BRAIN GAIN:
TECHNOLOGY AND THE QUEST FOR DIGITAL WISDOM

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Chapter 1: The Human Mind
Improved, Extended, Enhanced, Amplified (and Liberated) by Technology

Technology.

You may be a fan or a foe. A believer or a skeptic. You may be a "crackberry" addict, a person who can't live without your iPhone or iPad (or whatever those technologies have become by the time you read this) or you may be someone with a huge desire to turn it all off. You may be a constant upgrader of every gadget, or a reluctant user of any.

But whether you are personally for or against modern digital technology (or have, as most of us do, a view somewhere in between), today's technology is *changing your mind*—and all of our minds—for the better. Modern technology is, in the terms of different writers, "extending our minds," "cognitively enhancing" us, "amplifying" our consciousness, creating a "cognitive surplus," offering us "mental prostheses," "extending our thinking powers," and "improving our thought processes and concentration."[1]

As a result of technology, we are all becoming, at different speeds, better thinkers, and better, wiser *people.*

Why can I say this and claim it is true with such certainty? I can make this assertion with confidence because every human today who both has access to modern technology and is willing to use it can:

- sift through terabytes of information, quickly sorting the wanted from the unwanted, the good from the bad in ways they couldn't do before
- accurately and rapidly find and compare old and new thoughts and ideas that they couldn't find in the past
- discover links and influences that no one knew existed
- create much more than previously what is in their imaginations
- liberate far more of their creativity than people used to
- understand their own biases and overcome them better than before
- make more accurate predictions than ever
- perform much deeper, more accurate analyses, foreseeing unintended consequences of actions
- plan and prioritize better
- understand their body far more accurately and forestall or prevent disease
- make better medical decisions than they ever could
- remember much about our lives (including what we read) that we used to forget
- communicate their thoughts and emotions directly, even at long distances.

And that is just a sampling of what technology-enhanced humans can now do that people couldn't do in the past.

Attitude Matters

Many of these enormous technological benefits come to us today more or less automatically, without our having to take any action at all, and often in ways over which we have little or no control. We all benefit, for example, without really doing anything special, from technology's increasing ability to help us predict the weather, to make our transactions secure, to provide us with communications networks, and to offer us up-to-date information.

Awareness of other benefits of technology depends on our particular situation. Farmers many have a special appreciation of the kinds of agricultural help that technology can provide in their area of the world. People with disabilities may have a greater awareness than others of technology's ability to create better prostheses.

But there are a great many benefits that technology offers that depend heavily on our *attitude* toward that technology and our willingness to accept and use it. People certainly can, as many do, regard technology with a very skeptical eye, and not adopt

anything unless they are absolutely forced to. But my belief is that if people, rather than resist or reject the technical changes that come at them, maintain a positive—though critical—attitude toward technology, and if people take positive, proactive steps to integrate technology with their minds and their lives, they will all be far better off.

Of course, in today's world, keeping a positive attitude toward technology is not always easy. Pretty much everyone in the world—rich or poor—has problems and issues with whatever technology they use, often on a daily basis. Parts break down. Components go missing. Power gets interrupted. Signals are weak. No one is immune to this.

Even the great *New York Times* technology writer David Pogue, author of countless books on technology's benefits and host of several TV shows on that topic, and certainly no technophobe, recently worried on his blog about the fact that his son did not want to part from his iPad no matter where he went. "I think my six-year-old is addicted to the iPad," he wrote on his blog, soliciting help from other parents, who responded in droves.[2] If Pogue, one of the world's great technology advocates, is concerned about technology's effects, where does that leave the rest of us?

Not to worry.

We should, of course, all be concerned about technology's problems, for multiple reasons. There are, we all know, people who misuse technology, some deliberately. There are people who become addicted to practically anything, technology included, (and I hope Pogue's son is not among these). No one wants to be inconvenienced unduly by technology, without a "backup" way of getting what they need done.

But in my experience, when it comes to technology, far too many people confuse the specific "I was inconvenienced this morning" with the general "technology can't be relied on." Far too many conflate someone's—particularly a child's—heavy use and enjoyment of technology with the type of clinical addiction that actually ruins people's lives.

It takes only a few obvious counter-examples to quickly expose the flaws in this type of thinking. Does the fact that most of us carry watches (or cell phones) make us addicted to them, in the clinical sense that they ruin our lives? Few would answer yes (although some might want to change "ruin" to "run.") Does the fact that the activities of "rabid" sports fans, devout religious practitioners, or even avid readers often interfere with things they have to do make those people addicts? Very infrequently. People rarely cross that line.

A favorite example of mine is air travel, which is a complex combination of many technologies. We often hear people complaining about it, citing problems with lost luggage, or telling stories about being trapped for long periods in planes on the ground. Yet as a frequent traveler around the globe, I can attest to the fact that commercial airline technology, taken as a whole, is one of the very *best* and most reliable technologies in the world. I *always* get to where I am going, I am rarely late, and the chance of an accident is miniscule. This despite the enormous technological complexity of all the equipment. But one bad flight can form your attitude about the whole industry.

And that is what too often happens with all technology: People's bad experience with some aspect of technology overwhelms their sense of the whole. For the vast majority, technology, taken as a whole, greatly helps and enables us—it often helps us do more of whatever we really enjoy, and improves our lives.

In general, most people, at some level, know this.

But even with this knowledge, when many of those same individuals look around and see people's noses buried in cell phones, or see children spending huge amounts of their time on their computer or Xbox, they start to get concerned. That's somehow *different.* Now the technology is somehow affecting our *minds.*

Yes, it is. *Everything* we do affects our minds. And, at the same time it affects our brains. It has always been thus.

