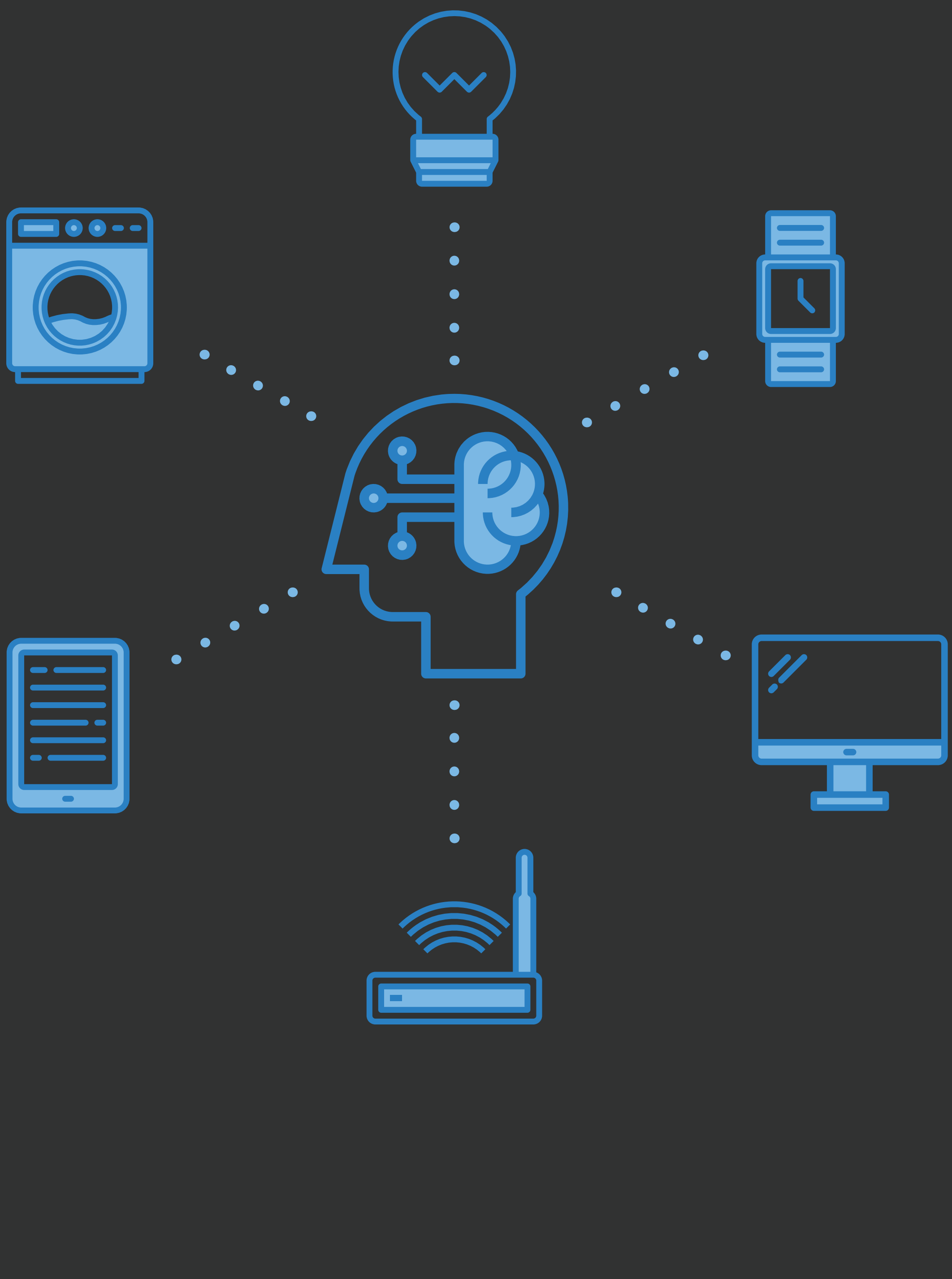
THE ART OF SYMBIOSIS



