Chapter 1

Why Deep Learning is So Important... and So Hard

“So convenient it is to be a reasonable creature, since it enables one to find or make a reason for everything one has a mind to do.” Benjamin Franklin

Why Deep Learning is So Important

One of the tectonic changes of the early 21st Century has been the democratization of information. We are in an era unlike any before: instead of having access to information limited to libraries and media conglomerates, the Internet has made information from virtually every source available to anyone with a computer, smartphone, WiFi signal, or data plan. At first, I applauded this development, and even wrote an article in the early 90’s about how expert knowledge that once was stored in university libraries had now transcended those physical boundaries. I predicted that this new “information democracy” would open up minds everywhere and transform how we learn.

A quarter-century later, it turns out that I was half-right. Learning indeed has transformed, but unfortunately in the wrong direction. The fact is that in many ways the Internet has increased closed-mindedness and made deep learning more difficult. Consider the unintended outcomes of Twitter. Originally designed as a way to convey brief messages to a network of followers, Twitter has become a form of “drive-by learning” in 240 characters. The American presidential election in 2016 spawned three new entries in our common lexicon: fake news, inaccurate information propagated by social media intended to solidify existing beliefs; post-truth, “relating to or denoting circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion and personal belief,” the Oxford Dictionary Word of 2016; and truth decay, the blurred line between fact and opinion. This latest entry comes from a sobering report by the RAND Corporation (Kavanaugh & Rich, 2018). The authors write:

Where basic facts and well-supported analyses of these facts were once generally accepted – such as the benefit of using vaccines to protect health – disagreement about even objective facts and well-supported analyses has swelled in recent years. In addition, a growing number of Americans view the U.S. government, media, and academic with new skepticism. These developments drive wedges between policymakers and neighbors alike. (p. 3)

Researchers at RAND have identified four major causes of truth decay: 1) humans’ proclivity to cognitive bias (which I discuss later in this chapter); 2) changes in the volume and dissemination of information, led by cable news and social media, leading

to “self-reinforcing feeds of information”; 3) an educational system that has reduced the emphasis on civic awareness and critical thinking; and finally, 4) polarization of the electorate into isolated communities, each with its own narrative and worldview.

This is a toxic brew indeed. The worrisome implications of these trends for our body politic have been covered extensively by many others. The consensus opinion, held by social scientists, educators, and professional journalists, seems to be that we need to learn to become better critical thinkers (cf. Levitin, 2016), more skeptical of what we read and hear, and better able to discriminate between truth and falsehood, between the plausible and the implausible.

This all seems perfectly reasonable and it is backed up by some solid research. For example, Pennycook and Rand (2018) found that the propensity to think analytically – that is, rational assessment using accepted logic and objective facts – plays a key role in the ability to ferret out misinformation and biased reporting, regardless of one’s political ideology. So far, so good. The question is, where does the ability to think analytically come from, and under what conditions are people motivated to use this skill – or not? A convergence of research has demonstrated that analytic thinking, while good for analyzing arguments, is of little help with what the authors have called “bull***t receptivity” when the BS serves to strengthen one’s own existing belief, and may in fact simply make us better at arguing our case and dismissing others’ points of view (Mercier & Sperber, 2017). In other words, better analytic thinking does not necessarily lead to better learning, and may even inhibit it. The more important question is: what has to happen in order for critical thinking to lead to deep learning? The answers to these questions are complex and often counterintuitive, as we’ll see shortly.

The stakes have never been higher. In his book Thank You for Being Late: An Optimist’s Guide to Thriving in the Age of Accelerations, Thomas Friedman, columnist for the New York Times, argues that the three largest forces on the planet – technology, globalization, and climate change – are all accelerating at once (Friedman, 2017). Not just changing, not just developing, but growing exponentially, all at the same time. For technology he points to Moore’s Law, which states that the power of microchips will double every two years. To date, the data bear this out and show no signs of leveling off. Friedman reports that as of 2017, Intel’s latest microchip improves performance 3500 times compared to the first one introduced in the early 70’s; improves efficiency by more than 90,000 times; and is 60,000 times cheaper!

Friedman defines globalization, the second of the accelerating forces, as “the ability of any individual or company to compete, connect, exchange, or collaborate globally” (pp. 126-127). Because technology has made it possible to digitize everything, Friedman argues, keeping up with the flow of information everywhere has become impossible.

Enter the spread of misinformation. In 2016, shortly before the US presidential election, Aviv Ovadya, Chief Technologist at the Center for Social Media Responsibility, saw something fundamentally wrong with the Internet. Calling it the “Infocalypse,” Ovadya warned of an impending crisis of misinformation. As reported by Buzzfeed:

Ovadya saw early what many — including lawmakers, journalists, and Big Tech CEOs — wouldn’t grasp until months later: Our platformed and algorithmically optimized world is vulnerable — to propaganda, to misinformation, to dark targeted advertising from foreign governments — so much so that it threatens to undermine a cornerstone of human discourse: the credibility of fact. (Warzel, 2018, n.p.)

Due to the combined effects of technology and globalization, the situation is likely to get worse: “ongoing advancements in artificial intelligence and machine learning … can blur the lines between fact and fiction; … those things could usher in a future where, as Ovadya observes, anyone could make it ‘appear as if anything has happened, regardless of whether or not it did’” (Warzel, 2018, n.p.).

Ovadya’s alarmist predictions have been verified in a massive study conducted by researchers at the Massachusetts Institute of Technology. Soroush Vosoughi and his colleagues analyzed about 125,000 of what they called “rumor cascades” spread through Twitter. These were systematically sorted using various fact-checking devices into “true” and “false” categories. The researchers found that not only did false news reach many more people than factual news, it also diffused “significantly farther, faster, deeper, and more broadly” (Vosoughi, 2018, p. 4).

More than a quarter-century ago Charles Handy (1994) predicted that the speed of technology will outpace our collective formation of values around how to use it, and his prediction has come true. The social implications of the “Infocalypse” phenomenon, namely continued “truth decay” and accelerating social polarization, are disquieting, to say the least. A particularly disturbing example is the recent Facebook scandal, during which the data of an estimated 87 million people were improperly shared with Cambridge Analytics for partisan political purposes. The scandal effectively erased the naïve assumption that if Facebook gave people tools, it was largely their responsibility to decide how to use them. It was “wrong in retrospect” to have such a limited view, Mark Zuckerberg later admitted. "Clearly we should have done more, and we will going forward… Today, given what we know... I think we understand that we need to take a broader view of our responsibility," he said, “[namely] that we're not just building tools, but that we need to take full responsibility for the outcomes of how people use those tools as well" (BBC, 2018).

The third of Friedman’s three accelerating forces is climate change. Temperature and
sea level records are being broken every year. Wildfires in California during the summer of 2018 broke all records for damage and loss of life. As Friedman notes, while the power of information flow is “reshaping the workplace and politics and geopolitics and the economy, and even some of our political choices, … the acceleration in Mother Nature is reshaping the whole biosphere, the whole global ecological system” (Friedman, 2017, p. 173).

Friedman’s advice on how to deal with these three accelerating forces might initially seem counter-intuitive: he suggests that we hit the psychological equivalent of a pause button – that we stop and reflect, question our assumptions, and entertain fresh questions that might lead to a change of perspective. Thus the title Thank You for Being Late, inspired by the author who realized he was given the gift of time while waiting for some friends who were late for a breakfast date.

His advice, while provocative, is hardly new. As I will show later in this book, making critical reflection a routine part of one’s life is an idea that has been around for centuries. Socrates, in particular, source of the axiom that “the unexamined life is not worth living,” believed reflection to be the most important value in life. Philosopher Immanuel Kant (1998 trans.) wrote in the 18th Century that humans are distinguished from animals by self-consciousness and the ability to reason. (As we’ll see shortly, this Enlightenment notion of humans as rational creatures, for all its benefits, has led to some of the most enduring myths about our “specialness” as a species.) A quarter-century ago developmental psychologist Robert Kegan, in his book In Over Our Heads: The Mental Demands of Modern Life (Kegan, 1994), wrote that the complexity of modern culture is evolving faster than the capacity of our brains to deal with it. In other words, the failure of our society to encourage the development of higher levels of consciousness retards our ability to keep pace in any meaningful way with the complex roles of modern life, as workers and learners, parents and partners. To continue Kegan’s metaphor, the best and in fact the only way to keep our heads above water, he argues, is to step back, adapt and reframe, and to see all of these life forces as part of a larger system. While Kegan’s focus is on individuals’ ability to cope with the larger social systems around them, parallels to organizations are easy to make.