But it doesn't have to be—or even for the most part—negatively. In fact, I believe what's happening is just the opposite: our minds are being enhanced and freed. What I hope to show you in this book is why and how.

Brain, Mind, and the State of Neuroscience

Given this book's title, you could be forgiven for thinking it is yet another book on neuroscience, one of the vast number being published these days. But it is not.

Neuroscience is doing some wonderful and deeply revealing things. I am a big fan of brain research and try to follow it closely. Some recent experiments, for example, suggest that one long-standing science fiction dream, the ability to read minds, may not be far off. Scientists have recorded brain signals that they think are associated with specific images.[3] They have recorded signals they believe correspond to specific spatial locations in a virtual world.[4] They have caused specific events to happen by playing previously recorded signals back.[5] Compared to what we could do only a few years ago, these results are extraordinary.

But we have to be very careful.

The human brain is the most complex thing on earth, and we are still very far from fully understanding it. Today, we know a great deal about how individual neurons work, how they communicate, and how they build additional structures in response to learning. We know a lot about the chemical communication that occurs at synapses, and more about how the strength of these connections gets reinforced or inhibited. We know more about the chemicals—neurotransmitters, such as dopamine, serotonin, norepinephrine, and many others—that wash around various areas of the brain in response to outside stimuli, creating pleasure rewards, elation, depression, and other feelings.

What we know much less about, however, is how groups of neurons work together to produce results, and, ultimately, our thoughts. We know that the various areas of the brain are massively interconnected, and that communication and feedback are continuously going on. We can identify some of the "superhighways" of our brains' neuron pathways, but we are just beginning to understand the smaller paths and how they work. This complex, often twoway interconnection is known as the "connectome" of the brain, the web of all the interconnections between neurons and areas. As we begin to better understand and map this web, we will still need to discover how it functions, in a similar way that just looking at the map of a place provides little information about traffic patterns or what happens there.

We are also learning more about the brain as an electrical machine, producing effects and fields that we are just beginning to measure and understand. "The brain is best understood as an energy landscape," says Dr. Shaun Jones.[6]

What this means is that we currently only understand *parts* of how the brain works—not the full picture. You might read in the popular press, for example, that some particular activity produces a "dopamine squirt," but the full picture is, almost certainly, a set of far more complex interactions. There are several systems that involve dopamine, and at least five types of dopamine receptors. A similar level of complexity exists everywhere in the brain. Although we learn more every day, there are whole parts of the brain the function of which is not completely understood, such as the glial cells, and many areas where neuroscientists' thinking is currently undergoing revision. Theories abound. Some hypothesize there may be structures called tubules, that we haven't even seen yet and don't understand at all, inside which quantum calculation takes place.[7] We are just at the beginning of exploring the brain's electrical micro-fields.[8]

In addition, some of the knowledge to come out of the neuroscience research is not very widely shared, partly because "relatively few people have the [required level] of understanding," says neuroscientist Dr. Michael Merzenich. And much of what *is* shared is disputed—I was surprised and appalled (as I'm sure you would be) by some of the adjectives very prominent neuroscientists apply to each other's work—and to each other.

One reason we still have such an incomplete knowledge of the brain, particularly the functioning brain, is that our tools, although highly sophisticated compared to what we had in the past, are still blunt and primitive relative to the sophistication level of the object they are studying. Several neuroscientists I spoke with used the word "crude" in characterizing their tools. For example, functional magnetic resonance induction (fMRI), a technique that allows us to see some of the brain's functioning, provides far less resolution than we require. It also requires that the patient lay flat in a huge, very noisy machine, which is hardly representative of the way we perform tasks in life. Some scientists try to do better by combining fMRI with other techniques such as transcranial magnetic imaging (TMI), electroencephalograms (EEG), and other techniques such as diffusion tensor imaging. But major disagreements occur. Some neuroscientists think, for example, that the many studies we have on animal brains are highly relevant to human brains, while others think the human brain is different enough in its organization that comparisons are difficult.[9]

As a result, although we have collected a great deal of data, many of the "conclusions" based on that data are just inferences and hypotheses—educated, intelligent guesses, really—that attempt to put the data into a coherent picture. It's not that our scientists are not smart or clever in their guesswork— they are. Some of their hypotheses will no doubt turn out to be right, or on the right track. But many of the theories conflict or differ. And some recent studies have indicated that some researchers need to be more careful in their analysis.[10] So, we do more experiments.

We are very early in the process of understanding the human brain's full functioning. "There are a great many blanks . . . huge gaps remain," says famed linguist Noam Chomsky.[11] Some of the most interesting developments are only just starting, with new tools to detect them just now being created.[12] Many ideas are still controversial. Many neuroscientists think new knowledge, yet to come, will change much of our current understanding of how the brain works.

Which is why this is *not,* despite its title, a book about neuroscience. But it *is* a book about our brains and minds getting better.

The brain gain I am concerned about in this volume is not an increase in our understanding about how the brain's components and structures work internally to produce ideas and wisdom—because we don't yet know much of this. This book is concerned, rather, with the ways that our brain interacts with external technologies and with the products that those technologies produce (such as new software, or new drugs, for example). It is brain gain in a less technical, and more metaphorical, sense than a neuroscientist using the term might wish. But it is brain gain (and mind gain) nonetheless.

The brain gain I am talking about here is also enormously subjective. It cannot be easily quantified. We cannot say today (and may never be able to say) that "because of this technology our brain is enhanced by x amount, or by y percent." But the brain gain is, nonetheless, happening, and can be recognized by almost all of us. Scientists already observe some physical brain gains, such when the hippocampi of London cab drivers expand to "contain" the "knowledge" of London's streets,[13] or when the cerebellum grows in professional musicians.[14] But mostly the gains show up as expanded human capabilities.