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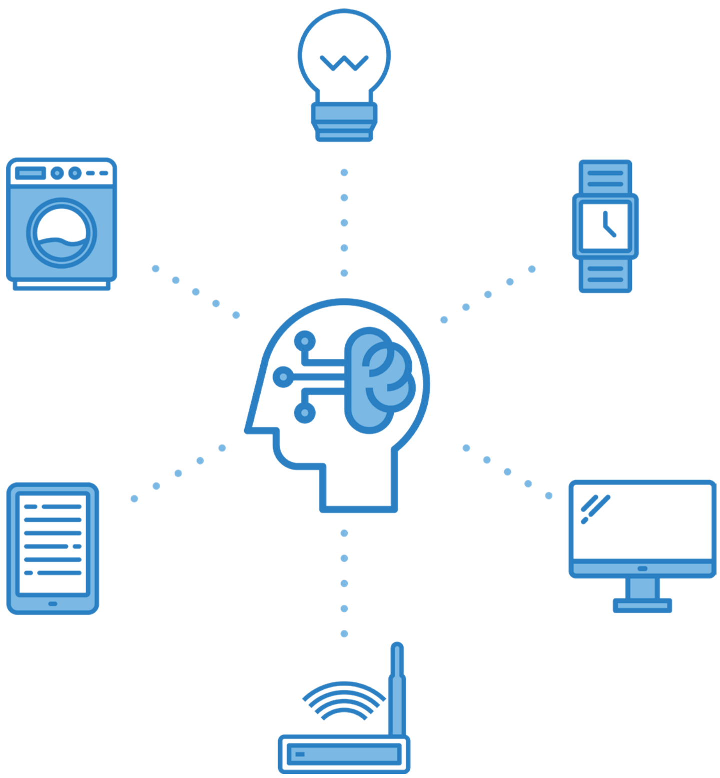