A good example of this is the work of Peter Vaill (1996), a central figure in organization development, who popularized the metaphor “permanent white water” as the continual state of turbulence facing most modern organizations. Permanent white water has five characteristics, according to Vaill:

- Permanent white water conditions are full of surprises.
- Complex systems tend to produce novel problems.
- Permanent white water conditions feature events that are “messy” and ill structured.
• White water events are often extremely costly.
• Permanent white water conditions raise the problem of recurrence.

In his book *Learning as a Way of Being*, Vaill asserts that the most important way to deal with white-water conditions is to become a more effective learner, because otherwise we experience “feelings of lack of direction, absence of coherence, and loss of meaning” (pp. 16-17).

Being effective in permanent white water requires, primarily, a different perspective about learning itself. The dominant educational model in Western society, what Vaill calls “institutional learning,” is characterized by several dubious assumptions:

1. Learning is a means to a socially desirable end, not an end in itself.
2. Those in authority are in the best position to know what the means and ends should be.
3. A subject matter is “out there” to be learned, and this subject matter expands in predictable ways.
4. The major task for the learner therefore is to absorb this subject matter as efficiently as possible.

Recall my reference to Chris Argyris’ article on “teaching smart people how to learn” (1991) from the Preface to this book: the very success leaders and other professionals have experienced with schooling helps explain the problems they have with learning! Permanent white water poses lethal challenges to the assumptions of institutional learning and requires a different kind of learning altogether. Accelerating forces for change, causing the sensation of being “in over our heads” in “permanent white water,” require a different perspective about learning itself. Later on in this book I will describe this different perspective in detail. But first I need to make the case that getting there will not be easy.

**Why Deep Learning is So Hard**

*Farewell to the Rationalist Philosophy*

Rationalist philosophers, going all the way back to Plato, then re-popularized during the Enlightenment, believed that solving problems was a matter of employing rigorous logic and critical thinking. It turns out that rationalist philosophers simply had it wrong. Pure reason, that is, thinking logically and drawing conclusions based upon the principles of empiricism, is simply not how the brain works. We do not learn to understand the world that way. Contrarian Enlightenment philosopher David Hume had it right when he claimed that “reason is, and ought only to be, the slave of the passions and can never pretend to any other office than to serve and obey them.” Hume believed that reason can be understood only within the context of studying human nature itself. Michael Schermer in his book *The Believing Brain* captures what
we have learned from research on human cognition in the past half-century:

We form our beliefs for a variety of subjective, personal, emotional, and psychological reasons in the context of environments created by family, friends, colleagues, culture, and society at large; after forming our beliefs we then defend, justify, and rationalize them with a host of intellectual reasons, cogent arguments, and rational explanations. Beliefs come first; explanations for beliefs follow. (Shermer, 2011, pp. 261 ff.)

Realizing that most beliefs have a non-rational basis, and that rationality is introduced mostly to justify these beliefs, has been a hard pill to swallow for me personally. I spent much of my adult life convinced that beliefs are formed, and then revised, based upon facts and evidence. I believed tacitly in what Jonathan Haidt (2012) has called the “rationalist delusion” – the notion that reason and emotion are separate and incompatible, and that truth will be served only when passion becomes the servant of the logical mind. For years I took to heart John Adams’ dictum that “facts are stubborn things.” Sure, I thought, people can get things wrong based upon first impressions, but if you simply lay out the facts of the matter, minds will change. I spent a lot of time during the early years of my career doing evaluations of educational programs, and I learned about the limits of evidence the hard way, seeing how, in case after case, decisions were made that had little to do with the amount or quality of evidence presented. One particular case stands out in my mind. I was asked to be the external evaluator of a professional development program for university faculty. I followed all the usual procedures: pre-post surveys, observations of workshops, follow-up interviews of participants. I provided carefully-worded feedback to the project team, which adopted some of my recommendations – the supportive ones – and ignored the recommendations suggesting that they ought to re-think some of the premises on which the program was built. Looking back, I realize today that team members were too invested in their ideas to change them in any significant way. “You’re the evaluator,” I remember one of them telling me, “not one of the creative people.” It took me years to develop a significantly different and distinctly more nuanced view of the role of evidence in decision making. It has been a difficult, even painful, learning curve.

Why Personal Belief Systems Are So Resistant to Change

Understanding why we so resist changing our beliefs is critical to our understanding of deep learning and how to effect it. The roots of this understanding go back to the mid-20th Century and Leon Festinger’s cognitive dissonance theory (1957). Through a series of experiments, Festinger demonstrated that we humans have a strong need to search for internal consistency, so that whenever we experience inconsistency – for example, discovering that the new car we just bought has been poorly-rated by...
Consumer Reports – we are highly motivated to reduce the mental stress this causes by engaging in one of several adaptive responses. We don’t like having the sneaking suspicion that we may have made a mistake, and so we ignore the report, or remember the time we followed the consumer agency’s recommendation and purchased something we later regretted. Here is another example. Smokers routinely experience cognitive dissonance when they are exposed to information that reminds them just how dangerous smoking is to one’s health – or when they are forced outside in freezing weather to take a smoke break. They might do the difficult thing and quit smoking. Or they might:

• Justify their behavior by downplaying the source of the dissonance, e.g., “it’s ok to smoke once in a while.”
• Justify their behavior by adding new conditions, e.g., “if I stop smoking I’ll just gain weight and that’s just as bad.”
• Ignore or deny the dissonant information altogether, e.g., “my grandfather smoked like a chimney and he lived to be 95.”

As anyone who has ever tried to quit smoking knows all too well, it is much easier to justify or ignore the behavior than to change it. In his best-selling book Thinking, Fast and Slow (2011), a masterful compilation of decades of research on human cognition, Nobel laureate Daniel Kahneman puts to rest the view held for centuries that humans will behave in ways consistent with their economic interest. Kahneman demonstrates the myriad ways we humans default to the “automatic,” fast and easy ways of thinking – System 1 – rather than to the “effortful,” slow and difficult System 2. System 1 is innate and required for survival. It allows us to develop implicit understandings of the world around us, telling us what to notice, including potential threats, and giving us the capacity to respond without thinking. Imagine for example that you’re driving along a busy street and notice out of the corner of your eye that the car approaching the stop sign on your right appears to be going too fast to stop in time. You do not construct a mental equation factoring in the car’s velocity and distance to the intersection before you react – no, you realize instinctively that the driver may not stop in time and if you do not hit the brakes there is likely to be a collision. Your instincts keep you from potential harm. The problem is that because System 1 is automatic, fast, and easy, we do not let the effortful, slow, and difficult System 2 kick in often enough, and this can lead to foolish and even dangerous decisions. We act as if all decisions we face involve an impending crash. Moreover, as Kahneman points out, we often lull ourselves into a kind of seductive complacency: “We identify with System 2, the conscious, reasoning self that has beliefs, makes choices, and decides what to think about and what to do, [when in fact System 1] is where the action is” (p. 21).

Contrary to our smug assumptions about how rational we are, the “conscious, reasoning self” that we are so proud of takes over only when we make a conscious
effort. In the above example, someone might suggest to us that we may be stopping too suddenly and risking a rear-end collision. We are then forced into System 2 which considers whether we might be over-reacting.

Kahneman and others have catalogued all of the cognitive mischief that can result when we do not step back and question what is happening at a subconscious, System 1 level. One source lists as many as 36 different variations! (Shermer, 2011, pp. 261 ff.) Luckily, many of these overlap, and all are interconnected. See Figure 1.1. In the center is confirmation bias, “the mother of all cognitive biases” (p. 259). To the left are the enablers of confirmation bias and its underlying dynamics, and to the right are its effects, including its most pernicious, the polarization of group attitudes.

Confirmation bias is likely “the most widely accepted error to come out of the literature on human reasoning” (Evans, 1990, p. 41). The term was coined, most believe, by psychologist Peter Wason (1960) in an experiment testing the willingness of subjects to question their own hypotheses about the mathematical rule governing a series of numbers, such as “2-4-6.” He found that when provided with additional information, subjects were able to build upon and complexify their initial hypotheses, but they hardly ever tried to disconfirm these hypotheses. Wason termed this phenomenon “confirmation bias.” Defined by Michael Shermer as “the tendency to seek and find confirmatory evidence in support of already existing beliefs and ignore or reinterpret disconfirming evidence” (2011, p. 259), confirmation bias is a term that ten years ago almost no one other than cognitive psychologists had ever heard of, and now it is seemingly in everyone’s vocabulary. (There’s a joke about this, of course, along these lines: “since I learned about confirmation bias I now see it everywhere.”)

