

THINK LIKE A ROCKET SCIENTIST

*Simple Strategies You Can Use to Make
Giant Leaps in Work and Life*

The Workbook

by
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rocketsciencebook.com



GETTING STARTED

Welcome to the Think Like a Rocket Scientist workbook. The purpose of these complementary materials is to guide you through each of the nine essential principles as you convert your own small steps into giant leaps.



WHAT DO YOU NEED?

- These materials
- Your copy of Think Like a Rocket Scientist

WHAT'S INCLUDED

- Summaries, challenges, and exercises relating to each chapter. You can complete these at the end of each chapter as you read the book, or wait until you complete the book before beginning the exercises.

GROUND RULES

- It's fine to use these materials for yourself or with your colleagues at work
- It's not fine to use the materials for commercial purposes (e.g. as part of a coaching program). If you would like to use the materials for commercial purposes, please contact me at author@ozanvarol.com.

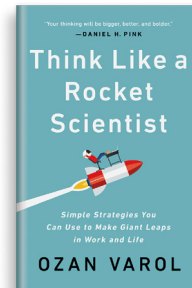
HIRING ME

If you're interested in inviting me to talk to your group about these principles, please contact me at author@ozanvarol.com. I travel the globe frequently to give keynotes to organizations across numerous industries.

CHAPTER 1

Flying in the Face of Uncertainty

Key Points



THE CERTAINTY FETISH

In the modern world we are focussed on controlling our surroundings as much as possible: we look for certainty in uncertain places, order in chaos, the right answer in ambiguity and conviction in complexity. But it's only when we take off the training wheels and move away from the safe and the familiar that we find the unexpected.

THE GREAT UNKNOWN

We are conditioned to believe that there is one right answer to each question and that the path to that answer is clear. Here's the problem: Answers are no longer a scarce commodity, and knowledge has never been cheaper. By the time we've figured out the facts—by the time Google, Alexa, or Siri can spit out the answer—the world has moved on. Answers simply serve as a launch pad to discovery. They're the beginning, not the end. Our ability to make the most out of uncertainty is what creates the most potential value. We should be fuelled not by a desire for a quick catharsis but by intrigue. Where certainty ends, progress begins.

UNKNOWN KNOWNS

When we assume we have a lock on the truth, certainty blinds us to our own paralysis. The illusion of knowledge, rather than ignorance, is the obstacle to discovery. When we admit we don't know, our egos deflate and our minds open. It's better to be uncomfortably uncertain than comfortably wrong.

CONNOISSEURS OF UNCERTAINTY

All progress—in rocket science, in movies, in enterprise—takes place in dark rooms. Although it's easy to be afraid of the dark, life offers more of itself when we treat the uncertain darkness as a friend not a foe. Remember that most dark rooms come with two-way doors and you can usually walk out if you don't like what you find.

A THEORY OF EVERYTHING

There isn't a definitive answer to every question asked. Reality is far more nuanced and the theories and paths are multiple: there's more than one right way.

THAT'S FUNNY

As children, we're taught to put things into two buckets: good and bad. This oversimplification helps us make sense of the world as children. But as we mature, we fail to outgrow this misleading theory. We go around trying to fit square pegs into round holes and pigeonholing things—and people—into neat categories to create the satisfying, but misleading, illusion of having restored order to a disorderly world. But it's only when we pay attention to the subtle clues—there's something off with the data, the explanation seems cursory or superficial, the observation doesn't quite fit the theory—can the old paradigm give way to the new.

GETTING PLUTOED

We tend to respond to uncertainty—no matter how benign—as alarming. The key to growing comfortable with uncertainty is figuring out what's truly alarming and what's not.

A HIGH-STAKES GAME OF PEEKABOO

If we figure out what we know and what we don't know, we contain uncertainty and reduce the fear associated with it. Writing down your concerns and uncertainties—what you know and what you don't know—undresses them. Once you

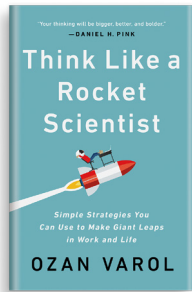
lift up the curtain and turn the unknown unknowns into known unknowns, you defang them. After you see your fears with their masks off, you'll find that the feeling of uncertainty is often far worse than what you fear. You'll also realize that in all likelihood, the things that matter most to you will still be there, no matter what happens.

WHY REDUNDANCIES AREN'T REDUNDANT

Redundancies refer to backup systems created to avoid a single point of failure that can compromise an entire mission or project. For redundancies to work, they must function independently so the malfunction of one component doesn't affect the other. Although redundancy is a good insurance policy, it obeys the law of diminishing returns. After a certain point, piling up additional redundancies unnecessarily increases complexity, weight, and cost.

MARGINS OF SAFETY

In addition to including redundancies, rocket scientists address uncertainty by building in margins of safety. For example, they build spacecraft stronger than what appears necessary or make thermal insulation thicker than required. Is the probability of failure high? If failure happens, would it be costly? Is the door one-way or two-way? If you're making irreversible one-way decisions, go for higher margins of safety.



Exercises

EXERCISE A: IDENTIFYING YOUR UNCERTAINTIES

In this exercise you will identify the uncertainties relating to a challenge you are tackling. It's important to do this in writing. Once identified, ask yourself questions to find out more about your concerns. By becoming specific you will begin to 'defang' your concerns and turn them into manageable hurdles ready to address in Exercise B.