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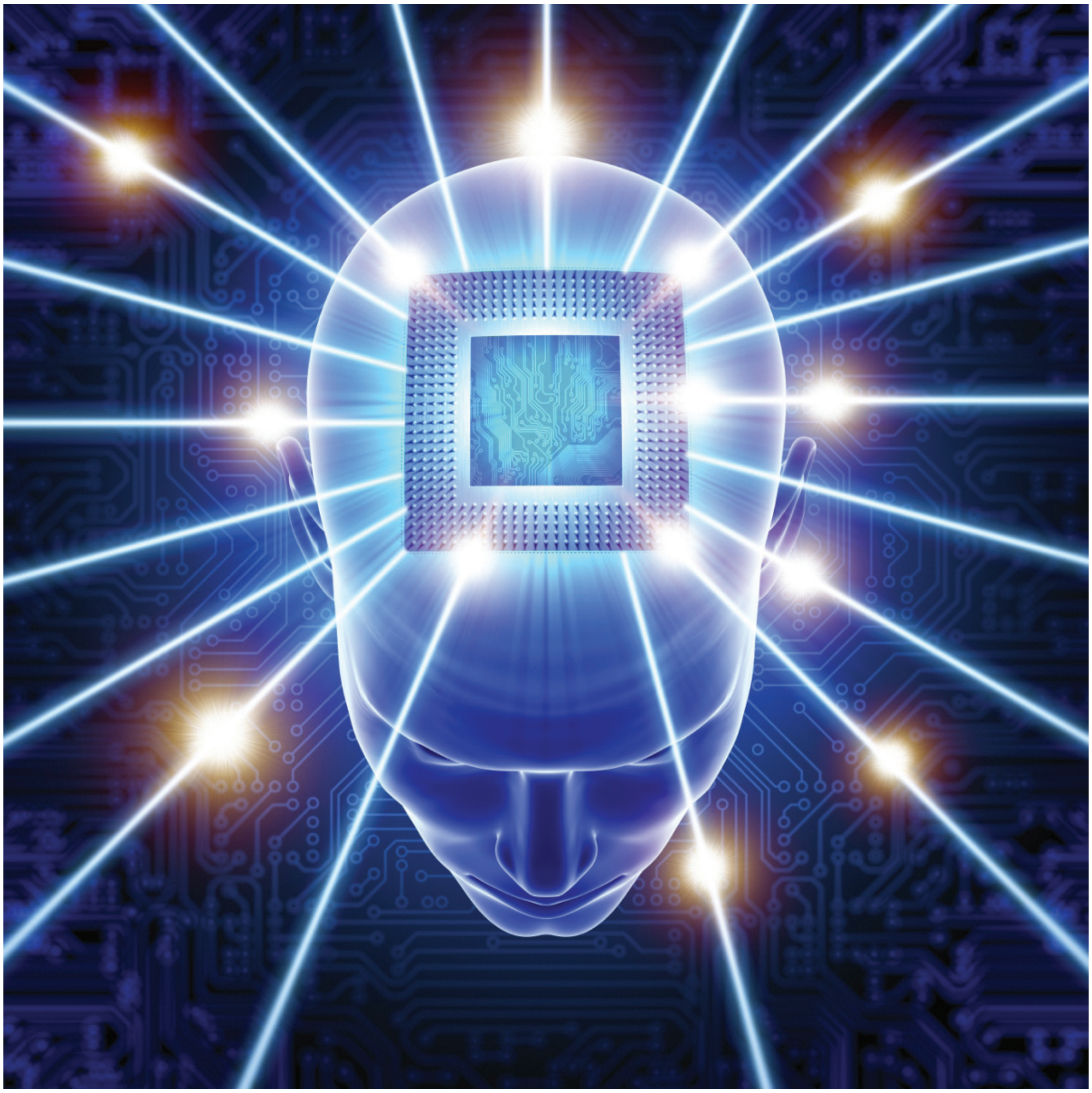