Like so many other deep insights about the human condition, the phenomenon of confirmation bias was recognized centuries ago. Back in the early 17th Century, Sir Francis Bacon was an early pioneer of empiricism. In his book Novum Organum (“new instrument”), he wrote:

The human understanding when it has once adopted an opinion… draws all things else to support and agree with it. And though there be a greater number and weight of instances to be found on the other side, yet these it either neglects or despises… in order that by this great and pernicious predetermination the authority of its former conclusions may remain inviolate.

(Quoted in Shermer, 2011, p. 294)

In an early and now-famous experiment on confirmation bias (Lord, Ross, & Lepper, 1979), researchers recruited American undergraduate students who either strongly supported or strongly opposed the death penalty and presented them with two fabricated studies of its effectiveness. One study showed the death penalty to be an
effective deterrent, the other did not. Supporters of the death penalty found the study that was consistent with their belief to be convincing and well-conducted; they judged the other one to be poorly designed and carried out. Students who opposed the death penalty had – you guessed it – the opposite reaction.

Numerous examples of confirmation bias exist in history. Among the best is the “Dreyfus Affair.” In the late 19th Century French officer Alfred Dreyfus was accused, on the flimsiest of evidence, of giving military secrets to Germany, a rival power at the time. All it took was an incriminating note that appeared to have handwriting similar to his. The fact that Dreyfus was the lone high-ranking Jew in an anti-Semitic military culture did not help matters any. He was convicted of treason, stripped of his officer’s rank, and sentenced to life on Devil’s Island off the coast of South America. The espionage continued, however, and evidence uncovered later pointed to another officer, whose handwriting was a perfect match for the note. On appeal none of this mattered. Dreyfus, it was argued, had had the foresight to train others to carry on if he were caught, and had even coached them in how to mimic his handwriting! It took the persistence of a fellow officer who was willing to put aside his own anti-Semitism in search of the truth to finally exonerate Dreyfus, but only after Dreyfus had suffered in exile for more than four years, between March 1895 and June 1899.

Other historical examples of confirmation bias have been shown by people who are otherwise famed for their intelligence and creativity. Thomas Edison, for example, continued to argue the superiority of his invention, direct current (DC), well after alternate current (AC) had been shown to be more powerful and efficient. Even more striking is the case of Nobel laureate Linus Pauling. Pauling had long believed in the supposed power of vitamin C to treat a variety of health problems, including serious diseases (Mercier & Sperber, 2017), and he was persuaded by a study that seemed to show the effectiveness of vitamin C on cancer patients. Pauling’s credibility as a scientist enabled series of large-scale, tightly controlled studies, none of which found any evidence to confirm the findings of the earlier study. Nevertheless, instead of acknowledging that his initial hypothesis might have been wrong, Pauling instead attacked the methodology of these followup studies, and he and his wife continued to take high doses of vitamin C daily. Ironically, both eventually died of the very illness they were convinced that vitamin C could prevent.

As the Linus Pauling story so graphically illustrates, pure intelligence and reasoning ability is no protection against confirmation bias. Neither is being a respected social scientist. Robert George (2019) cites several cases of studies where coding errors or outright fabrication somehow escaped the vetting process prior to publication of research articles, and even when discovered took years to retract. His culprit is confirmation bias:

Confirmation bias – and its converse, the aggravated denial of unfavored

results—flourishes when there is a lack of viewpoint diversity in scholarship. As such diversity has waned in the American academy, scholarly journals and federal funding agencies have too often become intellectually inbred. They sometimes constitute an academic version of interlocking directorates on corporate boards, in which decision makers who share the same outlook tend to view each other's work with an insufficiently critical eye. Research that pleases everyone in the club sometimes doesn't get enough scrutiny, even when its results are strikingly implausible. (George, 2019, p. A15)

Available evidence suggests that reasoning ability can make confirmation bias even stronger (Stanovich, 2013). This makes sense, because as we will see shortly, we use our reasoning skills to justify existing beliefs and to pick holes in those that differ from ours.

Hugo Mercier and Dan Sperber conducted a systematic review of the research on confirmation bias and concluded—convincingly, to my mind—that a more accurate term would be "myside bias":

People have no general preference for confirmation. What they find difficult is not looking for counterevidence or counterarguments in general, but only when what is being challenged is their own opinion... Reasoning systematically works to find reasons for our ideas and against ideas we oppose. It always takes our side. As a result, it is preferable to speak of a myside bias rather than of a confirmation bias. (2017, p. 218, emphasis in original)

Confirmation (or myside) bias helps us understand the persistence of belief, that is, holding onto one’s original belief—such as avoiding vaccinations, purchasing guns for “protection,” and drinking unpasteurized milk—in the face of overwhelming contradictory evidence. In their provocatively-titled book Denying to the Grave: Why We Ignore the Facts That Will Save Us, Sara and Jack Gorman (Gorman & Gorman, 2017) cite these and many other examples. Why, one might rightly ask, are people so stubborn?

Consider the flow of Figure 1.1. An individual experiences cognitive dissonance; it is not just a mental puzzler but a gut-level sense of disorientation that leads to a desire for resolution and a return to homeostasis. I have given several examples already of cognitive dissonance; here is another. A young mother sees a posting on Facebook from a close friend that is linked to a website purporting to show the link between childhood immunization (specifically the vaccine for measles, mumps, and rubella, or MMR) and the development of autism. Alarmed by the mental image of her young son becoming autistic, she thanks her friend and clicks on a link to a video featuring a Hollywood celebrity who has a child with autism. The celebrity interviews other parents of autistic children, all of whom have been immunized, and points to a
“scientific” study claiming to establish a cause-effect relationship. The video ends with a chart showing the profits pharmaceutical firms make from manufacturing the vaccines, darkly insinuating a conspiracy to suppress the evidence of harm. “That does it,” the mother thinks, “I need to protect my children from Big Pharma.” She now has an intuitive theory about the relationship between MMR and autism, made stronger by the desire to protect her son, setting her up for probable confirmation/myside bias. Some months later the child’s pediatrician suggests that it’s time for the boy to get the MMR vaccine. The mother declines, whereupon the physician warns her about the risks of these diseases, giving her data showing how dangerous and even life-threatening they can be. Immediately, the young mother experiences the same sensation she had when she saw the video of autistic children and recalls how she imagined her own son suffering the same fate. She does not have a similar image of her son with measles and holds firm to her decision. After the office visit she watches the video again, and does not look for any readily available materials challenging the validity of the video. The mother’s fear speaks louder than data.

This vignette is an example of what has become known as the “Dunning-Kruger effect”: the failure of those who lack expertise to accurately appraise their own knowledge compared to the expertise of experts (Dunning, 2011). A study reported in 2018 on the influence of the Dunning-Kruger effect on beliefs about the relationship between childhood vaccination and autism contains some illuminating findings (Motta, Callaghan, & Sylvester, 2018). After surveying more than 1000 US adults, the authors discovered that more than a third of respondents thought they knew as much or more than either doctors or scientists about the subject; those with the highest levels of over-confidence also knew the least about it! Researchers also found that overconfidence was related to opposition to mandatory vaccination policy and increased support for the role that non-experts should play in determining such policies. The authors did not find that over-confidence was significantly related to a loss of confidence in experts, but rather that it tended to give more credence to the testimonies of celebrities and other non-experts. Still, the researchers concluded that Dunning-Kruger effects should be “carefully considered in future research on anti-vaccine policy attitudes” (p. 274).

As Figure 1.1 indicates, intuitive theories can arise from a variety of sources. I have just illustrated one of these, the formation of causal assumptions. Humans specialize in reasoning about how the world works, about causality: why something happened, what caused it. Other sources include lived experience, patternicity, and reductive thinking. All of us experience seeing the sun “coming up” in the morning and “going down” in the evening; for some this leads to a mental model of the sun revolving

around the earth, despite what we learned in elementary school. Our perceptual experience can easily override conceptual models.

Another contributor to intuitive theories is “patternicity,” or “the tendency to find meaningful patterns in both meaningful and meaningless noise” (Shermer, 2011, p. 60). We are hard-wired to find patterns in incoming data. The idea that some things are random is hard to handle. And yet, the laws of probability make even unlikely events happen rather often. There’s a clever little law called “Littlewood’s Law of Miracles (Lane, 2018). It goes this way: imagine the odds of something happening are a million to one; now imagine that we perceive one bit of information per second. If you calculate the number of seconds in a month, more than a million, this means that you will experience a “miracle” on the average of once a month! You run into someone from your high school graduating class 20 years ago on a street in Paris; you see the image of the Virgin Mary on a piece of toast; and so on.