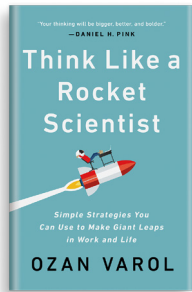
- What am I afraid of?
- What is the worst-case scenario?
- How likely is the worst-case scenario, given what I know now?
- What is the best-case scenario?
- How likely is the best case scenario, given what I know now?

EXERCISE B: PEEKABOO! MITIGATING RISKS

In this exercise you'll determine how you can mitigate the concerns you identified in Exercise A, by figuring out how you can build in redundancies and margins of safety.

1. Redundancies. This requires building an independently functioning backup. Ask yourself the following questions:
 - Where are the redundancies in your own project? Where's the emergency brake or the spare tire in your company? How will you deal with the loss of a valuable team member, a critical distributor, or an important client? What will you do if your household loses a source of income?
 - If there are no redundancies, how can you include one or more?
2. Margins of Safety. Building in margins of safety means addressing concerns by designing your spaceship (or process or solution) to be stronger and more versatile than appears to be necessary. As the stakes go up, so should the margins of safety. To identify suitable margins of safety, ask yourself the following questions:
 - Is the probability of failure high, and if failure happens, would it be costly? Remember the one-way or two-way door analogy: Do you have an easy way out?
 - Where the cost of a possible failure is high, and the door is one-way, how can you increase margins of

safety? How do you make your solution more versatile so that you can adapt to any unforeseen problems that may arise?



CHAPTER 2

Reasoning from First Principles

Key Points

WE'VE ALWAYS DONE IT THIS WAY

We are often constrained by what we've done in the past. Without realizing it, our own knowledge can make us a slave to convention, with our patterns of thinking and processes becoming more important than the end objective. Knowledge is important, but we need to use knowledge to inform and not constrain.

THEY'RE DOING IT THIS WAY

We are genetically programmed to follow the herd. Particularly in conditions of uncertainty, we tend to look to peers and competitors for guidance, assuming they know something we don't. This strategy can work in the short term, but it's a recipe for long-term disaster. The winds of fashion are fickle, and trends are transitory. Over time, imitation makes the original obsolete. The same path that led to glory for one person can cause catastrophe for another. Conversely, the same path that led to catastrophe for one person can yield glory for another.

BACK TO FIRST PRINCIPLES

Getting back to first principles means abandoning all allegiances to your original vision, or the visions of others, and hacking through your original assumptions until you are left with the fundamental components or raw materials. When you apply first-principles thinking, you switch from being a cover band that plays someone else's songs to an artist that does the painstaking work of creating something new.

HOW INVISIBLE RULES HOLD YOU BACK

Invisible rules are habits and behaviours that have unnecessarily rigidified into unwritten rules. We often make things worse by defending our self-imposed limitations (e.g. we could do things differently, we say, but X doesn't allow it). Where innovation matters, it's important to periodically question your assumptions and limitations. Demand current—not historical—supporting evidence. Many of our invisible rules were developed in response to problems that no longer exist. But the immune response remains long after the pathogen leaves.

WHY YOU SHOULD RISK YOUR SIGNIFICANCE

When we look at the mirror, we tell ourselves a story. It's a story about who we are and who we aren't and what we should and shouldn't do. There's a certainty to the story. The story makes us feel significant and secure. But instead of us shaping the story, it shapes us. Over time, the story becomes our identity. We don't change the story, because changing it would mean changing who we are. Like all others, the story of your significance is just that: a story. A narrative. A tale. If you don't like the story, you can change the story. Even better, you can drop it altogether and write a new one. By risking our significance, we discover who we are.

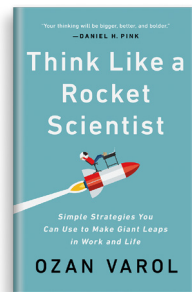
APPETITE FOR DESTRUCTION

Sometimes it's necessary to destroy and rebuild to return to first principles. However, destruction by itself isn't enough if it's not accompanied by a commitment to the right thought process. Unless you change the underlying patterns of

thought, you can expect more of the same.

I CAME IN LIKE A WRECKING BALL

Play the 'kill the company' exercise by putting yourself in the position of a competitor adversary and generating ideas to destroy your company, idea or product. By role-playing, you can discover the weak points in the system and recognize the imperative to strengthen them.



OCCAM'S RAZOR

When faced with two solutions that explain the data equally well, the simplest solution is often the correct one. Simple is sophisticated, has fewer points of failure, and reduces costs. If you want to soar, you must cut what weighs you down. Paint yourself a vivid picture of the future with the excesses wiped off your plate. What does it look like? Ask yourself, as one innovative CEO does, "What if you had not already hired this person, installed this equipment, implemented this process, bought this business, or pursued this strategy? Would you do the same thing you are doing today?"

Exercises

EXERCISE A: INVISIBLE RULES

In this exercise you will work through identifying and overcoming the types of invisible rules that hold you back. By identifying our own invisible rules, we enable ourselves to see our challenges in a new light and free ourselves from meaningless restrictions.

Part 1: Consider the challenge that you were working through in the exercises for the previous chapter. Ask yourself the following questions, noting down your responses and your supporting evidence:

- What assumptions am I operating under?
- How did these assumptions come about?
- Are these assumptions true?
- Can I get rid of any elements of my project / challenge and replace them with something better?
- Why am I afraid of making a change?

