SCALING 4 GROWTH
— A BIG FIVE FOR LIFE ENTERPRISE —

Make it Stick
The Science of Successful Learning

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Authors' big thought: This is a book about what people can do for themselves right now in order to learn better and remember longer.

Chapter 1: Learning is Misunderstood

- Learning is deeper and more durable when it's *effortful*.
- We are *poor judges* of when we are learning well and when we're not.
- Rereading text and *massed practice* (repetition to burn something into memory) of a skill or new knowledge are by far the preferred study strategies of learners of all stripes, but they're also among the *least productive*.
- *Retrieval practice*—recalling facts or concepts or events from memory—is a more effective learning strategy than review by rereading. Flashcards are a simple example.
- *Periodic practice* arrests forgetting, strengthens retrieval routes, and is essential for hanging onto the knowledge you want to gain.
- *Spaced out practice* produces longer lasting learning and enables more versatile application of it in later settings.

- *Trying to solve a problem* before being taught the solution leads to better learning, even when errors are made in the attempt.
- The popular notion that you learn better when you receive instruction in a form consistent with your preferred learning style, for example as an auditory or visual learner, is not supported by the empirical research.
- We're all susceptible to illusions that can hijack our judgment of what we know and can do. Testing helps calibrate our judgments of what we've learned.
- In virtually all areas of learning, you build better mastery when you use testing as a tool to identify and bring up your areas of weakness. All new learning requires a foundation of prior knowledge.
- if you practice *elaboration*, there's no known limit to how much you can learn. Elaboration is the process of giving new material meaning by expressing it in your own words and connecting it with what you already know.
- People who learn to extract the key ideas from new material and organize them into a mental model and connect that model to prior knowledge show an advantage in learning complex mastery.
- Every time you learn something new, you change the brain—the residue of your experiences is stored.
- Learning is stronger *when it matters*, when the abstract is made concrete and personal.
- Mastery requires both the possession of ready knowledge and the conceptual understanding of how to use it.
- One of the best habits a learner can instill in herself is regular self-quizzing to recalibrate her understanding of what she does and does not know.

Chapter 2: To Learn, Retrieve

- *Reflection* can involve several cognitive activities that lead to stronger learning: retrieving knowledge and earlier training from memory, connecting these to new experiences, and visualizing and mentally rehearsing what you might do differently next time.
- To be most effective, retrieval must be repeated again and again, in spaced out sessions so that the recall, rather than becoming a mindless recitation, requires some cognitive effort.
- Practice at retrieving new knowledge or skill from memory is a potent tool for learning and durable retention. This is true for anything the brain is asked to remember and call up again in the future—facts, complex concepts, problem-solving techniques, motor skills.
- *Effortful retrieval* makes for stronger learning and retention. We're easily seduced into believing that learning is better when it's easier,
- The research that when the mind has to work, learning sticks better. The greater the effort to retrieve learning, provided that you succeed, the more that learning is strengthened by retrieval.
- After an initial test, delaying subsequent retrieval practice is more potent for reinforcing retention than immediate practice, because delayed retrieval requires more effort.
- *Repeated retrieval* not only makes memories more durable but produces knowledge that can be retrieved more readily, in more varied settings, and applied to a wider variety of problems. While cramming can produce better scores on an immediate exam, the advantage quickly fades because there is much greater forgetting after rereading than after retrieval practice. The benefits of retrieval practice are long-term.
- Simply including one test (retrieval practice) in a class yields a large improvement in final exam scores, and gains continue to increase as the frequency of classroom testing increases.

- Testing doesn't need to be initiated by the instructor. Students can practice retrieval anywhere; no quizzes in the classroom are necessary. Think flashcards—the way second graders learn the multiplication tables can work just as well for learners at any age to quiz themselves on anatomy, mathematics, or law. *Self-testing* may be unappealing because it takes more effort than rereading, but as noted already, the greater the effort at retrieval, the more will be retained.
- Students who take practice tests have a better grasp of their progress than those who simply reread the material. Similarly, such testing enables an instructor to spot gaps and misconceptions and adapt instruction to correct them.
- Giving students *corrective feedback* after tests keeps them from incorrectly retaining material they have misunderstood and produces better learning of the correct answers.
- Students in classes that incorporate low-stakes quizzing come to embrace the practice. Students who are tested frequently rate their classes more favorably.