One thing everyone *does* know is that the mind can change. As we learn and acquire experience, we frequently "change our minds" (as we say)—some of us more often than others. We all know that people can learn new things and produce new thoughts and insights over the course of an entire lifetime, which is why we humans make the effort to create and provide education for both young and old—we believe it is important to help peoples' minds change in ways that are positive. We also know that much of the mind develops as we grow, with some parts of the brain continuing to develop long after we are born—that is one reason we often associate wisdom with older people whose minds have been influenced by a lifetime of experience.

Our Brain's and Minds' Strengths (and Weaknesses)

It is important to underscore that while the human brain, and the mind it creates, are in many ways amazing, they are far from being perfect. Everything in life has both strengths and weaknesses, and this is certainly true of the human mind and brain.

Despite our well-deserved place at the top of the pyramid of creatures, the limits of man's capabilities are many. We are born helpless. Our bodies can tolerate, without assistance from clothes and shelter, a pretty narrow range of conditions. Disease can ravage and kill us, often suddenly. Our physical attributes are often less capable than

those of other animals. Mentally, we are born prematurely—in order to be able to pass, some think, through the birth canal.

Still, there are clearly things the human mind can do brilliantly. Among the many things the human mind is known for doing especially well are

- reasoning,
- reflecting and contemplating,
- combining reason and emotion,
- solving problems,
- learning from experience,
- working with other people,
- creating,
- storing and retrieving,
- building up expertise,
- having empathy,
- having a sense of context,
- having a sense of humor,
- telling stories, and I should also mention

- lying.

I won't go into these, since all of these strengths are widely known and expressed continually by people in millions of ways, from our normal lives to mankind's great stories, accomplishments, and works of art.

But, wonderful and powerful as it is, the human mind also has severe limitations. And these do require some explanation. For example:

- ***Limitation:*** The human mind makes decisions based on only a portion of the available data.

It is well-known that the human brain has severe limitations on what it can store and process. In short-term memory the brain can retain as few as seven (plus or minus 2) digits at a time. Although with prompting we can often recall many long-forgotten things, we do know that even the best minds, with the best training (with which people can remember surprising amounts), are limited.

In previous eras, when the volume of information in the world was much more restricted, the limitations in the capacity of our memories were rarely much of a problem—people were able to keep most of what they needed in life in their heads. Yet even then we created reference books of logarithms and other information that that was considered a useless taking up of mental space. Now the volume of information has increased by many orders of magnitude. Almost unimaginable amounts of data are collected every day about the world's environment and about its inhabitants—collectively and individually. The total data is now measured in exabytes (i.e., 10 with 16 zeros), zettabytes (10 with 21 zeros) and soon yottabytes (10 with 24 zeros). With today's collection capabilities, the amount of information in the world, even on relatively narrow topics, is beyond the capacity of all the humans on earth put together to remember. Humans' inability to store even a tiny percentage of the useful available data in our heads is now a much more debilitating limitation.

There are also severe restrictions on human brains' ability to *process* information—that is, to keep it all in some kind of an array and manipulate it in useful ways. Scientists often equate a person's ability to process information to their amount of "working memory." At the current time there is still great debate as to exactly what working memory is, and how much of it individuals have. Some suspect that the amount of working memory a person has is closely related to his or her intelligence—and may, in fact, be that intelligence. Although people can often perceive patterns in large data sets, particularly if presented visually, the limit on what human minds can take in and think about all at once, compared to the amount of data now available, is quite low. Wouldn't it be brain gain if we could handle more?

- ***Limitation:*** The human mind fills in, and makes up, what it doesn't know.

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In his book *Thinking Fast and Slow,* Nobel Prize winner Daniel Kahneman points out that part of the mind will automatically make up a story to fit whatever facts it sees.[15] It matters little whether or not that story has any basis in truth—it just has to fit the facts as the people perceive them. That is one reason why eyewitnesses are often so unreliable—their brains have filled in pieces that were missing to create a believable narrative. Even scientists make up the parts of their story they don't know—it is called theorizing. The problem

with this situation, and with how our brains work, is that lots of things we may think are true are often wrong, and only made up.

Wouldn't it be brain gain if we had better tools to tell which things are made up and which are not?

- ***Limitation:*** The human mind makes assumptions, often inaccurate, about the thoughts or intentions of others.

  One highly positive feature of a healthy human mind is that it can read subtle clues, including facial expression, tone of voice, and body language, to ascertain the thoughts and intentions of others. Yet people cannot do this perfectly.

  Mistaking someone else's intentions is a common occurrence, and often leads to problems and embarrassment. This is even common among people who know each other quite well, including siblings and couples who have been together for many years. It is certainly commonplace in business and in all negotiations. The limitation on understanding the thoughts and intentions of others is exacerbated when people try, for one reason or another, to conceal their thoughts and intentions, as when they are negotiating or playing poker.

  While this particular failing of our minds can at times provoke humor—as in, for example, Shakespeare's *Comedy of Errors*—in the extreme not understanding other's intentions and thoughts can lead to terrible problems, and even to war.

  Wouldn't it be brain gain if we could overcome this limitation, even in part?

- ***Limitation:*** The human mind depends on educated guessing and verification (i.e., the traditional scientific method) to find new answers.

  Because humans often cannot not know or understand things just by looking at them, we needed to invent a good procedure for figuring things out. That procedure, which was perfected only over recent centuries, is known as the scientific method. It consists of making educated guesses (hypotheses) based on what is known and observed, and then doing experiments to see if results predicted by those guesses are true.

While the scientific method has proved enormously useful to humanity, it is a particularly difficult, time-consuming, and inefficient way to find things out. It also doesn't lead necessarily to the "correct" answer, because new data may appear later, and because better-designed experiments or more sensitive equipment may detect something different.