Part 2: Now, review each response you gave and the supporting evidence you supplied, and ask the following questions:

- Is the evidence based on the current or historical position? Where the evidence is historical and no longer relevant, delete the assumption.
- How many invisible rules were you able to identify and delete?

EXERCISE B: I CAME IN LIKE A WRECKING BALL

This exercise will help you identify possible flaws in your plans so that you can take measures to address them. Consider some of the questions below:

- Why might my boss pass me for a promotion?
- Why is this prospective employer justified in not hiring me?
- Why are customers making the right decision by buying from our competitors?
- How could our competitors beat us to market?

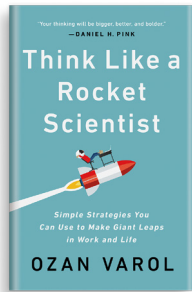
In answering these questions, avoid answering them as you would that dreadful interview prompt, "Tell me about your weaknesses," which tends to induce humblebragging ("I work too hard"). Instead, really get into the shoes of the people who might reject your promotion, refuse to hire you, or buy from your competitors. Ask yourself, Why are they making that choice?

Once you've got a good answer to these questions, switch perspectives and find ways to defend against these potential threats.

BONUS EXERCISE: EVERYBODY ELSE IS DOING IT SO...

To help you break away from the herd, think of a time when you did something simply because others were doing it.

- What could you have done instead?



CHAPTER 3

A Mind at Play

Key Points

THE LABORATORY OF THE MIND.

Thought experiments rely on you and your imagination alone and enable you to construct a parallel universe where things work differently. Through thought experiments, we transcend everyday thinking and evolve from passive observers to active interveners in our reality. As shocking as it sounds, we can generate breakthroughs simply by thinking. No Google. No self-help books. This external search for answers impedes first-principles thinking by focusing our attention on how things are rather than how they could be.

CURIOSITY KILLED SCHRÖDINGER'S CAT

...but it might just save you. We often discourage curiosity because it requires an admission of ignorance. What's more, in this era of "move fast and break things," curiosity can seem like an unnecessary luxury. But seemingly unnecessary investigation and experimentation are precisely what you need to uncover epiphanies. Hustle and creativity are antithetical to each other. You can't generate breakthroughs while clearing out your inbox. You must dig the well before you're thirsty and become curious now—not when a crisis inevitably presents itself.

A LIFELONG KINDERGARTEN

Thought experiments are your own reality distortion field, your choose-your-own-adventure game. Think about how children, before they are stuffed with facts and assumptions, question the world around them with awe. Play and intelligence should be complementary, not competitive, because play can be a portal to intelligence. The key word is "experiment": this framing lowers the stakes and allows room to create without collateral damage. The purpose of a thought experiment isn't to find the right answers, but to ignite a process of open-minded enquiry as a path to discovering insights. The thought experiment is the starting point, not the end.

GET BORED MORE OFTEN

Boredom is central to learning and creativity. It's a time where our brains are let loose to wander and daydream. It might feel like we are drifting aimlessly, but our subconscious is hard at work consolidating and connecting ideas and memories. Epiphanies can appear effortless, but they are usually the product of a long, slow burn. A breakthrough begins with asking a good question, laboring over the answer intensely, and being stuck in idleness for days, weeks, and sometimes years. Research shows that incubation periods—the time you spend feeling stuck—boosts the ability to solve problems. The next time you feel boredom arising, resist the temptation to take a hit of data or do something "productive." Boredom might just be the most productive thing you can do.



COMPARING APPLES AND ORANGES

Our resistance to comparing seemingly dissimilar or unrelated things stifles the cross-pollination of ideas from different disciplines. Life, it turns out, doesn't happen in compartmentalized silos. There's little to be learned from comparing similar things. To facilitate cross-pollination, creative people often develop diverse interests, recognizing that a revolution in one industry can begin with the adoption of an idea from another. The fit often won't be perfect, but the act of comparing will spark new lines of thinking. To compare different ideas, you have to collect them first. The more diverse your collection, the more interesting your output.

THE MYTH OF THE LONE GENIUS

Optimal creativity doesn't happen in complete isolation. Breakthroughs almost always involve a collaborative component. Research shows that optimal creativity arises when teams cycle between isolation and interaction. Connection is important, but so is time for individual reflection. Constant interaction can hamper creativity. People should be able to cultivate insights alone and then come together with the group to exchange ideas before returning again to solitude.

BEGINNER'S MIND

First principles thinking often has an inverse relationship to expertise because outsiders, or beginners, have no stake in the status quo. Standing outside the establishment, amateurs can see flaws and recognize outdated methods. Expertise is valuable, but experts shouldn't work in isolation.

Exercises

EXERCISE A: BORED TO DEATH... OR LIFE!

In these days of instant gratification and endless technological distractions literally at our fingertips, we are increasingly denying ourselves the opportunity to think, to let our minds wander aimlessly wherever they wish. For a period of one week, take 15 (consecutive!) minutes of each day where you are disconnected from all distractions. You can either choose to sit still, take a walk, go into a sauna... the choice is yours so long as you are in quiet contemplation!

At the end of each 15 minutes, take 5 minutes to note down how you felt and jot down any thoughts (however random!) that came to mind.

