Goes with section 1.3.**

https://doi.org/10.1126/science.146.3642.347

ORIGINAL PAPER

Ioannidis (2005), Why Most Published Research Findings Are False

The argument is more careful than the title suggests.

https://doi.org/10.1371/journal.pmed.0020124

ORIGINAL PAPER

Simmons, Nelson & Simonsohn (2011), False-Positive Psychology

With enough analytic freedom, almost any hypothesis can be made to look significant.

https://doi.org/10.1177/0956797611417632

ORIGINAL PAPER

Feynman (1974), Cargo Cult Science

Caltech commencement address, widely reprinted. On leaning over backwards to report what might prove you wrong.

https://calteches.library.caltech.edu/51/2/CargoCult.htm

AL BASIRA

Gomosani, A., & Marghalani, H. (2026). *Basira Curriculum*. Zenodo. https://doi.org/10.5281/zenodo.21791751

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