Patternicity is often quite benign, as when we say a basketball player has a “hot hand,” when in fact the laws of probability dictate that sooner or later that player will hit five shots in a row. Patternicity becomes more serious when the suggestion that an event is “random” creates the uncomfortable feeling that we lack control over our environment. We therefore have evolved to look for cause-effect relationships, even where none exist. Given incomplete or unrepresentative data, we tend to jump to invalid conclusions. A common rule in statistics is that correlation does not equal causation. Some years ago, when teaching a research methods course I decided to test the students’ comprehension of this principle, and so brought in a newspaper article from the day before, stating that researchers had found a relationship between children’s reading scores and whether they normally had breakfast in the morning. I casually asked the students, “so what are the educational implications of this finding?” You guessed it: make sure kids have breakfast so they’ll learn better! Now just imagine how many other explanations, how many potential intervening variables, there might be for this.

Our discomfort with the random and uncontrollable is why terrorism works: the fear that something that could strike anywhere at any time is more acute than the worry that we might be involved in a traffic accident, even though the latter is much more likely. In their book Denying to the Grave, the Gordons provide a number of examples of how we persistently over-estimate small risks and underestimate large ones. One of these is the widespread concern over the Ebola virus, which posed a negligible risk to those living in the Western Hemisphere. One can almost feel their exasperation when they write, “How many people smoked a cigarette or consumed a sugary breakfast cereal while reading about the threat they faced in catching Ebola?” (Gordon & Gordon, p. 2).
Another contributor to intuitive belief is *reductive thinking*. The propensity to default to System 1 leads to the avoidance of complexity. As Steven Sloman and Philip Fernbach put it, “We ignore complexity by overestimating how much we know how things work, by living life in the belief that we know how things work even when we don’t” (Sloman & Fernbach, 2017, p. 35). This leads to the Dunning-Kruger effect – the “illusion of understanding,” tolerating complexity by failing to understand it – and thus, for example, the seductive appeal of Twitter, reducing complex issues to a series of sound-bites, not that hard to understand in this era of complexity and rapid change.

Again, Daniel Kahneman’s research (2011) helps explain the pervasiveness of reductive thinking in our lives. Our natural drive to make meaning of the world around us (which I explore more fully in the next chapter) leads to forming mental models of how the world works. Inevitably, because these mental models represent our constructions of reality, they lead us to think in terms of categories: “chairs,” “buildings,” “planets.” We get into trouble when we assume homogeneity within categories and ignore the diversity, which leads to stereotyping.

Intuitive beliefs, as Andrew Shtulman notes in his book *Scienceblind*, are a “double-edged sword”:

> On one hand, they broaden our perspective of the phenomena they seek to explain and refine our interactions with those phenomena because holding an intuitive theory is better than holding no theory at all. On the other hand, they close our minds to ideas and observations that are inconsistent with those theories and they keep us from discovering the true nature of how things work… To get the world right, we cannot simply refine our intuitive theories; we must dismantle them and rebuild them from their foundations. (Shtulman, 2017, p. 11).

To review the chapter to this point: Intuitive beliefs arise from perceived experience. We attempt to make easy meaning of experience through patternicity, causal assumptions, and reductive thinking. When presented with information that is discordant with these beliefs we experience cognitive dissonance, which System 1 thinking encourages us to resolve through confirmation bias.

Confirmation bias is not, unfortunately, a one-off phenomenon. As suggested earlier in this chapter, and as indicated in Figure 1.1, confirmation bias promotes *belief persistence*, holding on to one’s original belief in the face of overwhelming contrary evidence. In their fascinating book, *The Enigma of Reason* (2017), Mercier and Sperber explore what they call a “double enigma”: why did human reason evolve to be so complex and different from other animals? And if evolution is the result of useful
adaptations to the environment, then why did human reason evolve in such a flawed way? Sperber and Mercier, both cognitive scientists, argue that intuition and reasoning are not separate phenomena but that reasoning is a kind of “intuitive inference.” “Reasons,” they write, “play a central role in the after-the-fact explanation and justification of our intuitions, not in the process of intuitive inference itself” (p. 117). Reason, therefore, is intuition about reasons, used in interactions with others for the purpose of producing arguments in favor of “myside” and evaluating critically the reasons of the “otherside.”

So how is this environmentally adaptive? Mercier and Sperber argue that humans are unique in how we have evolved complex forms of cooperation. Using what they call an “interactionist” perspective, they point to a body of research undertaken by them and many others to argue that human reasoning is ineffective, even counterproductive, when done alone. As we have seen already, solitary reasoning often fails to correct intuitive beliefs, and, due to various forms of confirmation bias, can even make matters worse. Reasoning works best when it takes place when interacting with others. “Take reason out of the interactive context in which it evolved,” the authors note, “and nothing guarantees that it will yield adaptive results” (p. 10).

But how can “cooperation” emerge from interactions characterized by one side generating arguments for their own beliefs, while also criticizing the validity of beliefs on the other side – and while the other side is doing the same thing? Mercier and Sperber (2017) point to a substantial body of evidence that if a group has a common interest in finding the “truth,” or has a shared interest in solving a problem, argumentation generally arrives at the “best” decision. But this, I would argue, is a big if. Jonathan Haidt, psychologist and expert in moral reasoning, has demonstrated how impervious moral judgments are to opposing arguments. No matter how strong they are, rebuttals of one’s moral judgments by others will seldom change their minds (Haidt, 2012). As persuasive as arguments for the interactionist approach may be, they fail to account for how reason might deal effectively with intuitive beliefs that have a strong affective basis. When someone is emotionally invested in a belief, especially when that belief is part of one’s identity, pure rationality fails to deliver.

Belief persistence is reinforced in two ways, according to Sperber and Mercier (2017): by the “lazy production” of supporting reasons and the “strong production” of opposing reasons. Just as we are not very good at acknowledging our own biases, we are very good at recognizing biases in others. We are able to come up with justifications for our beliefs quickly and easily. For example, if one opposes capital punishment s/he will be able to generate a list of reasons for that view with little

trouble: it’s not an effective deterrent; it costs the state more than life imprisonment; it systematically discriminates against those without means to hire quality legal representation; it forestalls the possibility of correcting a potential injustice; it is a barbaric practice that most civilized nations have foresworn long ago. (As an opponent of capital punishment myself, I generated this list in less than a minute.) I have a much harder time critiquing my position, and it takes longer. In the amount of time it took to generate all of the supporting reasons, I could come up with only one in opposition: that the state ought to have an ultimate penalty available for the most heinous of crimes. If, on the other hand, I were in a discussion with someone on the other side, I’d be able to shoot down virtually all of that person’s arguments (at least to my satisfaction), and feel pretty good about doing so.

A point that I will make over and over in this book is that we over-emphasize the role of cognition and downplay the role of emotion, both in how we learn and in how we change. Belief persistence is not just a function of a highly-evolved ability to argue in a social context. It is also a function of psychological defense mechanisms that protect our egos from attack. One of these is what Ori and Ron Brafman have called “loss aversion” (Brafman & Brafman, 2008). Simply stated, “we experience the pain associated with a loss much more vividly than we do the joy of experiencing a gain” (p. 18). Loss aversion explains why casino owners make so much money: they count on customers chasing rather than cutting their losses. Loss aversion also accounts for what Zachary Shore calls “exposure anxiety,” one of several reasons he cites for why otherwise-smart people make dumb – and in some cases disastrous – decisions. Shore explains: “Exposure anxiety is more than just a fear. It is a belief that the failure to act in a manner perceived as firm will result in the weakening of one’s position” (Shore, 2008, p. 14). It is, in other words, fear of loss of face. I leave the reader to imagine just how many times this very fear has led political and military leaders to blunder into decisions that history has judged to be complete disasters.4

Developmental psychologists Robert Kegan and Lisa Lahey have done some ground-breaking research on the psychological mechanisms behind the emotional grip that irrational beliefs have on us. They call these mechanisms, collectively, “immunity to change (ITC),” arguing that real change is not just a matter of overcoming old beliefs but rather unearthing, naming, and facing what they call “competing commitments” (Kegan & Lahey, 2009). Kegan and Lahey chose the term “immunity” deliberately, intending to show that just as our bodies have complex immune systems designed to protect us from disease and other threats to our physical well-being, we also have psychological immune systems that serve to ward off anxiety. These immunities, Kegan and Lahey argue, are often dysfunctional, keeping us from making the developmental changes we sincerely want to make. Because immunities are

subconscious, we are unaware of their existence and their power over us, and we thus experience anxiety, not just from change but also at the thought of change. Thus, when we engage in a self-improvement effort such as losing weight, we find ourselves unable to stick with the goal we have set for ourselves, ending up with frustration and self-blaming.

Kegan and Lahey demonstrate how these immunity systems can be changed, situating their model in constructive-developmental theory and sharing examples, both personal and organizational, from their own practices. They introduce a five-step exercise designed to uncover the unconscious immunities, make them conscious, and create experiences that mitigates their hold on us. I will be exploring this process as a tool for deep learning later in this book.