Chapter 3: Mix Up Your Practice

- *Spaced practice* is more effective than *massed practice*. It appears that embedding new learning in long-term memory requires a process of consolidation, in which memory traces (the brain's representations of the new learning) are strengthened, given meaning, and connected to prior knowledge—a process that unfolds over hours and may take several days. Rapid-fire practice leans on short-term memory.
- Durable learning, however, requires time for mental rehearsal and the other processes of consolidation. Hence, spaced practice works better.
- Interleaving the practice of two or more subjects or skills is also a more potent alternative to massed practice.
- The learning from *interleaved practice* feels slower than learning from massed practice.
- Compared to massed practice, a significant advantage of interleaving and variation is that they help us learn better how to assess context and discriminate between problems, selecting and applying the correct solution from a range of possibilities.
- Conceptual knowledge requires an understanding of the interrelationships of the basic elements within a larger structure that enable them to function together. Conceptual knowledge is required for classification.
- We harbor deep convictions that we learn better through single-minded focus and dogged repetition, and these beliefs are validated time and again by the visible improvement that comes during "practice-practice-practice." But scientists call this heightened performance during the acquisition phase of a skill "momentary strength" and distinguish it from "underlying habit strength." The very techniques that build habit strength, like spacing, interleaving, and variation, slow visible acquisition and fail to deliver the improvement during practice that helps to motivate and reinforce our efforts.
- *Cramming*, a form of massed practice, has been likened to binge-and-purge eating. A lot goes in, but most of it comes right back out in short order. The simple act of spacing out study and practice in installments and allowing time to elapse between them makes both the learning and the memory stronger, in effect building habit strength.
- The interval is: enough so that practice doesn't become a mindless repetition. At a minimum, enough time so that a little forgetting has set in. A little forgetting between practice sessions can be a good thing, if it leads to more effort in practice, but you do not want so much forgetting that retrieval essentially involves relearning the material.

- The time periods between sessions of practice let memories consolidate. Sleep seems to play a large role in memory consolidation, so practice with at least a day in between sessions is good.
- Something as simple as a deck of flashcards can provide an example of spacing. Between repetitions of any individual card, you work through many others.
- Beware of the familiarity trap: the feeling that you know something and no longer need to practice it. This familiarity can hurt you during self-quizzing if you take shortcuts.
- *Interleaving* two or more subjects during practice also provides a form of spacing. Interleaving can also help you develop your ability to discriminate later between different kinds of problems and select the right tool from your growing toolkit of solutions.
- In interleaving, you don't move from a complete practice set of one topic to go to another. You switch before each practice is complete.
- Like interleaving, *varied practice* helps learners build a broad schema, an ability to assess changing conditions and adjust responses to fit. Arguably, interleaving and variation help learners reach beyond memorization to higher levels of conceptual learning and application, building more rounded, deep, and durable learning, what in motor skills shows up as underlying habit strength.

Chapter 4: Embrace Difficulties

- The process of strengthening mental representations for long-term memory is called *consolidation*. New learning is labile: its meaning is not fully formed and therefore is easily altered.
- In consolidation, the brain reorganizes and stabilizes the memory traces. This may occur over several hours or longer and involves deep processing of the new material, during which scientists believe that the brain replays or rehearses the learning, giving it meaning, filling in blank spots, and making connections to past experiences and to other knowledge already stored in long-term memory.
- *Prior knowledge* is a prerequisite for making sense of new learning, and forming those connections is an important task of consolidation.
- The process of learning something often starts out feeling disorganized and unwieldy; the most important aspects are not always salient. Consolidation helps organize and solidify learning, and, notably, so does retrieval after a lapse of some time, because the act of retrieving a memory from long-term storage can both strengthen the memory traces and at the same time make them modifiable again, enabling them, for example, to connect to more recent learning. This process is called *reconsolidation*. This is how retrieval practice modifies and strengthens learning.
- Learning, remembering, and forgetting work together in interesting ways. Durable, robust learning requires that we do two things. First, as we recode and consolidate new material from short-term memory into long-term memory, we must anchor it there securely. Second, we must associate the material with a diverse set of cues that will make us adept at recalling the knowledge later. Having effective retrieval cues is an aspect of learning that often goes overlooked. The task is more than committing knowledge to memory. Being able to retrieve it when we need it is just as important.
- Knowledge, skills, and experiences that are vivid and hold significance, and those that are periodically practiced, stay with us.
- There's virtually no limit to how much learning we can remember as long as we relate it to what we already know. In fact, because new learning depends on prior learning, the more we learn,

the more possible connections we create for further learning. Our retrieval capacity, though, is severely limited.