EXERCISE B: CROSS POLLINATE YOUR LIFE

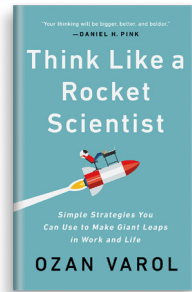
In this chapter, we learned about the importance of diverse interests in opening up our minds to new ideas and associations. In this exercise, challenge yourself to do one of the following:

- Read a book or a magazine on a subject you know nothing about.
- Attend a conference designed for an industry unrelated to the one you work in.
- Sign-up for a class to learn something new (e.g. painting, ceramics, a new language – the choice is yours!).
- Listen to a style or genre of music that wouldn't ordinarily be on your playlist.

CHAPTER 4

Moonshot Thinking

Key Points



THE POWER OF MOONSHOT THINKING

Moonshots force you to reason from first principles. If your goal is 1 percent improvement, you can work within the status quo. But if your goal is to improve tenfold, the status quo has to go. Pursuing a moonshot puts you in a different league—and often an entirely different game—from that of your competitors, making the established plays and routines largely irrelevant. Some moonshots are too impractical to materialize in the near future—if ever. But you don’t need all your moonshots to take flight. As long as your portfolio of ideas is balanced—and you’re not betting your future on a single moonshot—one big success will compensate for the ideas better left to novels and movies.

EMBRACING THE FAR-FETCHED

Divergent thinking is a way of generating different ideas in an open-minded and free-flowing manner, like flies bouncing around in the glass bottle. During divergent thinking, we don’t think about constraints, possibilities, or budgets. We just throw around ideas, open to whatever might present itself. Research shows that divergent thinking is a portal to creativity. It boosts people’s ability to discover innovative solutions and make new associations.

SHOCKING THE BRAIN

Left to its own devices, your brain will strive for the path of least resistance. Although this is comfortable, order and predictability get in the way of creativity so we need to shock our brains into action. Research supports the link between cognitive contradictions and creativity. One way to shock your brain and generate wacky ideas is to ask, What would a science-fiction solution look like? Often, our moonshots aren’t impossible enough. If people want to chuckle at your seeming naivete or call you unreasonable, wear it as a badge of honor.

THE BUSINESS OF MOONSHOTS

Shocking the brain through moonshot thinking doesn’t mean we stop considering practicalities. Once we have our wacky ideas, we can collide them with reality by switching from divergent to convergent thinking—from idealism to pragmatism. This is where it is vital to ask the practical questions that allow you to work out what is achievable and potentially profitable.

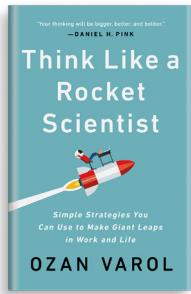
BACK TO THE FUTURE

Most of the time we try to predict the future by forecasting based on our current assumptions and biases. This means that the status quo remains the driving force of our vision and artificially restricts us to what appears feasible. Going back to the future flips this script and encourages us to backcast: to visualise our ideal future and sketch out what steps are required to get us there. Rather than forecasting the future, backcasting aims to determine how an imagined future can be attained. Backcasting requires taking our bold ambition and introducing actionable steps. We visualize our ideal job and sketch out a roadmap to get there. We picture the perfect product and ask what it takes to build it. Only when you face the real prospect of sketching a blueprint for success—now, not later—will you be forced to separate fact from fiction.

MONKEY FIRST

When a difficult project presents itself, it’s frequently tempting to begin with the easiest part. But here’s the problem: If the project has an Achilles heel, you want to know that up front. What’s more, when we invest significant time, money, and resources, the sunk-cost fallacy makes it harder for us to walk away from our investments. To counter the sunk-

cost fallacy, we need to tackle the hardest part of the project first. What's easy often isn't important, and what's important often isn't easy.



Exercises

EXERCISE A: PRACTICING DIVERGENT AND CONVERGENT THINKING

In this exercise you will begin to apply divergent and convergent thinking to a challenge in your personal or professional life.

Once you identify a challenge, take the following steps:

- Identify three elements of the challenge where your current thinking revolves around feeling an obligation that you 'should' do something.
- For each of these three 'shoulds,' write down the three elements again but replace the word 'should' with the word 'could.'
- For each of the three 'coulds,' ask yourself whether this is the only course of action? Apply science-fiction thinking. If there were no constraints, what could you do instead?
- Now transition from divergent to convergent thinking and begin considering constraints (e.g., financial, physical, etc.). You'll find that the ideas you generate will tend to be more creative than if you had begun with convergent thinking.

EXERCISE B: FINDING THE MONKEY

In this exercise, you will look at a challenge you are facing and work out the most difficult aspect – your project's Shakespeare reciting monkey! The monkey might not be completely obvious from the outset. If that's the case, try using these prompts to help you find it:

- Are there any elements of the project that I am avoiding or procrastinating?
- Which part of the project am I most fearful of tackling? What am I afraid of?

CHAPTER 5

What if We Sent Two Rovers Instead of One

Key Points

THE SENTENCE BEFORE THE VERDICT

In solving problems, we instinctively want to identify answers. Instead of generating cautious hypotheses, we offer bold conclusions. Instead of acknowledging that problems have multiple causes, we stick with the first cause that pops to mind. When you're familiar with a problem and think you have the solution it's easy to become blind to alternatives—our thinking becomes fixed. But every chess master knows that there are many different ways to checkmate someone. They need to look past the familiar move to see the optimal one.