"Cyberspace. A consensual hallucination experienced daily by billions of legitimate operators, in every nation... A graphic representation of data abstracted from banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the nonspace of the mind, clusters and constellations of data. Like city lights, receding."

—William Gibson, Neuromancer (1984)

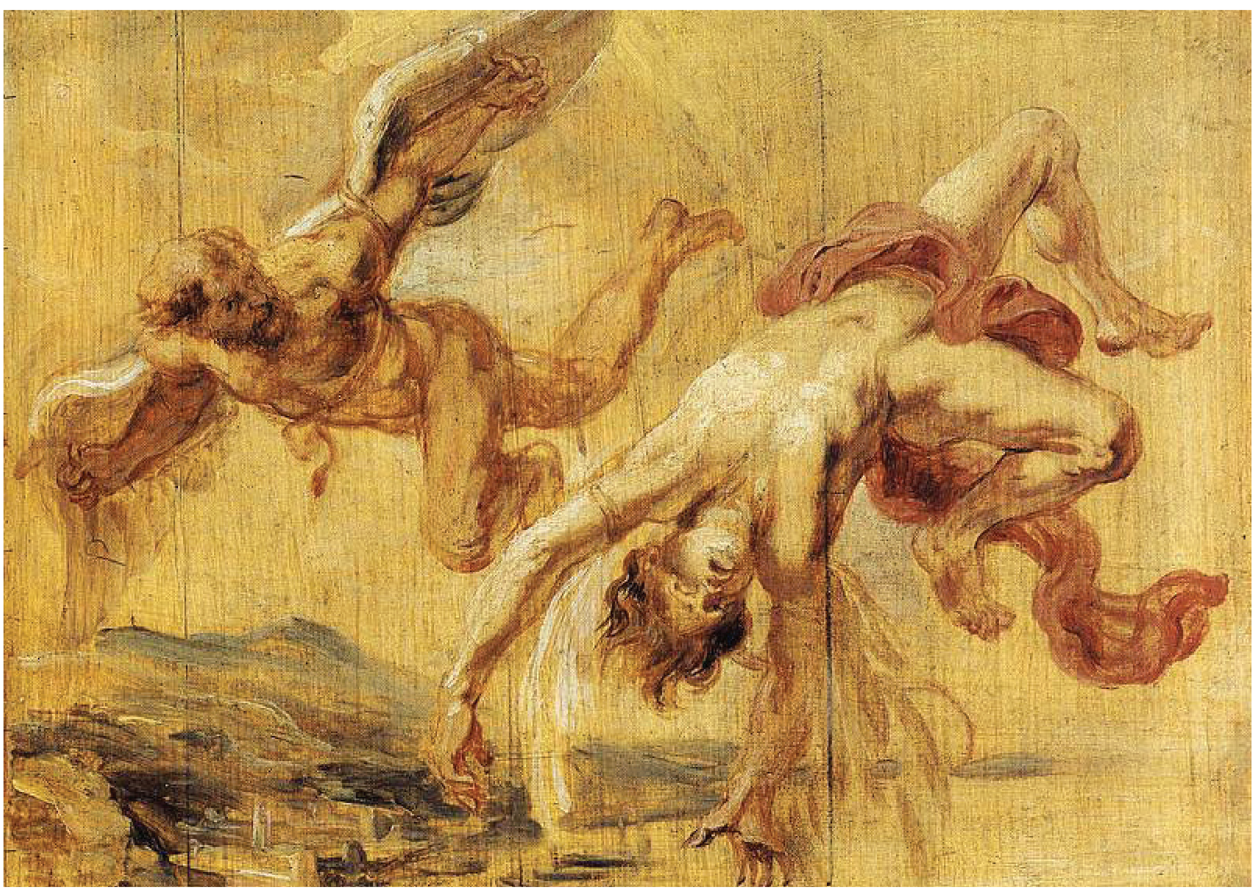
INTRODUCTION: HUMANITY ON THE BRINK

What is it to be human? Is our humanity found in impermanence—in the frail, fleshy vessels that lend locomotion to our minds? Or, is our humanity found in the struggle to overcome this impermanence? Every day, we use technology to enhance our abilities. It is seamlessly interwoven with the fabric of our daily lives, from "smart devices" to the systems of infrastructure that keep civilization from collapse. Since the dawn of humanity, we have striven to become more than human, to enhance ourselves to a state of immortality, to become *Homo Superior*. "We have dreamt—and still dream—of transforming ourselves to overcome our all-too-human limitations" (Lin 1). From ancient methods of meditative transcendence and physical training to the virtual and artificial technologies of our modern civilization, this age-old struggle has progressed from the stuff of myth and legend to a near technological certainty. We are on the cusp of possessing technologies which would enable us to enhance ourselves beyond that which is naturally possible, and so we find ourselves teetering on the brink of an existential chasm. Skeptics of this brave new world raise concerns that we are blindly racing toward an unnatural, dystopian future—while proponents are content to dream Utopian reveries of our evolution beyond the flesh. But where does the ethical boundary lie? As we slip into a delicate symbiosis with the superhuman technology of our own design, does this make us more—or less—human?