- This limitation on retrieval is helpful to us: if every memory were always readily to hand, you would have a hard time sorting through the sheer volume of material to put your finger on the knowledge you need at the moment.
- Knowledge is more durable if it's deeply entrenched, meaning that you have firmly and thoroughly comprehended a concept, it has practical importance or keen emotional weight in your life, and it relates to other knowledge that you hold in memory. How readily you can recall knowledge from your internal archives is determined by context, by recent use, and by the number and vividness of cues that you have linked to the knowledge and can call on to help bring it forth.
- The paradox is that some forgetting is often essential for new learning.
- It is a critical point that as you learn new things, you don't lose from long-term memory most of what you have learned well in life; rather, through disuse or the reassignment of cues, you forget it in the sense that you're unable to call it up easily.
- Psychologists have uncovered a curious inverse relationship between the ease of retrieval practice and the power of that practice to entrench learning: the easier knowledge or a skill is for you to retrieve, the less your retrieval practice will benefit your retention of it. Conversely, the more effort you have to expend to retrieve knowledge or skill, the more the practice of retrieval will entrench it.
- This paradox is at the heart of the concept of *desirable difficulties* in learning: the more effort required to retrieve (or, in effect, relearn) something, the better you learn it. In other words, the more you've forgotten about a topic, the more effective relearning will be in shaping your permanent knowledge.
- *Effortful recall* of learning, as happens in spaced practice, requires that you "reload" or reconstruct the components of the skill or material anew from long-term memory rather than mindlessly repeating them from short-term memory. During this focused, effortful recall, the learning is made pliable again: the most salient aspects of it become clearer, and the consequent reconsolidation helps to reinforce meaning, strengthen connections to prior knowledge, bolster the cues and retrieval routes for recalling it later, and weaken competing routes.
- Spaced practice, which allows some forgetting to occur between sessions, strengthens both the learning and the cues and routes for fast retrieval when that learning is needed again. The more effort that is required to recall a memory or to execute a skill, if the effort succeeds, the more the act of recalling or executing benefits the learning.
- Massed practice gives us the warm sensation of mastery because we're looping information through short-term memory without having to reconstruct the learning from long-term memory. But just as with rereading as a study strategy, the fluency gained through massed practice is transitory, and our sense of mastery is illusory. It's the effortful process of reconstructing the knowledge that triggers reconsolidation and deeper learning.
- With enough effortful practice, a complex set of interrelated ideas or a sequence of motor skills fuse into a meaningful whole, forming a mental model somewhat akin to a "brain app".
- Retrieval practice that you perform at different times and in different contexts and that interleaves different learning material has the benefit of linking new associations to the material. This process builds interconnected networks of knowledge that bolster and support mastery of your field. It also multiplies the cues for retrieving the knowledge, increasing the versatility with which you can later apply it.
- The retrieval difficulties posed by spacing, interleaving, and variation are overcome by invoking the same mental processes that will be needed later in applying the learning in everyday

settings. By mimicking the challenges of practical experience, these learning strategies conform to the admonition to “practice like you play, and you’ll play like you practice,” improving what scientists call transfer of learning, which is the ability to apply what you’ve learned in new settings.