QUESTIONING THE QUESTION

In our rush to find solutions, we often fail to properly consider the problem at hand. New answers emerge when we

reframe questions, and the best way to reframe a question is to spend more time thinking about the problem than potential solutions. Define your problem as a missing hammer, and the only possible solution is a hammer. Reframe the problem as a protruding nail, and other solutions might work just as well.

THE DOPPELGÄNGER

Two questions that reframed problems ended up producing one of the most successful interplanetary missions of all time (the 2003 Mars Exploration Rovers): What if we used airbags instead of a three-legged lander? What if we sent two rovers instead of one?

STRATEGY AND TACTICS

Although the terms are often used interchangeably, they refer to different concepts. A strategy is a plan for achieving an objective. Tactics, in contrast, are the actions you take to implement the strategy. When we focus on the tactics, we lose sight of the strategy. Ask what problem your tactics are intended to solve and you'll often discover the strategy. Once you see the strategy, you can walk away from a flawed tactic and find a better one. If you're having trouble zooming out, bring outsiders into the conversation. People who don't regularly use hammers are less likely to be distracted by the hammer sitting in front of you.

THINKING OUTSIDE THE THUMB TACK BOX

When is a box not a box? Once you know the function of an object, it's hard to see it as anything else. When we look past the function and see the form—move from what something is supposed to do to what something can do—we can discover other ways that the product, service, or technology can be used.

WHAT IF WE DID THE REVERSE?

Instead of repeating the same tactics over and over again, try reversing your approach. Instead of adopting a common best practice or the industry standard, reframe the question by asking, "What if I did the reverse?" Even if you don't execute, the simple process of thinking through the opposite will make you question your assumptions and jolt you out of your current perspective.

Exercises

EXERCISE A: REFRAMING THE QUESTION TO FIND BETTER ANSWERS

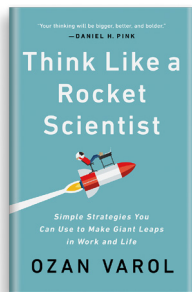
When we rush to judgement by following our impulses, we close ourselves off not only to potentially better solutions, but sometimes to the very problem we're facing. One way to sharpen your problem solving skills is to slow down and give yourself the time and space to think more broadly.

This exercise will help you develop the habit of carefully examining challenges in order to determine whether the problem you're trying to solve is actually the problem that needs solving. Choose a challenge or problem from your personal or professional life.

- What's the first set of solutions that spring to mind? Write them down.
- Now move from tactics to strategy and frame the problem broadly in terms of what you're trying to do—instead of your favored solution. Ask yourself, What problem are these tactics here to solve? This question requires abandoning the what and the how and focusing on the why.
- Once you identify the strategy, find other tactics that you initially missed.

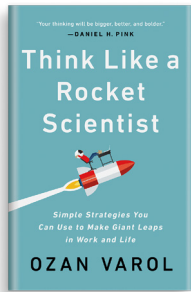
EXERCISE B: SEPARATING THE FORM FROM THE FUNCTION

Once we become accustomed to what a particular tool or device does, it's difficult to see different ways in which it can



be used. Try this exercise to get yourself in the habit of seeing past the function to the form.

- Think of something simple and commonplace that you use almost every day—for example, a coffee cup. How do you describe the object in a way that focuses on its form, rather than its function?
- Once you've described the form of the object, think of alternative uses for the object. For example, if you can view the typical barometer simply as a round object, it can also be used as a weight. If you view a box as a flat platform with sides, it can also be used as a stand.
- Now that you're warmed up, pick either (1) a skill that you have or (2) a product or service your company provides. Apply the same approach to look beyond the function and find the form. What other uses are there for that skill, product, or service?



CHAPTER 6

The Power of Flip-Flopping

Key Points

FACTS DON'T CHANGE MINDS

We undervalue evidence that contradicts our beliefs and overvalue evidence that confirms them. We misinterpret data so that it confirms our preconceived notions, ignore contrary evidence placed right before our eyes, and refuse to listen to opposing arguments for fear of being proven wrong.

SOMETHING FUNNY'S GOING ON

No one comes equipped with a critical-thinking chip that diminishes the human tendency to let personal beliefs distort the facts. The more confident we feel about what we know, the harder it is to see what we don't. Regardless of your intelligence, Richard Feynman's adage holds true: "The first principle is that you must not fool yourself—and you are the easiest person to fool."

THE CASE AGAINST OPINIONS

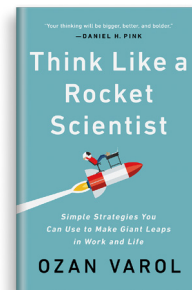
We tend to fall in love with our opinions. When someone questions our opinions, we feel personally attacked, becoming defensive instead of receptive to well-reasoned arguments. To separate your beliefs from your identity, replace "opinion" with "working hypothesis." It's easier to be objective when you're testing a hypothesis than when you're defending an opinion.

A FAMILY OF HYPOTHESES

A hypothesis—even a working one—is still an intellectual child. When we start with a single hypothesis and run with the first idea that pops into mind, it's much easier for that hypothesis to become our master. It anchors us and blinds us to alternatives sitting in the periphery. To make sure you don't fall in love with a single hypothesis, generate several hypotheses. When you've got multiple hypotheses, you reduce your attachment to any one of them and make it more difficult to quickly settle on one. As they compete for your attention new and better ideas will emerge.

WHAT'S MISSING?