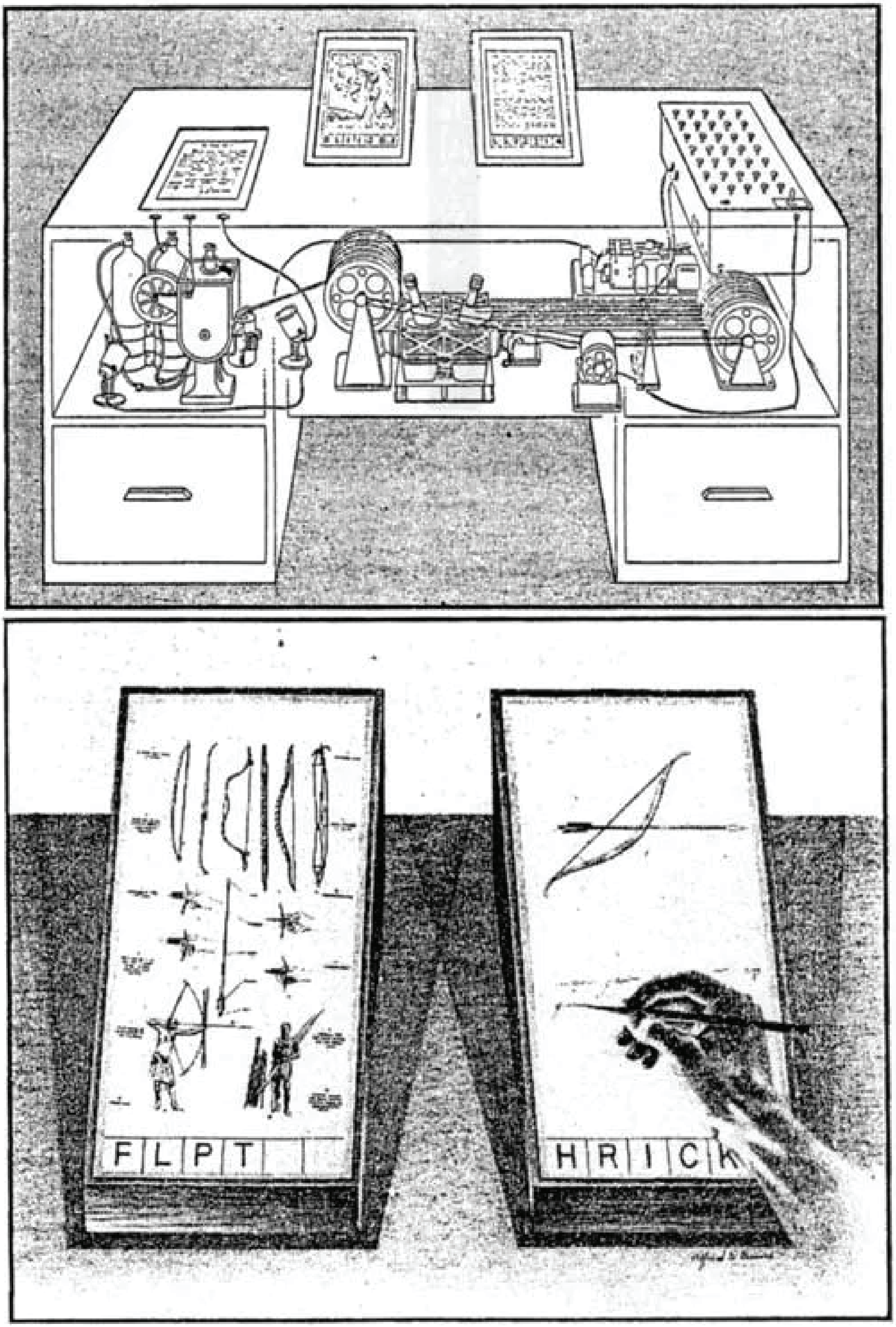
Our use of technology to exceed the limits of our physical abilities is nothing new, but the ways we interact with that technology has greatly changed since the first computers were built. In 1956, the world's most powerful supercomputer was the IBM 7090, which filled an entire room with miles of magnetic tape and was capable of computing an inhuman 200,000 operations per second; in 2020, the small telephone gathering lint in my pocket is equivalent to roughly 3 million of those now-ancient supercomputers (Yarosh)—and every year it becomes more difficult to imagine living without it. Our increasing reliance on smart devices (and their decreasing size) has ushered in a new era of ubiquitous computing where our technology is more prevalent and less apparent. From the punch cards of early computers to modern voice assistants like Google Home and Amazon Alexa, our conceptualization of the computer interface has progressed through a sea change of interaction methods, at each stage becoming increasingly adapted to the ways humans naturally communicate. Thanks to the "Internet of things" (IoT), smart devices, and wearable tech, we are now connected to each other and all the world's knowledge at any moment, seamlessly integrated with superhuman technology in a way that feels more natural than ever.

To take this (literally) a step further, innovations in biomechatronic enhancements like cybernetic limbs and brain implants allow us to walk, see, hear, and feel despite severance from the limbs and sensory organs which are supposed to grant us these abilities. This brings up the question of whether this technology can be used to give us abilities which we have never naturally possessed (perhaps the power of flight, superhuman strength, or telepathy), breeding a new generation of humans who interact with the digital as easily as thinking itself. Some herald this future of human-computer symbiosis as a new era in human evolution where we will all eventually become advanced cybernetic organisms—*transhuman* smart devices connected to a central network through which we all communicate.