Kegan and Lahey’s work, along with that of the other scholars cited in this chapter, should reveal the critical importance of paying attention to the role of emotion in learning. We need to become more critical thinkers, yes: in both school and in our adult experience we need to learn how to step back, evaluate facts, and form evidence-based conclusions. But we also need to learn that we will not always behave that way in real life. Much of what cognitive science has taught us over the years is what individual humans can’t do – what our limitations are. Ignoring the power of these limitations leads to the sort of self-delusion that in turn leads to myside bias, belief persistence, and ultimately the pernicious effects of polarized attitudes, of the sort described at the beginning of this chapter. What we need are useful, research-based ways of dealing with and overcoming these limitations, the central focus of this book. First, however, I want to review how the brain works.
Chapter 2

How We Learn: A Short Primer

“Education consists mainly in what we have unlearned.” Mark Twain

So far in this book I have argued that understanding deep learning and how to promote it is both important and difficult, especially in today’s turbulent world and with the seductive appeal of drive-by learning. In this chapter I go back to the basics of human learning, focusing less on its flaws and more on the process itself. My goal is to lay the groundwork and provide an evidentiary basis for proposals I make later in the book.

In many ways, what we know today about how people learn has been a matter of rediscovering some old truths. Consider the following maxims:

“Teachers open the door. You enter by yourself.” Chinese proverb

“What we have to learn to do, we learn by doing.” Aristotle

“You cannot teach a man anything; you can only help him find it within himself.” Galileo

“Tell me and I forget. Teach me and I remember. Involve me and I learn.” Benjamin Franklin

Think about these for a moment. What do they have in common?

If you are like most people, you will observe that all four statements speak to learning as an activity that requires intentionality and action, and is best achieved when that learning is facilitated more than dictated. Recent research in human cognition has largely confirmed the ancient wisdom, but has also challenged it in two ways: first it has exposed the limits of rationalism, as we saw in the previous chapter; second and relatedly, it has demonstrated the critical partnership between cognition and emotion. I will get to both of these shortly; first I need to provide a very brief foundation with some basic neuroanatomy.

Inside Your Brain

For an organ that consumes so much energy, generates such enormous activity, and holds the keys to our individual identities, our brains are smaller than most people think: they weigh only about four pounds in the average adult, and are small enough to hold in the palm of your hand. Thanks to developments in positron-emission tomography (PET) and magnetic resource imaging (MRI), today’s neuroscientists are better able to connect structure with function. The largest portion of the brain is the...
cerebrum, responsible for thinking, body movement, interpreting stimuli, and memory. The cerebrum has four regions, or lobes, each with a specific function. (See Figure 2.1.)

[Figure 2.1 about here.]

The occipital lobe, at the very back of the brain, is where visual stimuli are processed; the temporal lobe, near the ears, deals with language, sound, and understanding speech; the parietal lobe, at the top of the brain and the back of the head, handles motor skills, movement, and orientation; and the frontal lobe, right behind the forehead, deals with intellectual tasks, planning and decision making. It is the last to develop, not fully until early adulthood. The thin outside surface of the cerebrum, about the thickness of a grapefruit skin, is the cerebral cortex containing about 100 billion neurons, which essentially manage the work of the brain.

Deep inside our brains is the limbic system, which manages emotions (see Figure 2.2).

[Insert Figure 2.2 about here.]

Among the key structures of the limbic system, two are most responsible for learning. One is the amygdala, which seeks to make meaning of experience, mostly at an unconscious level. In situations of uncertainty it stimulates the frontal lobe to kick in, encouraging us to think it through. The other is the hippocampus, which is more concerned with memory. It takes in information from the senses, packages and processes the separate stimuli and then sends them to the cortex where the information becomes part of long-term memory.

Finally, just below the cerebrum is the cerebellum, the primary source of motor control (Wright, et al. 2016). The cerebellum is where somatic learning resides, the source of “muscle memory.” When a behavior is practiced over and over again, the sequence of actions required becomes automatic, such as typing on a keyboard, driving a car with a manual transmission, or staying upright on skies.

This has been a drastically truncated tour of the brain, and here is why: while technology has enabled scientists to map various sensations to certain regions based on analyses of neural firings, as the technology has become more sophisticated, linking regions with functions has become murkier. For example, the cerebellum used to be thought of as almost a separate organ, representing more primitive evolutionary stages; now it appears to play a role in various aspects of cognition, including language. This makes understanding the interplay between sensation and meaning-making a more complex challenge. For example, where do emotions come from? How are they triggered? How are they regulated? The answers to these questions are still a matter of debate, and some of the evidence may seem counterintuitive. More on this shortly, but first I want to provide some further context.

The physiology of learning. Here are some amazing statistics about how we learn to make meaning of the world around us. A child is born with about 100 billion neurons, all he or she will ever have. If these neurons are energized they will become part of the brain’s circuitry, but they will die if un-stimulated. A newborn’s neurons have relatively few connections, or synapses, between them, but these increase rapidly as a function of the child’s experience with his or her environment. In the first years of life a child will have created many thousands of synapses with each neuron, so that by the age of two he or she will have already created the same number of synaptic connections as a fully-grown adult. Now here is the amazing part: by about age 6 our brains have created twice that number, and are twice as active; but then after age 8 or 10 or so, the number of synapses gradually decreases, until by about age 18 we’ve gone back to the same number we had when we were age 2. (Not that we go back to thinking like a two-year old, of course: the adult brain retains a remarkable degree of flexibility, and if exercised, continues to mold its physical structure well into old age.) So, I ask, why is this? How does this happen? Why is so much synaptic pruning going on after early childhood? My guess is that the reader’s first response is, “school!” Formal schooling indoctrinates us on what to think and how – basically what is important to know. And yes, there is certainly some truth to this. But there is a biological answer, demonstrated by a lot of cross-cultural research (Shatz, 1992). Consider for a moment the life of a 6-year-old. Everything is interesting, everything is important. Kids that age are veritable sponges of information, as every parent knows. Now imagine what it would be like if adults had the same synaptic connections they had at age 6, and imagine the mental chaos. Our brains use middle and late childhood to figure out how the world works by reinforcing some networks and letting others die out. Only those that are reinforced survive. We create individual mental models, the key to survival dating back to our earliest days as humans, to make meaning out of chaos.

Unfortunately, meaning making can take us in strange directions, as we saw in Chapter 1. Here are some more examples:

In 2008 the International Center for the Advancement of Scientific Literacy at the University of Michigan put together a short quiz and administered it to a random sample of 2500 US citizens. One of the questions was, “How long does it take for the earth to go around the sun?” The three choices were: “one day,” “one month,” and “one year.” Only 67% of respondents had the correct answer. The clear inference here is that about one person in every three walking down the street doesn’t know a basic fact about our solar system – that the earth is a planet taking a year to revolve around the sun – even though virtually every kid in school has to make a model of the solar system at one time or other (King, 2015).
Now in case these researchers just picked an unusually dull group to survey, consider this: a researcher gets the bright idea of going around with a video camera after Harvard’s commencement exercises, when new graduates are standing around looking smug, taking photos with their parents. She sticks the camera in their faces, asking common-sense questions like, “why is it warmer in the summer than in winter?” Out of 23 randomly-chosen graduates (plus some alumni and faculty), 21 were factually incorrect, most stating that seasons are caused because the earth is closer to the sun in the summer and further away in the winter. One of the students answering incorrectly had taken several physics courses at Harvard, including one in “planetary motion”! (A Private Universe, 1987). These people learned the same stuff about the solar system in elementary school that the people in the Michigan survey did, so what is going on? It turns out that when asked to reconsider their answers, most did in fact get it right; but they had seized upon the first mental model that came to mind, which is the simple principle that the closer an object is to a heat source, the hotter it will get. Retrieving a more complicated mental model, about how the earth is tilted on its axis, which affects the angle of the sun’s rays, is harder. These people were, in essence, relying on System 1 thinking, when what they really needed to do was to pull up System 2 (Kahneman, 2011).

Here is a short thought experiment. Read through the following carefully. What is being described?

A newspaper is better than a magazine, and on a seashore is a better place than a street. At first, it is better to run than walk. Also, you may have to try several times. It takes some skill but it's easy to learn. Even young children can enjoy it. Once successful, complications are minimal. Birds seldom get too close. One needs lots of room. Rain soaks in very fast. Too many people doing the same thing can also cause problems. If there are no complications, it can be very peaceful. A rock will serve as an anchor. If things break loose from it, however, you will not get a second chance.

Give up? The answer is in the endnote.