Wouldn't it be brain gain if there were other approaches that got around these limitations?

- ***Limitation:*** The human mind cannot deal well with complexity beyond a certain point.

Most real-life situations involve many interactions and competing forces. The human mind is actually good at handling much of this complexity and weighing and evaluating many variables, particularly with experience to draw on. Sometimes we call on "eggheads" and "wonks" with advanced degrees to do this for us, but many people can deal naturally with a great deal of complexity, even without any formal training.[16]

Still, there are only so many variables the human mind can accurately keep track of. Many of the complex projects and undertakings that humans are now capable of quickly exceed that limit. Unaided, the human mind cannot track all the variables even in projects of moderate size, and many of today's projects, whether they be space exploration, scientific research, large engineering efforts, or worldwide business endeavors, are, in their detail, far beyond the scope of any unaided human mind or group of minds to deal with.

Wouldn't it be brain gain if this could be made more possible, and even easy?

- ***Limitation:*** The human mind is constrained in its ability to predict the future and construct what-if scenarios.

A great many useful things that humans do, from understanding our climate to waging war, depend on our ability to think ahead and predict what the consequences of various actions will be. The human mind can do this, but only to a limited extent.

When projecting out into the future, at some point the mind can no longer keep track of all the possibilities; it must rely on shortcuts, hunches, and rules of thumb (technically known as heuristics). Such shortcuts are often considered wise, when they predict correctly, but very often they are inaccurate. No human can predict complex situations perfectly—many weather reports have us wearing snow boots for nothing. In order for human minds to simplify the process of making predictions so-called second-order and third-order effects (i.e., the effects of effects) are often misjudged or ignored.

Wouldn't it be brain gain if we could get better at predicting?

- ***Limitation:*** The human mind cannot see, hear, touch, feel, or smell beyond the range of our senses.

We know the human mind is terrific at integrating and interpreting the results of its built-in sensors for sight, hearing, smell, touch, taste, and detecting things like temperature, pain, and balance. That's how we get along in the world.

The range of a human's built-in sensors, however, is extremely limited. Human eyes can detect only a tiny portion of what we know is an extremely broad electromagnetic spectrum. Our ears and noses detect far less than those of many animals—dogs can have up to 300 million scent receptors, compared to a human's 5 million. We are just learning that human diseases and cancers can give off recognizable smells that dogs and other animals are able to detect. But even the best animals often detect far less than what is out there to be detected.

As we discover the full potential spectrum of the world in which we live, we increasingly come up against limitations in what we, as humans, can sense directly. Instruments such as radio telescopes, electron microscopes, seismometers, etc., clearly do much to augment this.

But wouldn't it be brain gain if there were better ways to sense, and to integrate all the sensors' data into our brains?

- ***Limitation:*** The human mind finds it difficult to hold multiple perspectives simultaneously.

Most of us are familiar with the optical illusions in which one can see either the face or the vase, either the old hag or the young woman, but not both at once.

Our minds tend, particularly without help and training, to view things in a polarized way (as we say in the vernacular, as either black or white). Much of our education is learning to see and deal with the "grey areas" in between the extremes. There are always multiple perspectives of the same event, yet our minds, unaided, typically accept only one of them. The human mind is also subject to a number of other limiting biases, or "mental illusions," such the "priming" influence of things we see in advance of our decisions. Daniel Kahneman discusses several of these mind limitations and mental illusions in his book *Thinking Fast and Slow.*[17])

Wouldn't it be brain gain if we could hold and deal with multiple perspectives more easily, and overcome other biases in our thinking as well?

- ***Limitation:*** The human mind has difficulty separating emotional responses from rational conclusions.

  Humans are always balancing the emotional and the rational. Kahneman theorizes that that the human mind has, in fact, evolved two separate and distinct modes (or "systems" as he calls them) for thinking: a quick emotional mode (what Malcolm Gladwell refers to as "blink."[18]) and a slower more rational mode.[19] It takes effort to distinguish between the modes and to know which is operating. "Engage brain before opening mouth" is a humorous way to express this.

  Wouldn't it be brain gain if we could more easily both detect which system we were using and, even better, combine them to best effect in most situations?

- ***Limitation:*** The human mind gets bored.

  Humans are not particularly fond of doing the same thing over and over, time after time (except, interestingly, when the reward is random, variable, and has a large potential upside, as with slot machines).

  When required to do repetition, the mind typically creates what neuroscientists call "patterns" or "zombies"—brain structures that allow us to go through the needed pattern over and over while removing it from our conscious thought. This is what happens when you knit while talking, or find yourself suddenly arriving home when you had planned to stop at the cleaners: Your zombie took over. While zombies have certain advantages, they remove critical thought. We speak, for example, of "mindless" repetition.

Wouldn't it be brain gain if we could find ways to do repetitious tasks and still keep them under our conscious control when useful, and even enjoy them?

- ***Limitation:*** The human mind forgets.

  Humans are horrendous at remembering. "Even as I read," says Pierre Bayard, author of *How to Talk about Books You Haven't Read,* "I start to forget what I have read, and this process is inevitable."[20] "I am a man of no retentiveness," said Montaigne.[21] "To think," says writer Jorge Luis Borges, "is to forget."[22] We forget

far more than we remember, far more, generally, than we want to. Some, like Borges, argue it would harm us if we did remember everything, clogging up our mind with useless data. Our minds have evolved some ways of selecting what is important to remember, often by tying this to an emotional connection. But this is an imperfect system, sometimes leading to trauma from unwanted memories.

Wouldn't it be brain gain if we could store everything and recall whatever we want exactly when we want or need it?