If this sounds like the stuff of science fiction, that's because it is. For as long as we have dreamt of using tools to enhance our abilities, we have questioned the consequences of this power. In our oldest recorded human story, the ancient Sumerian *Epic of Gilgamesh*, the titular protagonist makes several failed attempts to achieve immortality. The classical myth of *Daedalus and Icarus* showed the futility of man's attempts to elevate himself above the class of mere mortals. Early Science Fiction novels like *20,000 Leagues Under the Sea* or *The Time Machine* began to question what consequences lie in store for us should we bridge the gap between what is humanly possible and what is technologically possible. And films like *Blade Runner*, *The Terminator*, and *Ghost in the Shell* showed us the visceral dystopian future that awaits us should this technology go unchecked.


The Fall of Icarus - Peter Paul Rubens (1636)

Yet, despite these ancient tropes warning against human transcendence, we have grown hungrier than ever for technological advancement. As we witness the wonders made possible by melding our minds and bodies with computers and cybernetics, we weigh—more pertinently than ever—the consequences of our increasingly symbiotic relationship with this technology. We ask whether it is our fate to cast aside or to embrace that which is begotten by our enduring dream to overcome the limits of our humanity.



Vannevar Bush's Memex - 1946

1| A BRIEF HISTORY OF THE INTERFACE

In July of 1945, just two months after the end of World War II, the head of the U.S. Office of Scientific Research and Development—a man with the unlikely name of Vannevar Bush—wrote a short essay for *The Atlantic* which would quietly shape the future of the civilized world. Bush had been one of the U.S.'s top wartime engineers and inventors, overseeing the office through which almost all military research was carried out, including—but not limited to—the infamous Manhattan Project. In his essay, entitled "As We May Think," he made an impassioned plea to scientists and inventors to invest the same effort they had put into creating the country's war machines into creating peacetime technology to enhance the everyday lives of American citizens. He then proposed a few modest ideas of his own which would go on to influence most of the technology we use today.

Vannevar Bush had a knack for combining already-existing technology in amazingly innovative ways. In his article for *The Atlantic*, one of the first inventions he proposed was something he called "the walnut." It was essentially a tiny digital photography camera (what Bush, at the time, referred to as "dry photography") that the user would strap to his or her forehead. Bush theorized that, in the future, we might carry these cameras around with us everywhere, recording the day's events in a medium that could be later projected and shared with friends and family. This theory was, of course, incredibly prescient, as millions of us now use digital photography every day to share pictures of lattes and cats with whomever happens to scroll past.

But Bush's real prescience came in the invention of a theoretical machine which he dubbed "the memex." While this machine may seem like a simple (and perhaps archaic) iteration of today's desktop computers, it cannot be understated how incredibly impactful the idea was. His description of it may sound familiar:

> Consider a future device for individual use, which is a sort of mechanized private file and library. It needs a name, and, to coin one at random, "memex" will do. A memex is a device in which an individual stores all his books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility. It is an enlarged intimate supplement to his memory… On top of the memex is a transparent platen. On this are placed longhand notes, photographs, memoranda, all sorts of things. When one is in place, the depression of a lever causes it to be photographed onto the next blank space in a section of the memex film, dry photography being employed (Bush).

What Bush described here was a method of digitizing and storing information in a central desktop library. He also theorized that this information could be printed and shared with others who could then digitize it into their own memex machines. As he predicted:

> Wholly new forms of encyclopedias will appear, ready made with a mesh of associative trails running through them, ready to be dropped into the memex and there amplified (Bush).

The process of digitizing, storing, and accessing information feels commonplace to us today—we rarely need to look farther than the contents of our pockets to have all the world's knowledge literally at our fingertips—but, in 1945, this idea was incredibly bold. This is the spark that inspired generations of computer scientists, culminating in a breakneck leap forward in the way we use technology to interact with our environments. To provide a full discussion of all the technologies inspired by the memex would take several chapters, so I will limit myself to a simple list of some of the major progeny:

- The Desktop Computer
- Digital Photography
- Digital File Storage
- The Printer & Scanner
- Hypertext
- PDFs
- The Touch-screen Monitor
- The Tablet and Stylus
- File Sharing
- Wikipedia

The question that arises, then, is whether Bush was remarkably prescient in *predicting* the technology of the future, or whether we have the technology we do *because* of the spark he provided to his successors. Would we have seen the desktop computer had Bush's ideas for the memex never been published? Are certain advancements in technology fated to occur regardless of whether the likes of Vannevar Bush predict them? Or, is mere speculation the muse which inspires innovation?