Now it all seems obvious. The reason it was not so obvious right away is that a mental model did not exist in which to put the description.

The above example illustrates how important the process of meaning-making is. Every time we are presented with new information, we first attempt to fit it into an existing knowledge structure, a whole network of categories that our brains have organized for us. If a category immediately occurs to us, that is where the new information goes, and that is what Daniel Kahneman (2011) means by “thinking fast,” or System 1. The same principle applies to recalling information, such as in the Harvard example above. Without any clues, however, our brains scramble to find a

connection, and System 2 thinking kicks in. As Kahneman points out, System 2 makes our brains work harder, and so our usual preference is to default to System 1 whenever possible; therefore, he advises, we must learn to recognize situations in which mistakes are likely and try harder to avoid significant mistakes when the stakes are high.

Fair enough; but the problem is, how can we do that when our intuitive biases exist at a subconscious level? How do we keep from becoming ensnared by cognitive traps without even knowing it?

**Experiential learning theories**

Key to addressing these questions is the nature of human experience. The central role of experience in learning, as shown by the quotes that opened this chapter, has been appreciated for centuries. Paradoxically, however, the period known as the Enlightenment, ushered in by Galileo and others in the 17th Century, also ushered in one of its more dubious achievements, what is known as “Cartesian thinking,” named after philosopher Rene Descartes’ notion of dualism, that “there is a great difference between mind and body, inasmuch as body is by nature always divisible, and the mind is entirely indivisible… the mind or soul of man is entirely different from the body” (quoted in McNerney, 2011, pp. 1-2).

We have already seen in Chapter 1 the mischief this kind of purely rationalist thinking can cause. Some serious cracks began to appear in dualistic, Cartesian thinking in the late 19th Century with the writing of philosopher William James, and later John Dewey, both pioneers of American pragmatism. In a landmark essay, “What Is an Emotion?” James debunked the thinking that emotion is simply a byproduct of cognition:

> Our natural way of thinking about standard emotions is that the mental perception of some fact excites the mental affection called the emotion, and that this latter state of mind gives rise to the bodily expression. My thesis on the contrary is that the bodily changes follow directly the perception of the exciting fact, and that our feeling of the same changes as they occur is the emotion. (James, 1884, pp. 4-5, emphasis in original)

In other words, how we feel about something is not determined by how we think about it, but just the reverse. The sensation – the experience – comes first, followed by the brain’s interpretation and meaning-making of that experience. With his anticipation of the function of the amygdala as the chief interpreter of sensation, James demonstrated in this essay a remarkable ability to foresee advances in neuroscience by nearly a hundred years. He also understood the key role of emotion in human judgment, and how it can often lead us astray. In the uniquely Victorian vernacular of his time he wrote, “peculiarly conformed pieces of the world’s furniture.

will fatally call forth most particular mental and bodily reactions, in advance of, and often in direct opposition to, the verdict of our deliberate reason concerning them” (p. 4).

Later in the early 20th Century philosopher/educator/engaged citizen John Dewey laid out a comprehensive theory of experiential learning, first in 1916 and revised 22 years later (Dewey, 1938). Dewey, too, recognized the key role of emotion in human judgment, seeing it as the main entry into what he called “a life of thought.” He envisioned the human mind not as a storehouse of ideas but as how humans make meaning of experience, and thus manage and lead lives of useful activity. Early in his career, spurred by such social upheavals as the Pullman Strike in 1893 – a widespread work stoppage and boycott of the railways that turned violent – Dewey turned to schools as democracy’s best hope. Children’s “inner nature,” he felt, grows from within but must be completed through relationships, and thus schools must be a reflection of life. To the degree that schools are laboratories for living, society progresses toward greater democracy and social justice. Dewey’s ideas were central to what became known as the “progressive education” movement (Martin, 2002). In the late 1930’s, following attacks on freedom of expression in schools and universities in the USA, Dewey published *Experience & Education* (1938), a powerful restatement of the role of experience in learning. First he debunked the misunderstood notion that children, and people generally, “learn by doing.” Some experiences, he averred, can be “mis-educative,” that is, can be “unintelligent doing” that results in learning the wrong things. An “educative” experience, on the other hand, “arouses curiosity, strengthens initiative, and sets up desires and purposes that are sufficiently intense to carry a person over dead places in the future” (1938, p. 38). In this one sentence, Dewey encapsulates core ideas of deep learning, and I will be returning to his work extensively later in this book.

Part of what Dewey meant by “educative experience” is what has become known as *experiential learning theory*, introduced by psychologist David Kolb (Kolb, 1984). In his “experiential learning cycle,” Kolb essentially turned formal education upside down: Instead of building knowledge by learning abstract concepts and then applying them, what radical educator Paulo Freire (1970) called the “banking model” of formal education, what the learner does in real life is to build knowledge by experiencing an event, reflecting on it, developing an abstract interpretation of it, and finally acting on this interpretation, thus generating further experience, reflection, theorizing, and action.

[Insert Figure 2.3 about here.]

This model, probably because it is simple, plausible and easy to grasp, has been used and adapted thousands of times in every conceivable learning context over the years, and, inevitably, due to its simplicity and intuitive appeal, has also been the target of From Wergin, J.F. (2019, forthcoming). *Deep Learning in a Disorienting World*. Cambridge University Press. Do not cite or copy without permission of the author.
harsh criticism. Still, Kolb’s learning cycle, with its clear connections to neuroscience research and to emerging models of adult development, has had an enormous impact on how we think about learning and about connecting learning with action, and has led to such paradigm-changing epistemologies as action research (cf. McNiff, 2017), and practice-based research (Jarvis, 1999).

One offshoot of the renewed interest in the interaction between action and cognition is research into embodied cognition, “the idea that the mind is not only connected to the body but that the body influences the mind” (McNerney, 2011, p. ). The key to understanding embodied learning that we do not just learn from experience, we also learn in experience. It is a felt reaction to experience that feels “right” or “wrong,” and in adults this reaction can be quite nuanced. For example, the positive feeling created by the friendly behavior of a gracious hostess may lead someone who doesn't know her well to perceive her as “sincere,” in contrast, someone who has experienced her cordiality as superficial in prior experiences would think of the same conduct as “smarmy.” Cognition that does not occur from and in experience will not create learning for experience. Sharan Merriam and her colleagues cite as an ironic example college courses that take on issues of social justice but only in an abstract, disembodied way, leading to students becoming quite sophisticated in critical social analysis but unable to apply these skills in real life – or even in simulations of real life (Merriam, Caffarella, & Baumgartner, 2007).

Aristotle understood the importance of embodied learning centuries ago, when he described three kinds of knowing: episteme, knowing what and why; techne, knowing how; and phronesis, knowing when. Quite simply, we may know a lot about issues of power and inequality, for example, and be skilled at knowing how to analyze them, but we may not know when and in what context to use these skills most effectively. One of the most dramatic examples of phronesis is the story of a nomadic tribe of “sea gypsies” in Thailand (Freiler, 2008). Most were able to survive the catastrophic tsunami of 2004, unlike thousands of others. When asked how they survived when so many others did not, they replied that they sensed a change in their environment, both in the sea and in other living things, that caused them to take higher ground before the tsunami actually struck. Another example is what is known in mining as “pit sense.” In the dangerous setting of a coal mine, miners must learn to detect minute changes in their environment as a way of constantly assessing their safety; tellingly, this way of knowing depends not only on the miners’ individual perceptions but also the senses of others in the mine (Freiler, 2008). Note how, in both of these examples knowing when is triggered by a sensory experience which is interpreted intuitively as a potential threat. Knowing when an experience feels “right” can be powerful as well. In baseball an experienced base-stealer will often know when to try for second base because it just “feels” right. An expert poker player will know when it is “right” to

bluff with a weak hand. *Phronesis* is, in essence, practical wisdom, the ability to know when to rely on intuition (System 1) and when to make the effort to dig more deeply (System 2) (Kahneman, 2011). Practical wisdom is a topic I will return to later in the book.

Intuition, as I have pointed out numerous times already, is necessary for our survival; and it can also keep us from making wise choices. Given that intuitive biases exist at a subconscious level, what then has to happen in order for them to surface and be acted upon?