The above is just a sample of the human mind's limitations, weaknesses, and failings. More examples can be found in Malcolm Gladwell's *Blink* (2005), Daniel Kahneman's *Thinking Fast and Slow* (2011), Nassim Taleb's *The Black Swan* (2011) and in many other volumes.[23] Even though philosophers and psychologists have been thinking about these issues for quite a while, we are still learning more about our mind's limits. Some of these limits may have been, at one time, useful adaptations, such as the ability to clear our minds by forgetting. They have only become limitations as our culture has changed— which, of course, it has, dramatically.

This is why the kind of technology-enhanced evolution that I describe in this book is so important. In many cases, it is the limitations of the human brain that are now preventing twenty-first-century humans from reaching the heights to which we are potentially capable.

In the past these failings were more easily compensated for (and less widely acknowledged). Our unaided minds, in most cases, were sufficient to solve the problems presented to us. Today that is no longer the case. Today our minds, to be their most effective, require the addition of technology. As writer David Brin puts it, "Technology is the most recently evolved part of the brain."[24]

Technology's Weaknesses (and Strengths)

Technology, of course, and particularly the digital technology we use today, has its own set of inherent weaknesses and issues. Technology has traditionally been thought of as "dumb," although the reality is that this is changing: "Smarter Than You Think" was the title of a 2010–2011series of articles about technology in the *New York Times.*25 Writes Richard Dawkins: "There is a popular cliché . . . which says that you cannot get out of computers any more than you have put in . . . , that computers can only do exactly what you tell them to, and that therefore computers

are never creative. This cliché is true only in a crashingly trivial sense i.e., in the same sense in which Shakespeare never wrote anything except what his first schoolteacher taught him to write—words."[26]

Still, machines do not think in the same sense that humans do. They cannot holistically grasp an entire context. They lack human judgment. They require programming and typically stay within its bounds. They have a reputation of being easily misled, and for making what for humans would be stupid mistakes, which often amuse us. Machines have a great deal of trouble with many types of reasoning, and with complex types of pattern recognition (such as recognizing human faces) that are trivial to the human mind.

On the plus side, machines are tireless workers. When programmed correctly, they will do the same task or analysis over and over indefinitely, totally accurately, with infinite amounts of data. They can instantly recall information from anywhere and combine and pool their resources, processing power, and memories. They can wait and watch eternally for a single event. They can, of course, do calculations—trillions and even quadrillions of calculations— incredibly quickly.

People's thinking about what machines and technology can do is often wildly outdated. Machines can now self-correct. They can learn from their mistakes. They can adapt to changing circumstances, weigh competing variables, reason (to a certain extent), and utilize some of the kinds of "fuzzy" logic that humans do. Machines can sense the world and act on what they sense, customizing their responses to each situation.[27] Machines like IBM's Watson (the computer that won on *Jeopardy*) can read and understand huge numbers of documents, recognize puns and plays on words, arrive at answers in multiple ways, can answer complex questions, with confidence, in time to beat a human contestant to the buzzer. Machines can also detect hidden patterns in very large data sets that unaided humans cannot find, or sense, at all.

The most interesting and important thing to realize about the strengths and weaknesses of human minds and the strengths and weaknesses of machines and technology *is that they are often complementary.* And that is the point of this book. It is because of the complementary nature of the two sides—innate human capacities on the one hand, and technology-based extensions on the other—and through their symbiotic combination that digital wisdom can and does emerge. The combination, says Ray Kurzweil (from whom we will hear much more at the end of this book), is "formidable."[28]

Increasing Our Mind's Power

Humans have always wanted and tried to increase their mind's power, and have taken, in the past, two traditional paths for doing so.

One path has been to look inward, and to use more of the power we already have—or potentially have—in our own living cells. This is the approach of generations of meditators and monks, as well as of many analysts and "brain exercisers." That it is possible to achieve much via this path is shown, for example, in the many books on memory gains—Amazon has a list of 100 of these. Books also exist on increasing human capabilities to do art (e.g., *Drawing on the Right Side of Your Brain),* to do crossword puzzles, to meditate, to do Sudoku, to play video games, and, in fact, to increase our capacity for almost every mental activity. What these books demonstrate is that people can, in many cases, make their brains better (i.e., achieve brain gain) just by working those brains harder, or in different ways. This is certainly a good thing, and it is a long-established path to mind enhancement. Humans have always known that working our brains produced gains—it's why we have school. And we have recently learned, from neuroscience, some of the ways that our brains respond *physically* to hard work, for example, by causing neurons to grow additional branches (dendrites) and connect them. Exercised parts of brains get denser, and can grow larger. Today scientists can observe additional dendrites actually being grown by rats' brains in learning situations and identify useful chemicals being released as a result of efforts. So we know from this path that our brains—and, as a result our minds—can be greatly improved through our own effort.

But we also know other things.

First, we know are limits to these improvements. These limits almost certainly differ from individual to individual. People have different inherent capacities; we can't all become chess or memory champions—or pass the London cab driver test—no matter how hard we try.

But more importantly, we know that there is another road to brain gain, one that is often far more wide open, is accessible to many more people, and is more far-ranging in its effects and power. This road consists of *external* tools that we can use—some of which man has been using for millennia, and some of which are brand new—to overcome and push past many of the inherent limits in our brain.

Before the advent of language, for example, humans grunted and pointed, but then they learned to use external drawing tools as a way of enhancing their mind's ability

to record and communicate their ideas—pictures and maps are powerful mind enhancement technologies and a source of brain gain.

Once speech (itself a huge mind-enhancing technology) developed, humans memorized and told stories—but later adding the external tools of written records, stories, and eventually books—storytelling and books are among our most powerful enhancements and sources of human brain gain.

For a long time humans could only approximate measurement. Then they invented external technologies, such as rulers, geometry and trigonometry, and, using these powerful tools, they calculated. All of those technologies provided brain gain.