If you focus on what's right in front of you, you'll miss everything that's just out of view. Ask yourself, "What's missing?" When you think you've exhausted all possibilities, keep asking, "What else?" Make a deliberate effort to repeatedly turn your head and check your blind spot.



KILL YOUR INTELLECTUAL DARLINGS

Our instinct in our personal and professional lives is to prove ourselves right. Every yes makes us feel good. Every yes makes us stick to what we think we know. Every yes gets us a gold star and a hit of dopamine. But every no brings us one step closer to the truth. Every no provides far more information than a yes does. When our focus shifts from proving ourselves right to proving ourselves wrong, we seek different inputs, we combat deeply entrenched biases, and we open ourselves up to competing facts and arguments. In the end, if we don't prove ourselves wrong, others will do it for us.

A LIGHT-FILLED BOX

Everything we observe in the world is through our own eyes. Step outside your echo chamber. Before making an important decision, ask yourself, "Who will disagree with me?" Expose yourself to environments where your opinions can be challenged, as uncomfortable and awkward as that might be. Ask people who normally agree with you to disagree with you. If you can't find opposing voices, manufacture them. Build a mental model of your favorite adversary, and have imaginary conversations with them.

Exercises

EXERCISE A: RECONSIDERING YOUR BELIEFS

Take one of your strongly held beliefs. Now consider the following:

- What fact or new evidence could change your mind?
- Change your perspective and defend the opposing viewpoint. Avoid the instinct to caricature the opposing position, making it easier to debunk—a tactic called the straw man. Instead, engage in steel-manning: Find and articulate the strongest, not the weakest, form of the opposition's argument.
- Do you agree with any of the opposition's arguments? Which one(s)?

EXERCISE B: SEEING THE INVISIBLE

Answer the following questions with a problem you're mulling over or a project you're working on:

- What is missing from your solution or method? What haven't you taken into account?
- Pick a mentor or trusted friend. How do you think they would approach the problem?
- Ask yourself, "What would a rocket scientist do?" and imagine a rocket scientist, armed with the tools in this book, critically questioning your ideas.

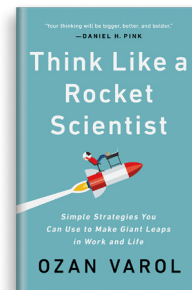
CHAPTER 7

Test as You Fly, Fly as You Test

Key Points

THE PROBLEM WITH TESTS

Most of our decisions in life are based not on tests, but on hunches and limited information. We launch a new product, we change careers, or we try a new marketing approach—all without a single experiment. Even when we conduct



tests, we do so not to prove ourselves wrong, but to confirm what we believe is true. Rocket science offers a way forward with the “test as you fly” principle. According to the principle, experiments on Earth must mimic, to the greatest extent possible, the same conditions in flight. Rocket scientists test the spacecraft as the spacecraft will fly. If the test is successful, the flight must take place under similar conditions. Any significant deviance between the test and the flight can cause catastrophe—whether it’s a rocket, your job interview, or your next product.

BREAKING POINT

If you want to find out how strong something is, break it. Once you discover the breaking point of your latest theory or Mars lander airbag, you can correct the flaw in your redesign. Don’t shrug off unlikely odds. Instead, design tests for the worst-case—rather than the best-case—scenario. If a problem crops up during testing, isolate and exaggerate it, then find a way to solve it.

FRANKENSTEIN’S MONSTER

Testing as you fly requires a multilayered approach. Rocket scientists begin testing with the subcomponents—for example, the individual cameras that will form a rover’s vision system, as well as the cables and connectors. Once the cameras are fully assembled, the vision system is tested again as a whole. Systems are made up of complicated interactions and sometimes individual parts of a system behave in completely unexpected ways during those interactions. Test the pieces and then test the whole.

THE RIGHT STUFF

Astronauts spend years preparing for a mission that will last only days. They endure grueling worst-case-scenario drills for hours on end in extreme environments meant to mimic the reality of spaceflight. As a result, astronauts are conditioned to sidestep panic and respond to crises in a cool, rational manner. Treat every training session as if it’s the real thing. Never rely on a treadmill to prepare yourself to run a marathon.

THE ROCKET SCIENCE OF PUBLIC OPINION

People are unreliable when they report their own behavior. Direct observation is always better than asking someone to respond to a hypothetical situation. Don’t ask someone to imagine how they’ll use a new piece of software. Instead, watch them use a prototype. The results will be more accurate and, like the six-minute long video of a hospital ceiling, will reveal a new reality that you may have missed

THE OBSERVER EFFECT

We behave differently when we know that we’re under observation. Just as shifting couch cushions to look for a quarter moves the quarter, focus group participants change how they scrutinize a product when they know they have to offer opinions once it’s over. Even trained researchers can subconsciously influence results in subtle ways. The most accurate data comes from people in real world scenarios who don’t know that they’re being observed.

MULTIPLE TESTERS

Using only one instrument to test a lens for a \$1.5 billion space telescope is a good way to launch a very expensive mistake into orbit. Never rely on a single test, and never rely on a single testing device—duplicate results on several. If you’re redesigning your website, make sure that it works as intended on different browsers and computer models.