- When you’re asked to struggle with solving a problem before being shown how to solve it, the subsequent solution is better learned and more durably remembered.
- We usually think of *interference* as a detriment to learning, but certain kinds of interference can produce learning benefits, and the positive effects are sometimes surprising.
- The change from normal presentation introduces a difficulty—disruption of fluency—that makes the learner work harder to construct an interpretation that makes sense. The added effort increases comprehension and learning. (Of course, learning will not improve if the difficulty completely obscures the meaning or cannot be overcome.)
- The act of trying to answer a question or attempting to solve a problem rather than being presented with the information or the solution is known as *generation*.
- The act of taking a few minutes to review what has been learned from an experience (or in a recent class) and asking yourself questions is known as *reflection*.
- Reflection can involve several cognitive activities we have discussed that lead to stronger learning. These include *retrieval* (recalling recently learned knowledge to mind), *elaboration* (for example, connecting new knowledge to what you already know), and *generation* (for example, rephrasing key ideas in your own words or visualizing and mentally rehearsing what you might do differently next time).
- The process of trying to solve a problem without the benefit of having been taught how is called *generative learning*, meaning that the learner is generating the answer rather than recalling it. Generation is another name for old-fashioned trial and error.
- Learning is at least a three-step process: initial encoding of information is held in short-term working memory before being consolidated into a cohesive representation of knowledge in long-term memory. Consolidation reorganizes and stabilizes memory traces, gives them meaning, and makes connections to past experiences and to other knowledge already stored in long-term memory. Retrieval updates learning and enables you to apply it when you need it.
- Learning always builds on a store of prior knowledge. We interpret and remember events by building connections to what we already know. Long-term memory capacity is virtually limitless: the more you know, the more possible connections you have for adding new knowledge.
- Because of the vast capacity of long-term memory, having the ability to locate and recall what you know when you need it is key; your facility for calling up what you know depends on the repeated use of the information (to keep retrieval routes strong) and on your establishing powerful retrieval cues that can reactivate the memories.
- Periodic retrieval of learning helps strengthen connections to the memory and the cues for recalling it, while also weakening routes to competing memories. Retrieval practice that’s easy does little to strengthen learning; the more difficult the practice, the greater the benefit.
- When you recall learning from short-term memory, as in rapid-fire practice, little mental effort is required, and little long-term benefit accrues. But when you recall it after some time has elapsed and your grasp of it has become a little rusty, you have to make an effort to reconstruct it. This effortful retrieval both strengthens the memory but also makes the learning pliable again, leading to its reconsolidation.
- Reconsolidation helps update your memories with new information and connect them to more recent learning. Repeated effortful recall or practice helps integrate learning into *mental models*, in which a set of interrelated ideas or a sequence of motor skills are fused into a meaningful whole that can be adapted and applied in later settings. Examples are the

perceptions and manipulations involved in driving a car or in knocking a curveball out of the ballpark.
- When practice conditions are varied or retrieval is interleaved with the practice of other material, we increase our abilities of discrimination and induction and the versatility with which we can apply the learning in new settings at a later date. Interleaving and variation build new connections, expanding and more firmly entrenching knowledge in memory and increasing the number of cues for retrieval.
- Trying to come up with an answer rather than having it presented to you, or trying to solve a problem before being shown the solution, leads to better learning and longer retention of the correct answer or solution, even when your attempted response is wrong, so long as corrective feedback is provided.

Chapter 5: Avoid Illusions of Knowing

- At the root of our effectiveness is our ability to grasp the world around us and to take the measure of our own performance. We're constantly making judgments about what we know and don't know and whether we're capable of handling a task or solving a problem. As we work at something, we keep an eye on ourselves, adjusting our thinking or actions as we progress.
- In his book ***Thinking, Fast and Slow***, Daniel Kahneman describes our two analytic systems. What he calls *System 1* (or the automatic system) is unconscious, intuitive, and immediate. It draws on our senses and memories to size up a situation in the blink of an eye.
- *System 2* (the controlled system) is our slower process of conscious analysis and reasoning. It's the part of thinking that considers choices, makes decisions, and exerts self-control. We also use it to train System 1 to recognize and respond to particular situations that demand reflexive action.
- System 1 is automatic and deeply influential, but it is susceptible to illusion, and you depend on System 2 to help you manage yourself: by checking your impulses, planning ahead, identifying choices, thinking through their implications, and staying in charge of your actions.
- System 1 is powerful because it draws on our accumulated years of experience and our deep emotions. System 1 gives us the survival reflex in moments of danger, and the astonishing deftness earned through thousands of hours of deliberate practice in a chosen field of expertise.
- Of course, when System 1's conclusions arise out of misperception or illusion, they can steer you into trouble. Learning when to trust your intuition and when to question it is a big part of how you improve your competence in the world at large and in any field where you want to be expert.
- Our understanding of the world is shaped by a *hunger for narr*ative that rises out of our discomfort with ambiguity and arbitrary events. When surprising things happen, we search for an explanation. The urge to resolve ambiguity can be surprisingly potent, even when the subject is inconsequential.
- We strive to fit the events of our lives into a cohesive story that accounts for our circumstances, the things that befall us, and the choices we make.
- It is a confounding paradox, then, that the changeable nature of our memory not only can skew our perceptions but also is essential to our ability to learn. As will be familiar to you by now, every time we call up a memory, we make the mind's routes to that memory stronger, and this capacity to strengthen, expand, and modify memory is central to how we deepen our learning and broaden the connections to what we know and what we can do.