The extended Mind Theory

Humans have always been dependent on external mind enhancements, and today we are even more so. Integrating these tools into our minds, however, is not dependence in a negative sense, but is closer to symbiosis. As philosophers Andy Clark and David Chalmers wrote in a 1998 paper, "extended cognition is a core cognitive process, not an add-on extra." "The brain," they write, "develops in a way that complements the external structures and learns to play its role within a unified, densely coupled system."[29] According to Clark and Chalmers, the brain is continually actively integrating useful components it finds in the external world, such as our fingers for counting, pen and paper for writing, and more recently slide rules, calculators, and computers. They use terms like "active externalism," and "coupling" of internal and external mental parts.

According to their thinking, when today's young person says, "When I lose my cell phone I lose half my brain," he means it literally.[30]

And he is right.

Many would express the same sentiment in regard to a computer or an iPad; humans are already embracing a basic level of digital technology enhancement, and we will be offered—and most will accept—ever more sophisticated enhancements as that technology, and other new technologies continue to develop.

All Moving Forward

We are all moving, each at our own speed, toward digital technology enhancement of our minds. In terms of availability (although not distribution), we are already there;

digital enhancement is or will soon be available for a large percentage of the cognitive tasks we do. Digital tools already extend and enhance our cognitive capabilities in a great many important areas (although distribution of these tools, unfortunately, moves more slowly). Digital technology enhances our memory via data input/output tools and electronic storage. Digital data-gathering and decision-making tools enhance judgment by allowing us to gather more data than we could on our own. Digital enhancements enable us to perform more complex analyses of this data than we could unaided and increase our power to ask "what if?" and pursue all the implications of that question. Other cognition-enhancing digital tools facilitate communication and enhance understanding. Cognitive enhancement is a reality in almost every job and every profession, even in nontechnical fields such as law and the humanities. I will examine a large number of these cognitive enhancements in Chapter 3.

And as technologies that link directly into our nervous systems and brains become widely available, technology enhancement will become even more vital for everyone.[31] I sometimes joke to audiences that the piercings and studs that so many young people have inserted all over their heads and bodies are really places to attach new technology chips as they emerge. The nervous laughter I get shows that this is not out of the realm of their imaginations. People living in the very near future (i.e., ourselves and our children) will have instant access to ongoing worldwide discussions, everything ever written, all of recorded history, massive libraries of case studies and collected data, and highly realistic simulated experiences equivalent to years or even centuries of actual experience.

Human Goals

Human goals have of course expanded, but overall, they may not have not changed much over history. As listed and prioritized by psychologist Abraham Maslow in 1943, human goals are to survive, to obtain food and shelter, to make a living, to find happiness and self-esteem, and then, once those basic needs are taken care of, to "self-actualize," as Maslow puts it, by becoming wiser, more productive and creative members of society.[32] This last includes behaving morally, following personal ideas and goals, and working to improve and expand humankind.

But even as people get closer to achieving many of the more basic goals, they hit limits in their quest to achieve the higher levels. Because of limits in our brains and minds, we hit walls of misunderstanding. Our predictions about the future (and even

our conclusions based on the past) are far too often wrong. The human brain—powerful as it is, and as far as it has brought us—is no longer adequate, on its own, to achieve our most lofty twenty-first-century goals. To do that we must enhance it, extend it, connect it, and maximize its powers.

It was one of our best thinkers—Albert Einstein—who came to this conclusion, implicitly, when he said "a new type of thinking is essential if mankind is to survive and move to higher levels."[33]

New tools for thinking are required in the twenty-first century. Perhaps the most urgent of these tools is an "enhanced" mind. And the minds of those alive today have already begun to be enhanced—rapidly and radically.

Outsourcing: the Brain and Mind Extended, Enhanced, and Amplified

"It's all about outsourcing," says Ken Jennings, who lost to the computer Watson on the TV show *Jeopardy.*34

"In olden days," I recently heard a ten-year-old girl say, "you had to memorize phone numbers!"[35] Today, of course, we just outsource them to our phones.

More and more formerly internal cognitive functions are being outsourced to machines: How many of this book's readers would try to divide two multiple digit numbers in their head? We would almost all run for the nearest
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calculator or computer, which is, at least in many places, never far away, and often on our person. While some people are appalled by this, it is really no different than consulting the watch we all strapped to our wrists (until it got incorporated into our phones.) And watches replaced clocks, which replaced hourglasses, marked candles, and sundials.

Brain Enhancements, Past and Present

Outsourcing and enhancement of our minds is in no way a "new" phenomenon or issue, suddenly confronting humans. Man has outsourced and enhanced parts of his brain and mind for millennia. Marking a trail outsourced memory. Writing outsourced both memory and retrieval as did drawings and photographs. So did calculations on paper—Nobel prize winner Richard Feynman strongly maintained

that his written notes were actually a *part of his thinking* that resided outside his head.[36]

Even other people are a form of outsourcing via conversation and communication: "What was that name, or number, again?" you might ask a friend. Much of our knowledge is outsourced to our family, sometimes with particular knowledge such as driving directions stored in our partner's mind and not our own. We typically rely on the brains and minds of others for much knowledge and many specific tasks that our own brains cannot perform as well: Memory, Drawing, Directions, Art production. We hire assistants to remind us, and offload many of our mental tasks to them. And the brain itself outsources some of its conscious functions to its unconscious, in the form of habits and zombies.

With the exception, perhaps, of school test proctors, almost no one is uncomfortable with much of this mental outsourcing—we don't usually hear complaints, for example, that our phone remembers our numbers for us. But some people still get upset when others outsource functions like calculating a tip, or checking spelling. Somehow, they think, this makes us "lazy"—a complaint often heard from teachers. "There is a vast reservoir of bad will toward the idea of computers doing human-like tasks," says Ken Jennings.[37] I believe this attitude holds us back.