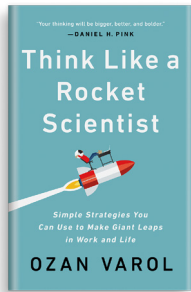
Exercises

EXERCISE: TEST EARLY, TEST OFTEN, AND TEST-AS-YOU-FLY

Your test results are only as reliable as how accurately the testing conditions reflect real world conditions. For this

exercise, focus on an upcoming life event. This could be a presentation at work, job interview, or product launch. Ask yourself:

- How can you adopt the test-as-you-fly principle to help you prepare and execute?
- How can you practice in a way that better simulates the real world environment?
- Have you remembered to test the individual pieces of your upcoming project, then the entire project as a whole, to make sure there are no unexpected interactions or complications?



CHAPTER 8

Nothing Succeeds Like Failure

Key Points

TOO AFRAID TO FAIL

Humans are wired to fear failure. To ward off the bogeyman of failure, we keep a safe distance from it. But this natural tendency to avoid failure is a recipe for failing. Behind every rocket unlaunched, every canvas unpainted, every goal unattempted, every book unwritten, and every song unsung is the looming fear of failure.

FAILURE IS AN OPTION

The much-quoted mantra “failure is not an option” is misleading. Doing anything ground breaking means taking risks, and taking risks means you’re going to fail, at least some of the time. A moratorium on failure is a moratorium on progress.

THE PROBLEM WITH “FAIL FAST”

It’s one thing to acknowledge that failure is an option, but something else entirely to celebrate it. To take the sting and shame out of failure, Silicon Valley overcorrected. When entrepreneurs are too busy failing fast and celebrating it, they stop learning from their mistakes, attribute failures to external factors, and fail to modify their actions.

LEARN FAST, NOT FAIL FAST

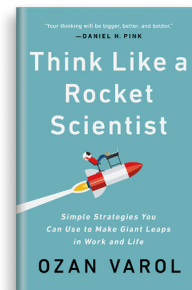
The goal isn’t to fail fast, it’s to learn fast. We should be celebrating lessons from failure, not failure itself. There are two responses to negative feedback from a credible source: deny it or accept it, and every great scientist chooses the latter. If you pay them proper attention, failures can teach us lessons we could not learn from success.

THE OPENING AND THE FINALE

The opening doesn’t have to be grand, as long as the finale is. A single failure can be the beginning not the end. Time can morph how we see events and something that looks like a failure in the short term changes when we zoom out and see the whole timeline. Breakthroughs are often evolutionary, not revolutionary.

INPUTS OVER OUTPUTS

Focusing on outputs leads us astray because it’s possible for good decisions to lead to bad outcomes. In conditions of uncertainty, outcomes aren’t completely within your control. The goal is to focus on the variables you can control—the inputs. With this approach, you avoid the wild swings of misery and euphoria that comes with chasing outcomes. Instead, you become curious about tweaking and perfecting the inputs.



HOW FASCINATING!

Curiosity takes a failure, turns the volume of drama all the way down, and makes failure interesting. It provides emotional distance, perspective, and an opportunity to view things through a different lens. Check out the exercises below to practice applying this approach to your own life.

FLYING BLIND

Most organisations suffer from collective amnesia over their failures. Mistakes remain concealed as employees are too afraid to share them. Companies pay lip service to tolerating and documenting failures but often fail in practice. People should be held accountable—not for failing intelligently—but for failing to learn from it.

PSYCHOLOGICAL SAFETY

Psychological safety means, in Amy Edmondson's words, "no one will be punished or humiliated for errors, questions, or requests for help, in the service of reaching ambitious performance goals." Research shows that psychological safety stimulates innovation. When people feel free to speak up, ask provocative questions, and air half-formed thoughts, it becomes easier to challenge the status quo. Psychological safety also increases team learning. In psychologically safe environments, employees challenge questionable calls by superiors instead of obediently complying with the commands.

ADVERTISE YOUR FAILURES

For employees to share their mistakes, the leaders must lead the way. If leaders fail to acknowledge their failures and there is a perception that the leader can do no wrong, then it's unrealistic to expect employees to take the risk of challenging the leader or revealing their own failures. The road to success is filled with potholes. You're better off acknowledging them than pretending they don't exist.

HOW TO FAIL GRACEFULLY

Rocket scientists use a constellation of tools to contain failures so they don't create a cascade of damage. For example, they conduct thought experiments where a failure produces no tangible damage. They build in redundancies so the mission doesn't fail even if a component fails. They use tests to lower the stakes because failures on the ground prevent far more disastrous ones in space. To apply this strategy, instead of rolling out an innovative policy across the whole company, you can use one division to create your own laboratory or experiment. Testing also gives us the opportunity to practice failure in a relatively safe environment.

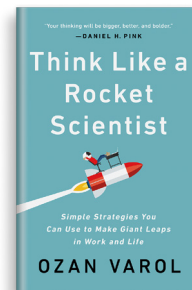
Exercises

EXERCISE A: FOCUSING ON THE INPUTS

In this exercise you will practice asking questions to help you to focus on the inputs rather than the outputs of the challenges you are facing.

Think of a failure that you have had in your life and ask yourself the following questions:

- What went wrong with this failure?
- If some of the inputs were suboptimal, how would you correct them?
- What went right with this failure?
- How do you retain the good quality decisions and inputs even if the outcome was a failure?



EXERCISE B: HOW FASCINATING!

In this exercise you will practice taking the sting out of failure, using a method described by Ros and Ben Zander in their book *The Art of Possibility*. Over the course of the next week, each time you make a mistake (however small), throw your arms up in the air and say “How fascinating!”