It turns out that we do have a solid theory about this, known as *transformative learning theory*, developed about the same time as experiential learning theory, and now arguably the dominant theory in adult learning. According to its originator Jack Mezirow, adults learn to become

… critically aware of how and why our presuppositions … constrain the way we perceive, understand, and feel about our world; of reformulating these assumptions to permit a more inclusive, discriminating, permeable, integrative perspective, and of making decisions or otherwise acting upon these new understandings. (Mezirow, 2009, p. 14)

And what transcends the cognitive traps that block the critical awareness that Mezirow describes? What nudges us from System 1 into System 2? Mezirow (2000) asserts that adults can learn deeply only by experiencing what he calls a “disorienting dilemma,” a problem that does not fit into existing mental models (or “meaning schemes,” as Mezirow called them). You experience something that catches you off-guard, off-balance, something you can’t quite make sense of, something you can’t easily make meaning of. And it is too disturbing to ignore. The disorientation causes System 2 to kick in and you are forced to examine your assumptions and create, through reflection, a new mental model, thus transforming your set of knowledge perspectives. Mezirow suggests that while transformative learning can happen within the individual, it is most powerful in group dialogue, where people can try on the perspectives of others. Disorienting dilemmas can be small, like having to find your way around a strange city when your GPS isn’t working, or they can be large, such as facing life-changing events like the loss of a job or a serious health or relationship problem.

Mezirow’s theory has been exhaustively studied and criticized. Available empirical evidence does support the notion that changes in one’s meaning perspectives are triggered by a disorienting dilemma, followed by a set of learning strategies that involve critical reflection and exploration of options in a social relationship (Taylor, 1994). Two criticisms are leveled most commonly at the theory. First is that his theory puts too much emphasis on rationality – that more intuitive and holistic views of

learning are needed. In an exhaustive review of empirical studies of transformative learning, Taylor (1994) concluded that “transformative learning is not just rationally and consciously driven but incorporates a variety of nonrational and unconscious modalities for revising meaning structures” (p. 48). (Note the connection here to the role of emotion in creating and protecting beliefs, as discussed in Chapter 1.) The second criticism is that the theory pays insufficient attention to transformation in the service of social change, the focus of the great emancipatory educator Paulo Freire. Oppressed peoples, Freire believed, become empowered to change the world through critical reflection in a community of learners (Freire, 1970). Praxis, the combination of reflection and action, is the key to overcoming oppression. True education, according to Freire, is always a political act.

I will be covering transformative learning on both an individual and group level much more extensively in later chapters. For now, I want to make two points about how useful this theory is to our understanding of cognitive bias, and more importantly, how it might help us deal with the challenges that bias poses to deep learning.

First is Mezirow’s emphasis on the importance of group dialogue. Recall from the previous chapter how private reflection on one’s strongly-held beliefs usually does not only not change these beliefs but can even make them stronger. With some exceptions, reflection and argumentation with others is what matters. I explore this in more depth in Chapter 6.

Second, we would not have a disorienting experience in the first place were it not for an emotional trigger. Without that an unusual experience is just a puzzle, one that we may be curious about and even want to explore. We may wonder, for example, how the magician David Copperfield could make the Statue of Liberty “disappear” in front of a thousand spectators, but our beliefs about the laws of physics are never at risk, because everyone knows that it’s a trick. On the other hand, feeling “tricked” is bound to create disorientation. Recently I was waiting for a connecting flight at New York’s Newark airport, browsing in a shop along the concourse. I was approached by a disheveled-looking young man who asked if I “traveled a lot.” He then proceeded to give me a long story about how he was a recent college graduate who had been stranded overnight by a canceled flight to Pittsburgh and could not get on another flight until the next day. He showed me his original and “new” boarding pass as evidence, along with a driver’s license and the business card of an executive in the company he was about to join. He was desperate for a place to stay overnight (and he certainly looked like he needed it), but he had no credit cards as yet and had to pay everything in cash. Could I please loan him money for meals and hotel room? He took my address and promised to pay me back right away. I took pity on him, withdrew some money from an ATM and gave it to him, and he scurried away with lavish thanks for how I confirmed his belief that “there were still good people in the
world.” Now, I would not be relating this story if he had paid me back. Instead, the experience gave me a disorienting dilemma and led to a modest shift in my self-concept, from “generous person” to “easily-duped person.”

Much of the research on human learning, particularly in adults, supports the basic tenets of transformative learning, without necessarily acknowledging so. Here is an especially impressive example. Higher education researchers Ernest Pascarella and Patrick Terenzini conducted an exhaustive investigation into learning in college, covering 35 years of research and more than 5,000 books, journal articles, and miscellaneous reports (Pascarella & Terenzini, 1991). The product of this work was so massive that their students referred to it, with grudging admiration, as “Moby Book.” The authors published an equally massive update, ten years later (Pascarella & Terenzini, 2005). Reflecting back on decades of research, Terenzini compiled a list of six “experiences that promote student learning” (Terenzini, 2014). Note how similar these six optimal learning experiences are to what has been reviewed so far on adult learning:

Experiences that promote student learning:

1. Almost uniformly involve encounters with difference, both with people different from themselves and with ideas different from those currently held. Because they challenge existing beliefs these encounters create cognitive dissonance.
2. Require active engagement with these challenges. Deep learning will not occur if the learner does not address the cognitive dissonance.
3. Occur in a supportive environment, offering opportunities for reasonable risk-taking without fear of failure.
4. Emphasize meaningful and real-world activities, including dealing with unstructured problems.
5. Involve other people and interpersonal activities that will spark a challenge.
6. Invite and encourage reflection and analysis.

The role of emotion in learning

As should be evident by now, learning is not just a cognitive process. Most experts now agree that without emotion, deep learning is at best hit-and-miss. Unless learning has an emotional component it is not likely to last. If you want to be sure that learning will stick, you have to be sure that the learner cares about the learning.

A landmark book by moral philosopher Martha Nussbaum explores how emotions shape the “landscape of our mental and social lives” (Nussbaum, 2001, p. 1). Emotions, she wrote, “involve judgments about important things, judgments in which, appraising an external object as salient for our own well-being, we acknowledge our own neediness and incompleteness before parts of the world that we

do not fully control” (p. 19). Thus, far from having to be bottled up or pushed aside, emotions are essential if we are to engage the world and allow deep learning to occur.

This philosophical view has been backed up by recent research, captured beautifully by Lisa Feldman Barrett’s pioneering work (2017) on how the brain creates emotions. From her research Feldman demonstrates that, contrary to conventional – and intuitive – thinking, sensations do not trigger certain “emotion centers” in the brain. Rather, emotions are constructed by the brain, in the same way that cognition constructs mental models of reality. Barrett defines her theory of constructed emotion this way:

In every waking moment, your brain uses past experience, organized as concepts, to guide your actions and give your sensations meaning. When the concepts involved are emotion concepts, your brain constructs instances of emotion. (p. 31)

The brain constructs emotions in the moment, as part of the way it makes meaning of sensory stimuli. It makes meaning of a situation so that we will know what to do in that moment. The brain will make meaning of the same visual stimulus in vastly different ways. Approaching the first drop of a roller coaster will produce physiological responses similar to those when approaching the edge of a steep cliff; the former will be constructed as “excitement,” while the latter will be constructed as “fear.” Further, emotions are socially-constructed and culture-specific. Feldman states: “your familiar emotion concepts are built-in only because you grew up in a particular social context where these emotion concepts are meaningful and useful, and your brain applies them outside your awareness to construct your experiences. Heart rate changes are inevitable; their emotional meaning is not. Other cultures can and do make other kinds of meaning from the same sensory input” (p. 33).

Today the key role of emotion in learning is clear and largely uncontested. Emotion does not only stimulate learning, it is part of the learning process itself. Emotion can be a force for deep learning, as when a disorienting dilemma leads to reflection and perspective transformation; it can also be a significant barrier to deep learning, as when someone encounters information counter to his or her belief system and reduces the anxiety this produces by resorting to myside bias.

So where, then is that sweet spot, that level of disorientation where people experience just enough discomfort with the status quo that they are able to reflect on what’s going on and try something new? That point where we experience not just a felt need to change but also a desire to change? What is the right balance between the body’s need to regulate stress and maintain homeostasis, as neurologist and neuroscientist Antonio Damasio (2018) has described it, and taking a creative risk that will upset that homeostasis, at least temporarily? To address these questions, I turn now to what we know about motivation to learn.

Motivation and learning in adults

I invite the reader to think for a moment about why you have chosen to read this far into the book. Is it because you are concerned about the amount of drive-by learning that goes on in the face of the accelerating challenges we face as a society? Because you are curious about the positive steps we might take to meet these challenges? Or, I hope, maybe both? Whatever the reason, you are demonstrating right now a motivation to learn. (I am assuming that the motivation is intrinsic, even if you’re reading this as a required text!) As we’ve already seen, this simple question: why do people behave the way they do? leads to complex, often counterintuitive, and sometimes paradoxical answers.