What we need to move forward is not to stop the outsourcing, but, rather, to reflect on, revise, refine, and redefine what we mean by "thinking" when we are enhanced with modern technology as so many of us now are. Like the updated quiz shows that now permit us to "phone a friend," we can no longer

think of our mind's activity as the work of only a single person in isolation. Certainly that's not the way most of the world functions these days; most of today's thinking—and work—is a symbiotic effort of people and machines. A person connected to the Internet might look up something he or she is thinking about, and be directed by the technology, to a great many additional thoughts and areas in an expanding virtuous cycle. Thinking and problem solving are increasingly done by people and machines—and often by large numbers of both of them, linked together.

Outsourcing doesn't just *replace* the capabilities that we have in our unaided brains and minds—it improves, enhances, extends, and amplifies them, making us freer and more capable human beings. Outsourcing allows us to make more of the things we are good at, and to add to our skill set many areas we're not. Shy or autistic

people uncomfortable with in-person connections often connect using technology. People from around the world collaborate online around their shared interests. People who live alone find online gaming or dating partners. People who have difficulty with reading or math work cash registers by looking at pictures on the keys. (And if this last doesn't seem like a gain to you, think about if you had just moved to China and needed a job!)

Yet many people seem to reject cognitive outsourcing and fear its consequences. I think those people are wrong, and so should you.

"Transparent" Cognitive Enhancements

Andy Clark, one of the creators of the extended mind theory (and a professor of philosophy and chair in logic and metaphysics at the University of Edinburgh in Scotland) has written about "supersizing our minds" through cognitive enhancements.[38] To Clark, the enhancements are an actual part of our thinking, because the "the cycle of activity that runs from brain through body and world and back again actually constitutes cognition."[39] Clark admits a possible distinction between "tools" and "parts of the mind," but says it is a "fuzzy" one. The difference, he thinks, turns principally on what he calls "transparency"—the more you don't have to "attend to" the technology to make it work, the more it can be considered part of your "core thinking process." In other words the more automatic the technology gets, the more attached it becomes to our minds.[40]

"We haven't yet gotten used to inhabiting a world with tools so well-fitted to us that when they are with us they become transparent," says Clark.[41] Clark offers as an example of a transparent tool a U.S. Navy flight suit for helicopter pilots that, in cases of instability, buzzes on the side that needs to be corrected. He claims the suit enables first-time helicopter pilots to cut the practice time needed to learn to hover from multiple hours to only 30 minutes.

Clark calls uses the term "cognitive prosthetics," for things we add on to extend our mind's capabilities, just as body prosthetics like artificial limbs extend our bodies'. Not only, he says, do the cognitive prosthetics extend the properties humans already have, but, like the physical prosthetics, they open up new ones. Clark offers text messaging as an example of a mental prosthesis that has extended our capabilities: "[Texting] didn't just fix or enhance [our former methods of communication]," he says, "it opened up a new channel." In fact, Clark sees the

greatest potential of extending our minds as "opening up new worlds" to humans. I agree.

Human Performance Enhancement

The U.S. military has for some time been interested in mind enhancement as a way to enhance warfighters' capabilities. A 2007 report from the Institute for Defense Analyses (IDA) entitled "Overview of Developments in Human Performance Enhancement" reports that "some leading militaries have adopted these technologies for military purposes." It goes on to say, "There is also evidence that potential adversaries are either conducting research on or wish to obtain HPE [human performance enhancement] capabilities for use against the United States and its allies," and that "significant research is already underway in many countries as part of their future soldier programs: many countries have programs underway that involve neurological and biological research that could be applied to internal HPE."[42]

The report defines human performance enhancement (HPE) as involving "any measure that can enhance, modify, protect, or restore human activity." It examines a number of enhancement technologies, which include pharmaceutical/neutraceutical enhancements, molecular and genetic technologies, nanotechnologies, and cognitive/neuro technologies. The authors remind us that there is a "dangerous duality" in these and other emerging technologies, in that the "opportunities for improvement" offered by HPE may be "either well or illintentioned." (I will return to these concerns later in the book.)

HPE technologies are often, for convenience, subdivided by researchers according to physical criteria, such as whether they are "skin-in" or "skin-out," "above the neck" or "below the neck." Some HPE technologies are already in use by the U.S. military, while others are still years away. Already in use today are pharmaceutical enhancements, including "using 'uppers/downers' and anti-sleep medication to extend continuous battlefield performance and alertness." This includes the widely used practice of giving pilots amphetamines to keep them alert on long flights.

There is also the use of nutrition to enhance performance. An emerging field that is under serious investigation by military researchers is nutritional genomics—how what we eat changes our genome. This is actually a subset of pharmacogenomics—how every compound that passes through our mouths changes our gene expression. For the military, the practical issues include both what to give to warfighters, and

how to keep steady-state levels of relevant compounds in the target organ—that is, the brain.

The study's conclusion is that "the convergence of nanoscience, biotechnology, information technology and cognitive/neuro science offers immense opportunities for the improvement of human abilities, social outcomes, and the nation's productivity, and has great potential for applications to enhancing the warfighter performance." But to underline the need for continued research, they also paint a darker potential scenario: "On the more extreme end of the genetic engineering spectrum, suppose genetic engineering becomes widespread and China's average IQ goes up by 30 points. Higher IQ causes qualitative differences in how people think. People with higher intelligence can think with concepts that are quite beyond the reach of lesser minds. But genetic engineering of the mind will not be done only for intelligence. It will be done for personality too. It seems very likely that there are personality types that are harder or easier to control. There may also be intelligence characteristics (e.g., inquisitiveness) that make one have a greater independence of mind, a lesser willingness to accept orders, a greater desire to feel unconstrained, and a lesser desire to bow to peer pressure. The biggest benefit and danger from human genetic engineering may come from the ability to do personality and intelligence selection. However, indications are that this is yet in the distant future of the technology (more than 20 years)."[43] Will this be brain gain? Will it happen to all of us? I discuss this in Chapter 8.