- Memory can be distorted in many ways. People interpret a story in light of their world knowledge, imposing order where none had been present to make a more logical story. Memory is a reconstruction. People remember things that were implied but not specifically stated.
- *Imagination inflation* refers to the tendency of people who, when asked to imagine an event vividly, will sometimes begin to believe, when asked about it later, that the event actually occurred. Hypothetical events that are imagined vividly can seat themselves in the mind as firmly as memories of actual events.
- Another type of memory illusion is one caused by *suggestion*, which may arise simply in the way a question is asked.
- *Interference* from other events can distort memory.
- What psychologists call *the curse of knowledge* is our tendency to underestimate how long it will take another person to learn something new or perform a task that we have already mastered. The curse-of-knowledge effect is close kin to hindsight bias, or what is often called the *knew-it-all-along* effect, in which we view events after the fact as having been more predictable than they were before they occurred.
- Accounts that sound familiar can create *the feeling of knowing* and be mistaken for true.
- *Fluency illusions* result from our tendency to mistake fluency with a text for mastery of its content. For example, if you read a particularly lucid presentation of a difficult concept, you can get the idea that it is actually pretty simple and perhaps even that you knew it all along.
- Our memories are also subject to *social influence* and tend to align with the memories of the people around us.
- In the obverse of the social influence effect, humans are predisposed to assume that others share their beliefs, a process called *the false consensus effect*. We generally fail to recognize the idiosyncratic nature of our personal understanding of the world and interpretation of events and that ours differ from others'.
- As we develop mastery in the various areas of our lives, we tend to bundle together the incremental steps that are required to solve different kinds of problems. We call them *mental models.*
- Incompetent people lack the skills to improve because they are unable to distinguish between incompetence and competence. This phenomenon, of particular interest for metacognition, has been named the Dunning-Kruger effect after the psychologists David Dunning and Justin Kruger.
- To sum up, how we navigate the world—Daniel Kahneman's Systems 1 and 2—rely on our perceptual systems, intuition, memory, and cognition, with all their tics, warts, biases, and flaws. Each of us is an astounding bundle of perceptual and cognitive abilities, coexisting with the seeds of our own undoing. When it comes to learning, what we choose to do is guided by our judgments of what works and what doesn't, and we are easily misled.
- The answer to illusion and misjudgment is to replace subjective experience as the basis for decisions with a set of objective gauges outside ourselves, so that our judgment squares with the real world around us. When we have reliable reference points, like cockpit instruments, and make a habit of checking them, we can make good decisions about where to focus our efforts, recognize when we've lost our bearings, and find our way back again.
- Most important is to make frequent use of testing and retrieval practice to verify what you do know versus what you think you know. Frequent low-stakes quizzes in class help the instructor verify that students are in fact learning as well as they appear to be and reveal the areas where extra attention is needed.
- *Peer instruction*, a learning model developed by Eric Mazur, incorporates many of the foregoing principles. The material to be covered in class is assigned for reading beforehand. In

class, the lecture is interspersed with quick tests that present students with a conceptual question and give them a minute or two to grapple with it; they then try, in small groups, to reach a consensus on the correct answer.

- Pay attention to the cues you're using to judge what you have learned. Whether something feels familiar or fluent is not always a reliable indicator of learning.
- Instructors should give *corrective feedback*, and learners should seek it.
- In many settings, your judgment and learning are calibrated by working alongside a more experienced partner:
- In other settings, *teams* are formed of people with complementary areas of expertise.
- Training that simulates the kinds of demands and changeable conditions that can be expected in real-world settings helps learners and trainers assess mastery and focus on areas where understanding or competency need to be raised.
- Sometimes the most powerful feedback for calibrating your sense of what you do and don't know are the mistakes you make in the field, assuming you survive them and are receptive to the lesson.