Motivation is the link between emotion and action. It is purposeful behavior focused on accomplishing a goal. Part of the challenge in understanding motivation, as Wlodkowski (2008) points out in his comprehensive treatment of the subject, is that because motivation is an abstraction, a construct, we cannot measure it directly but must instead rely on observing someone’s behavior. Nonetheless, the prodigious literature on human motivation over the years has led to some common understandings:

First, the drive for humans to make meaning of the world is innate (Chater & Loewenstein, 2016). “The brain has an inherent inclination for knowing what it wants… We are compelled to pay attention to things that matter to us. Every moment of our lives is a competition among our senses to perceive what matters most” (Wlodkowski, pp. 17-18). Sensations accompanied by emotion get preferential treatment. Motivation is thus a complex interplay of sensations, emotions, and thoughts that are mixing and re-mixing in any given moment, in the body’s constant attempts to achieve homeostasis (Damasio, 2018).

Second, motivation is not an inherent part of our character. Labeling someone as “unmotivated” is unhelpful and wrong (Ahl, 2006). The culture we grew up in and the networks of which we are a part have a huge influence, as does the immediate context. A recent study found that one’s identity – that is, the amalgam of what we understand about ourselves and understandings assigned to us through social position – is a major factor in motivation to learn, and is always socially negotiated. In their study of motivation to learn among novice teachers, researchers found that identification had two major consequences:

First, as might be expected, when teaching practices resonated with novices’ extant identities (i.e., they saw them as valuable and feasible), they engaged more readily and deeply in learning them… Second, when teaching practices did not resonate with novices’ extant identities – but messages in the environment linked them to desired identities – then novices overrode their...
initial concerns and persisted in learning them anyway. (Nolen, Horn, & Ward, 2015, p. 238)

Third, despite the importance of culture and social context, certain sources of motivation are, if not innate, certainly cross-cultural. These include curiosity about the world; the desire to belong and to feel valued; and to feel efficacious,"ii quite simply, the feeling that what we do matters, that we have had a desirable impact on the world around us. Each of these motivators has roots in other somatic-neurological processes. Curiosity arises from the need to make meaning, a drive that remains largely undiminished throughout the lifespan. The desire to belong and feel valued stems from an innate need to feel safe, in a community that accepts us and that will help protect us from harm. The need for efficacy stems from an innate disposition to not only make meaning of the world but to interact effectively with it. Together, these universal “motivators” help ease what Parker Palmer has called the “pain of disconnection” from the world around us (Palmer, 1998).

These universal sources of motivation will of course manifest themselves differently, depending on the social and cultural context. My own research on the factors that affect motivation among university faculty, for example, turned up four: autonomy, community, recognition, and efficacy (Wergin, 2001). “Autonomy” was closely related to curiosity: the freedom to experiment, to follow one’s own leads wherever they may go, and to do so without fear of the consequences. “Community” was related to the need for belonging, to feel as if one is part of a professional community that cares about them. “Recognition” was the need to feel valued by that community, to know that others see their work as worthwhile. And, “efficacy” in an academic community meant that faculty had a sense that their work had an impact on their scholarly disciplines.

Fourth, motivation not only mediates learning but is a consequence of learning as well (Wlodkowski, 2008). The more motivated someone is to learn, the more enjoyable the learning, and the greater the motivation is to learn more. At the same time, no matter how high, motivation will not help someone accomplish a learning task that is significantly beyond their skill level or their ability to cope with the increasing complexity of modern life. In fact, due to the frustration and anxiety this causes, the likely result will be paralysis or a desire to escape. Finding examples of this in one’s own life is, sadly, far too easy. I was clumsy and overweight as a youngster, but I wanted desperately to fit in with the other guys, so I went out for football. The coach used the daily practice as a way to act out his fantasies as an army drill instructor, and he made my life miserable. Not only did I stop going to practice, I developed an “unathletic” identity, one that lasted into early adulthood, and one that led me to avoid participating in competitive athletics of any kind.

Given this landscape, what then motivates adults to learn deeply? I have sprinkled a few clues throughout this chapter and will now make them more explicit.

Adults want to learn lots of things, for all kinds of reasons, related mostly to what is seen as practical and relevant to their lives. They want learning to be self-directed, not dictated by what others think they should learn (Knowles, 1984). They want to build new learning from life experience, to test this new learning, and to integrate it into their own lives. They want the learning to be enjoyable, but not necessarily easy: they seek competence but also value the challenge (Wlodkowski, 2008).

All of the above are necessary for deep learning to occur, but only the last one distinguishes deep learning from the others. Deep learning happens when existing beliefs are challenged, but only within the limits of a person’s perceived ability to handle the challenge. To put it another way, deep learning is achieved when an optimal tension exists: between a perceived challenge to one’s existing belief system on the one hand, and a perceived level of confidence in one’s ability to create new meaning in that system, on the other. Note the interaction of the “universal motivators” in this definition, how they are not independent and additive but intertwined and conflicting! A disorienting dilemma should make us curious, but not so curious that we put ourselves in a place that feels isolated and unsafe. We want to make meaning of and interact with the dilemma, but only within socially-sanctioned limits. We need to feel that changing our belief system will make us more competent in dealing with our environment, as long as doing so will not threaten our important social networks (and our cherished self-images).

Conclusion

My goal in this chapter has been to lay the groundwork and provide an evidentiary basis for proposals I make later in the book. Whereas Chapter 1 focused on the challenges to deep learning, Chapter 2 has considered the necessary ingredients for deep learning to occur. They can be summed up this way:

Deep learning depends on how we make meaning of experience. Most of the time, this occurs at a level below conscious awareness, and most of the time this is appropriate and necessary. Using existing mental models, our brains interpret sensations based on prior experience, judge their importance, and when necessary construct an emotion that leads to a behavioral response. Small deviations from expected experience are handled smoothly. For example, while driving we constantly monitor other motorists’ behavior, and have learned how to detect variations from “normal.” Behavior that is interpreted as abnormal will lead to a response dictated by the emotion the brain constructs: say, either contempt (“where’d that idiot learn to drive”?) or fear (“that car isn’t going to stop at the red light!”). The first leads to an action of (real or imagined) eye-rolling, the second to hitting the brakes. Sometimes, however, making meaning using existing neural networks and mental models is
insufficient: something feels particularly discordant or “off”; something creates enough cognitive dissonance that it elevates an experience to a conscious disquietude. For example, while reading the op-ed page of the newspaper we glance at the headlines of various columnists. For the familiar ones we have formed mental models of their views. We read with pleasure the views consistent with ours, and with irritation those that are not. If, however, a cherished pundit expresses an opinion that is significantly different from our own, cognitive dissonance ensues, and depending on the valence of the emotion constructed around that dissonance, we either choose to examine our beliefs or stop reading and write off the essay as an aberration. This is easy to do if we are reading alone but harder if the piece becomes a topic of discussion with others and we are forced to explain why we dismissed the op-ed piece so quickly.iii Our motivation to examine and possibly change our beliefs will then depend on the balance between the strength of the experienced challenge and the sense of our own competence in the moment. If the sense of challenge is too strong we experience anxiety and the motivation to escape the discussion. If the sense of competence is too strong we reinforce existing beliefs by constructing counterarguments. In either case the opportunity for deep learning disappears. If, however, the disorientation is experienced in a safe social space, safe enough to unlock our innate curiosity and allow us to imagine that changing our perspective will help us become more competent in dealing with our environment, the gate to deep learning opens.

1 The authors reference Frankfurt’s (On bullshit, 2005) intriguing distinction between lying and bullshit: “Whereas lying involves a deliberate attempt at concealing the truth, which implies a concern for the truth, bullshit is constructed absent concern for the truth” (p. 9). The idea of doing something about the creation and spread of BS seems to be catching on, exemplified by a popular course at the University of Washington, “Calling Bullshit: Data Reasoning in a Digital World” (McWilliams, 2019).

2 The Dreyfus case has been cited in several sources as a dramatic illustration of confirmation bias. One of the most engaging is a TED talk by Julia Galef (2016).

3 Pauling did however live to be 93.


vi See Bloom (2005) for a fuller treatment of neuroanatomy.

vii Much of the material in this section is adapted from Shatz, (1992).

viii Flying a kite. Thanks to Dr. Shelley Chapman for the example.

Defined as, “whenever people behave for the satisfaction inherent in the behavior itself.” (Ryan & Deci, 2017, p. 4).

Ahl argues that motivation should not be regarded as something that lies within the individual; it is rather “a construct of those who see it lacking in others” (p. 385).

See Bandura (1977) for a full treatment of efficacy and learning.

A great example of this is the famous TV newscast by respected American journalist Walter Cronkite who, after a trip to cover the Vietnam war in the late 1960’s, concluded that the war was at a stalemate, and unwinnable. Historians have pointed to Cronkite’s announcement as a pivotal moment, leading millions who had supported the war to then have grave doubts about it.