Fair warning: If you’re anything like me, you’ll grumble when you first do this. As you try to put your arms in the air, they’ll go up ever so slowly—as if you’re doing an imaginary bench press with really, really heavy weights. And the phrase “How fascinating!” will sound more petulant than joyous.

That’s okay. Do it anyway. As you bask in the glory of your fascination, ask yourself these questions:

- What can I learn from this?
- What if this failure was actually good for me?

Write down your answers. At the end of your week’s trial, look back at your notes and reflect on what you learned. You might see patterns that will provide additional learning opportunities. After the week of testing, try to continue this exercise in your everyday life.

CHAPTER 9

Nothing Fails Like Success

Key Points

WHY SUCCESS IS A LOUSY TEACHER

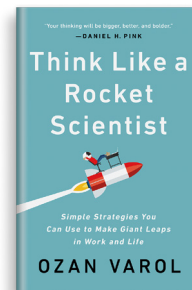
Success is the wolf in sheep’s clothing because it drives a wedge between appearance and reality. When we succeed we believe everything went according to plan and ignore the warning signs and the necessity for change. But it’s possible to do some wrong things and still succeed. A spacecraft with a design flaw can safely land on Mars when the conditions don’t trigger the flaw. It’s important to recognize that we may have succeeded despite making a mistake or taking an unwise risk.

PERMANENT WORKS-IN-PROGRESS

The modern world doesn’t call for finished products. It calls for works-in-progress, where perpetual improvement wins the game. The moment we pretend an activity is routine is the moment we let our guard down and rest on our laurels. The remedy is to drop the word “routine” from our vocabulary and treat all our projects—particularly the successful ones—as permanent works-in-progress. To foster this mindset, assume you are trailing slightly behind and your adversary is still in first place.

SUCCESS, INTERRUPTED

Research shows us that success and complacency go hand-in-hand. When we succeed we stop pushing boundaries. Our comfort sets a ceiling with our frontiers shrinking rather than extending. This works well, until it doesn’t. To prevent complacency, knock yourself off your pedestal once in a while. If we don’t experience variability in our track record—if we don’t prevent our confidence from inflating after a string of random successes—then a catastrophic failure will do that for us.



NEAR MISSES

In aviation lingo, a near miss is an incident that could have been a hit. A near miss means you came close, but not close enough to cause a collision. It means you got lucky. We tend to ignore near misses both in the air traffic control room and in the boardroom. Research shows that near misses masquerade as successes because they don't affect the ultimate outcome. Near misses lead people to take unwise risks. Rather than urgency, near misses create complacency. The goal is to spot near-misses before they snowball into something we can't control. Near misses are a rich source of data for a simple reason. They happen far more frequently than accidents. They're also significantly less costly. By examining near misses, you can gather crucial data without incurring the costs of failure. This means post-mortems should follow both failure and success.

OUTCOME BLIND

Only when we blind ourselves to the high beam lights of outcome can we more objectively assess our decision making. When we are blinded to the outcome, decisions look far less black and white. There's a trick to putting blind analysis into practice without playing it stupid: the premortem.

THE PRE-MORTEM

With a pre-mortem, the investigation comes before we have acted, when the actual outcome isn't known. We travel forward in time and set up a thought experiment where we assume the project failed. We then step back and ask, "What went wrong?" By visualising a doomsday scenario, we come up with potential problems and determine how to avoid them. Premortems can be a powerful way of organically uncovering dissent. Because they assume a bad outcome—that the project failed—and ask people to generate reasons for the failure, they can provide psychological safety for expressing genuine criticism and relaying it upward.

THE CAUSE BEHIND THE CAUSE

In a post-mortem, it's easy to focus on the most obvious and immediate causes of a problem. But the causes of failure in a complex system are usually multiple. Remedying only the most obvious causes leaves the others intact. When we pretend that curing the first-order cause will also eliminate the second- and third-order causes, we end up masking them and exposing ourselves to future catastrophe. Only through the hard work of looking beyond the first-order causes—particularly when we're afraid of what we might see—do we begin to learn from our failures.

THE UNSAFETY OF SAFETY

Measures intended to decrease risk sometimes backfire. Humans compensate for the reduced risk in one area by increasing risk in another. The safety net may be there to catch you if you fall, but you're better off pretending it doesn't exist.

Exercises

EXERCISE A: NEAR MISSES

In this exercise you will replicate an exercise you completed in the previous chapter, when you considered the inputs that produced a failure. This time, you'll examine the inputs that produced a success. This exercise will help you to adopt the habit of pausing after each success and determining what can be learned.

Think of a success that you had in your life. Now ask yourself the questions listed below, and take note of your responses:

- What went right with this success?
- How would you retain the good quality decisions and inputs that produced the success?

- What went wrong with this failure?
- If some of the inputs were suboptimal, how would you correct them?

EXERCISE B: THE PRE-MORTEM

In this exercise you will focus on a challenge that you are currently facing and take it through the pre-mortem process.

If you're a business leader, a premortem might focus on a product you're currently designing. You would assume the product failed and then work backward to determine the potential reasons.

If you're a job candidate, a premortem might involve an interview. You would assume you didn't get the job and generate as many reasons as possible for the failure.

Take the following steps:

- Write down your challenge.
- In a list, note as many things as you can think of that could go wrong to prevent you from succeeding.
- As you think through what can go wrong, assign percentage probabilities to each potential problem (e.g., there's a 10% chance of a delivery delay).
- Now, for each potential problem, note the actions you could take to prevent it.