Chapter 6: Get Beyond Learning Styles

- The idea that individuals have distinct learning styles has been around long enough to become part of the folklore of educational practice and an integral part of how many people perceive themselves. The underlying premise says that people receive and process new information differently: for example, some learn better from visual materials, and others learn better from written text or auditory materials.
- Moreover, the theory holds that people who receive instruction in a manner that is not matched to their learning style are at a disadvantage for learning.
- The authors acknowledge that everyone has learning preferences, but are not persuaded that you learn better when the manner of instruction fits those preferences.
- All people are different, a truism we quickly discern as children, comparing ourselves to siblings. It's evident in grade school, on the sports field, in the boardroom. One difference that appears to matter a lot is how you see yourself and your abilities.
- The stories we create to understand ourselves become the narratives of our lives, explaining the accidents and choices that have brought us where we are: what I'm good at, what I care about most, and where I'm headed.
- What you tell yourself about your ability plays a part in shaping the ways you learn and perform–how hard you apply yourself, for example, or your tolerance for risk-taking and your willingness to persevere in the face of difficulty. But differences in skills, and your ability to convert new knowledge into building blocks for further learning, also shape your routes to success. Your
- Each of us has a large basket of resources in the form of aptitudes, prior knowledge, intelligence, interests, and sense of personal empowerment that shape how we learn and how we overcome our shortcomings. Some of these differences matter a lot—for example, our ability to abstract underlying principles from new experiences and to convert new knowledge into mental structures. Other differences we may think count for a lot, for example having a verbal or visual learning style, don't.
- On any list of differences that matter most for learning, the *level of language fluency and reading ability* will be at or near the top. While some kinds of difficulties that require increased cognitive effort can strengthen learning, not all difficulties we face have that effect. If the additional effort required to overcome the deficit does not contribute to more robust learning, it's not desirable.

- It is difficult for learners with dyslexia to gain essential reading skills and this disadvantage can create a constellation of other learning difficulties, the high achievers interviewed for a Fortune article argue that some people with dyslexia seem to possess, or to develop, a greater capacity for creativity and problem solving, whether because of their neural wiring or the necessity they face to find ways to compensate for their disability.
- Belief in the learning styles credo is pervasive. The wrongheadedness of this conclusion is manifold. It's not supported by science, and it instills a corrosive, misguided sense of diminished potential.
- Given what is known about learning differences:
    - *Be the one in charge*. You have to suit up, get out the door, and find what you're after. Mastery, especially of complex ideas, skills, and processes, is a quest. It is not a grade on a test, something bestowed by a coach, or a quality that simply seeps into your being with old age and gray hair.
    - *Embrace the notion of successful intelligence*. Go wide: don't roost in a pigeonhole of your preferred learning style but take command of your resources and tap all your "intelligences" to master the knowledge or skill you want to possess. Describe what you want to know, do, or accomplish. Then list the competencies required, what you need to learn, and where you can find the knowledge or skill. Then go get it. Consider your expertise to be in a state of continuing development, practice dynamic testing as a learning strategy to discover your weaknesses, and focus on improving yourself in those areas. It's smart to build on your strengths, but you will become ever more competent and versatile if you also use testing and trial and error to continue to improve in the areas where your knowledge or performance are not pulling their weight.
    - *Adopt active learning strategies* like retrieval practice, spacing, and interleaving. Be aggressive. Like those with dyslexia who have become high achievers, develop workarounds or compensating skills for impediments or holes in your aptitudes. Don't rely on what feels best: use quizzing, peer review, and the other tools to make sure your judgment of what you know and can do is accurate, and that your strategies are moving you toward your goals. Don't assume that you're doing something wrong if the learning feels hard. Remember that difficulties you can overcome with greater cognitive effort will more than repay you in the depth and durability of your learning.
    - *Distill the underlying principles; build the structure.* If you're an example learner, study examples two at a time or more, rather than one by one, asking yourself in what ways they are alike and different. Are the differences such that they require different solutions, or are the similarities such that they respond to a common solution? Break your idea or desired competency down into its component parts. If you think you are a low structure-builder or an example learner trying to learn new material, pause periodically and ask what the central ideas are, what the rules are. Describe each idea and recall the related points. Which are the big ideas, and which are supporting concepts or nuances? If you were to test yourself on the main ideas, how would you describe them? What kind of scaffold or framework can you imagine that holds these central ideas together? Structure is all around us and available to us. By abstracting the underlying rules and piecing them into a structure, you go for more than knowledge. You go for knowhow. And that kind of mastery will put you ahead.