At the moment, one of the great *un*knowns is whether, or to what degree, technological brain enhancements can be passed on to offspring. The idea that humans can pass on such changes was proposed by Jean-Baptiste Lamarck roughly 200 years ago, but was later rejected by many scientists.[44] It has recently been revived as we learn more about so-called "epigenetic" changes— changes to our genetic structures that are environmentally caused. This is an area where we should all stay tuned—big changes in our understanding are coming, with wide-ranging implications.

The "Liberated" Mind: Useful Perspective

In this book's introduction, I use the term "perspective." Perspective is very much what this book, and this subject, is about. The most interesting and useful perspective to take regarding technology, I believe, is this:

We are all, as part of twenty-first-century human society, going through a period of intense transformation. Whether we like it or not, twenty-firstcentury humans are living through huge changes in how we behave and relate as people, as well as big changes in what we, as humans, consider important. Technology is a key part and driver of that change. It is important that we focus not just on the negatives, but rather on the positive changes that technology is producing in our lives. In particular, we need to look for, understand, and keep our focus on how technology is enhancing and liberating our minds to do new things.

For many in the world the changes now taking place are wrenching and difficult. In some places the changes are just beginning. But they are coming to everyone. And that is why there are new kinds of battles going on. As Thomas L. Friedman of the *New York Times* describes in his books *The World Is Flat* and *Hot Flat and Crowded,* the world is becoming equalized (or "flattened") because of technology.[45] Everything from school, to trade, to knowledge, to thinking is now more global. Places that used to be considered "backward" or "out of the way" by some now have the same power to influence the world as the so-called "big guys." The group that attacked America on 9/11 and the self-immolator in Tunisia who set off the Arab Spring are examples of this. As a result, we can no longer live in our own cocoons, however comfortable or physically isolated they may be, but must now, because of technology, continually interact with the entire world.

On top of which, the unsettling combination of variability, uncertainty, chaos, and ambiguity is increasing, in the world and in our lives.

And it's all happening faster and faster. These days, almost no matter where in the world one is, new technology is coming at humans and entering their lives, leaving them feeling, often, like they are on an out-of-control roller coaster. Word processing. Spreadsheets. Email. Instant messaging. Cell phones (even in remote villages in India and Africa). The Internet. Worldwide databases. Computers in our pockets. Instant connection to every person. Online shopping and banking. Social networking. Facebook. Twitter. Blackberries. Smart phones. Tablets. Personalized recommendations. Automated personal assistants. Electronic book readers. Personalized ads.

Something new, literally, every day.

And the technology arrives not just frontally, but it also inserts itself in our lives stealthily, without our often being fully—or even partially—aware. Many people find themselves caught up in a world of changing jobs, changing habits, changing attitudes, changing children—changing *everything,* it seems!

Shut It Off? A Different Take

In the midst of all this change, people look for means of control, and use of technology appears to some as one thing they have control over—control that they feel the need to assert. Many people whose lives have been made more stressful, or complicated, or hectic because of today's rapidly advancing technology are starting to say "hold on."

This does make sense. At some point *any* smart person would sit back and ask him or herself: Is this good? Is our quickly advancing technology helping or hurting us as individuals? As humans? Or are we being led downhill, toward dystopia, and perhaps even toward domination by our machines?

But we oughtn't overemphasize this problem. There are some real dangers, and I discuss them later. But I suggest we benefit more from considering technology not as a set of concerns and dangers, as many of these people do, but rather as the enormous boon to our lives that it is (a boon that comes, of course, with issues and trade-offs.) Even though there are some things we should watch out for and guard against, modern technology by far is "net-positive" for all humans and for humankind. Those alive today and their descendants are fortunate to live, and think, in a much more powerful and positive world.

In many cases, the truth is that there is little or nothing we can do to change technology's course. As Kevin Kelly points out in his book *What Technology Wants,* technology emerges, often in multiple places, when conditions are ready and when the supporting technologies are in place.[46] "We have no choice but to embrace it," says Kelly, "because we are already symbiotic with it: Technology underpins civilization."[47]

But humans love to worry—and these days there is good money to be made from doing so publicly. Articles appear frequently presenting yet another aspect of technology to worry about (the latest article I saw was about the huge amounts of data collected on its customers by Target stores[48]). Speakers focus on specific threats: If you are worried about computers taking over, hire Ken Jennings (the guy defeated by Watson on *Jeopardy*). Concerned about your kids' getting dumber? Hire Mark Bauerlein *(The Dumbest Generation).* Concerned about what is happening to adults? Hire Nicholas Carr *(The Shallows).* Concerned about overuse of technology? William Powers *(Hamlet's Blackberry)* and Sherry Turkle *(Alone Together)* will be happy to fuel your fires. They are all excellent speakers, and all draw applause. Each will be glad to tell audiences about the worrisome things that technology is doing to "our" minds (they almost always use the collective "we"). But few offer any solutions beyond

"turn it off." The wisest admit "I don't really have the answer."[49] I differ from all those individuals, and find little wisdom in their warnings and negative approach.

I do not see people getting dumber (including young people) I see them changing. I do not see public writing as getting shallower—I see more need to pick and choose what one reads and watches, and to look in new places.

I think what technology is doing to human minds is where we have the *least* to worry about. Instead, what technology is doing to people's minds is what we should all be celebrating.

It is, by any definition, brain gain.