Chapter 7: Increase Your Abilities

- All knowledge and memory are physiological phenomena, held in our neurons and neural pathways. The idea that the brain is not hardwired but plastic, mutable, something that

reorganizes itself with each new task, is a recent revelation, and we are just at the frontiers of understanding what it means and how it works.

- Of course, learning and memory are neural processes. The fact that retrieval practice, spacing, rehearsal, rule learning, and the construction of mental models improve learning and memory is evidence of neuroplasticity and is consistent with scientists' understanding of memory consolidation as an agent for increasing and strengthening the neural pathways by which one is later able to retrieve and apply learning.
- *IQ* is a product of genes and environment. It may be a very small genetic difference that makes one kid more curious than another, but the effect is multiplied in an environment where curiosity is easily piqued and readily satisfied.
- An environmental factor that shapes IQ is *socioeconomic status* and the increased stimulation and nurturing that are more generally available in families who have more resources and education.
- Nutrition affects IQ.
- In the realm of environmental effects, the authors found that enrolling poor children in early education raises IQ by more than four points, and by more than seven if the intervention is based in a center instead of in the home, where stimulation is less consistently sustained.
- Gains in IQ were found in several areas of cognitive training.
- It comes down to the simple but no less profound truth that *effortful learning changes the brain*, building new connections and capability. This single fact—that our intellectual abilities are not fixed from birth but are, to a considerable degree, ours to shape—is a resounding answer to the nagging voice that too often asks us "Why bother?" We make the effort because the effort itself extends the boundaries of our abilities. What we do shapes who we become and what we're capable of doing. The more we do, the more we can do.
- To embrace this principle and reap its benefits is to be sustained through life by a *growth mindset*.
- It comes down to the simple fact that the path to complex mastery or expert performance does not necessarily start from exceptional genes, but it most certainly entails self-discipline, grit, and persistence; with these qualities in healthy measure, if you want to become an expert, you probably can. And whatever you are striving to master, conscious *mnemonic devices* can help to organize and cue the learning for ready retrieval until sustained, deliberate practice and repeated use form the deeper encoding and subconscious mastery that characterize expert performance.

Chapter 8: Make it Stick

- In the final chapter the authors get specific with practical advice. They start with tips for students thinking in particular of high school, college, and graduate school students. Then they speak to lifelong learners, to teachers, and finally to trainers. While the fundamental principles are consistent across these groups, the settings, life stages, and learning materials differ. To help you envision how to apply these tips, they tell the stories of several people who, one way or another, have already found their way to these strategies and are using them to great effect.

Recommendation: The techniques for highly effective learning that are outlined in this book can be put to use right now everywhere learners, teachers, and trainers are at work. They come at no cost, they require no structural reform, and the benefits they promise are both real and long-lasting.

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Dr. Frumi Rachel Barr is truly an entrepreneur having started and run 5 entrepreneurial adventures prior to following her passion for guiding the success of CEOs and their teams to Scale Up.

Money and a plan don't guarantee execution
Execution depends on communication, cascading priorities throughout the organization and an external guide that holds the team accountable and keeps the momentum going. Lots of companies know **what** to do – it's the **doing** that needs an external guide. That's what we provide. We use the best systems on the planet, Gazelles and the Rockefeller Habits, as well as software to track team initiatives and progress.

Dr. Frumi's ***"Why"*** is to create a safe place for leaders and teams to discuss what matters most. She is known as The CEO's Secret Weapon. ***Her Who***: Dr. Frumi guides leaders and their teams who are under 40 and have a thirst for both discipline and learning. These creative, ambitious leaders want to grow their businesses so they have more freedom and a fabulous culture. The Gazelles system focuses on People, Strategy, Execution and Cash, using practical tools to create greater revenue and profitability, with greater collaboration and accountability.

Dr. Frumi is the author of a *CEO's Secret Weapon: How to Accelerate Success*. The book was ranked top business book of 2012 by ExecRank and has a forward by her colleague Simon Sinek, international author of best-selling *Start with Why*.