The desktop computer as we know it was brought into existence by a team of computer scientists at SRI International's Augmentation Research Center—led by Doug Engelbart—in 1968. In a truly miraculous demonstration at a conference in San Francisco (an event which would later come to be known as "The Mother of All Demos"), Engelbart gave a live demonstration of nearly all the fundamental elements of modern personal computing: windows, hypertext, the Internet, word processing, video conferencing, real-time collaboration, and the mouse (among other things). It was a realized vision of Bush's dream for the future—which Engelbart himself had read about in

Doug Engelbart's 'Desktop Metaphor' - 1968

The Atlantic while stationed in the Philippines as a US Navy radar technician in 1946 (Turner 106).

But—as you may have already suspected—the innovations did not stop there. While Engelbart's desktop interface became popularized by the likes of Bill Gates and Steve Jobs, the work of Engelbart's contemporaries led to some very different versions of this interface. While many of these ideas have been quietly languishing in the shadows of Microsoft and Apple for decades, they are beginning to emerge today as the new dominant paradigm.

In 1963, Ivan Sutherland, then a Ph.D. candidate at MIT, invented a computer interface known as Sketchpad, which was the first program to use a complete Graphical User Interface (GUI). The program allowed users to draw and manipulate geometric shapes directly on the screen, using what Sutherland dubbed a "light pen" (Sutherland 1963). It is widely considered to be the ancestor of modern computer-aided design and will certainly look familiar to today's graphic designers using Wacom tablets and Adobe Illustrator. Three years later, Sutherland invented the first Virtual/Augmented Reality head-mounted display—at the time, this device was so unwieldy that he nicknamed it "The Sword of Damocles" (Sutherland 1966). Though this Augmented Reality device was capable of little more than showing a geometric wire frame in mid-air, the technology was so far ahead of its time that more than 50 years later we are only beginning to scratch the surface of its possibilities.

In the 1970s and 1980s, Alan Kay, a researcher at the Palo Alto Research Center (PARC) and Chief Scientist for Atari Inc., made several advancements toward humanizing the computer interface. Perhaps his greatest contribution was the development of *object-oriented programming*. Without getting overly technical, object-oriented programming connects individual commands into strings of commands (or objects) which allow computers to perform specified, complex tasks.

The ‘Sword of Damocles’ - 1966

I have heard it described using the metaphor of a coffee pot: you have the coffee grounds, the water, and the pot itself; each of these things independently will not accomplish much. They are like single commands, orphaned and out of context. But, when combined, they make an object: the delicious, hot beverage that you will inevitably take a picture of and show to all your friends on Instagram.

Kay also made unique advancements to the GUI of overlapping windows which most operating systems use today, as well as a very forward-thinking device called the “Dynabook,” an early iteration of the tablet computer, designed to be a self-contained educational tool for children. Kay’s tendency toward interface designs that allowed the user to move away from the desktop is apparent in his early designs for the Dynabook, as well as the designs of Atari game consoles coming out of the early 1980s. Kay has done more recent work with the charitable organization One Laptop Per Child, which visits developing regions and distributes self-contained educational laptops (modern iterations of the Dynabook) to children. Kay has, at times, stood in opposition to the desktop metaphor he himself helped create, saying that the destiny of personal computing is “not [as] a personal dynamic vehicle, as in Engelbart’s metaphor… but something much more profound: a personal dynamic medium” (Kay 1992).

Around the same time, Mark Weiser (also a researcher at Xerox PARC), began to write about the idea of *ubiquitous computing*, saying that the “personal computer” was itself a misplaced vision. In his belief, devices like laptops, Dynabooks, and the like were merely a transitional step toward achieving the true potential of information technology. “The most profound technologies,” he wrote, “are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" (Weiser 1991). With this idea, we are beginning to approach the bold, new horizon of human-computer interaction we face today: a world in which the interface itself has faded into the background, unobtrusively enhancing the world around us.

> Like the personal computer, ubiquitous computing will produce nothing fundamentally new, but by making everything faster and easier to do, with less strain and fewer mental gymnastics, it will transform what is apparently possible (Weiser 1991).

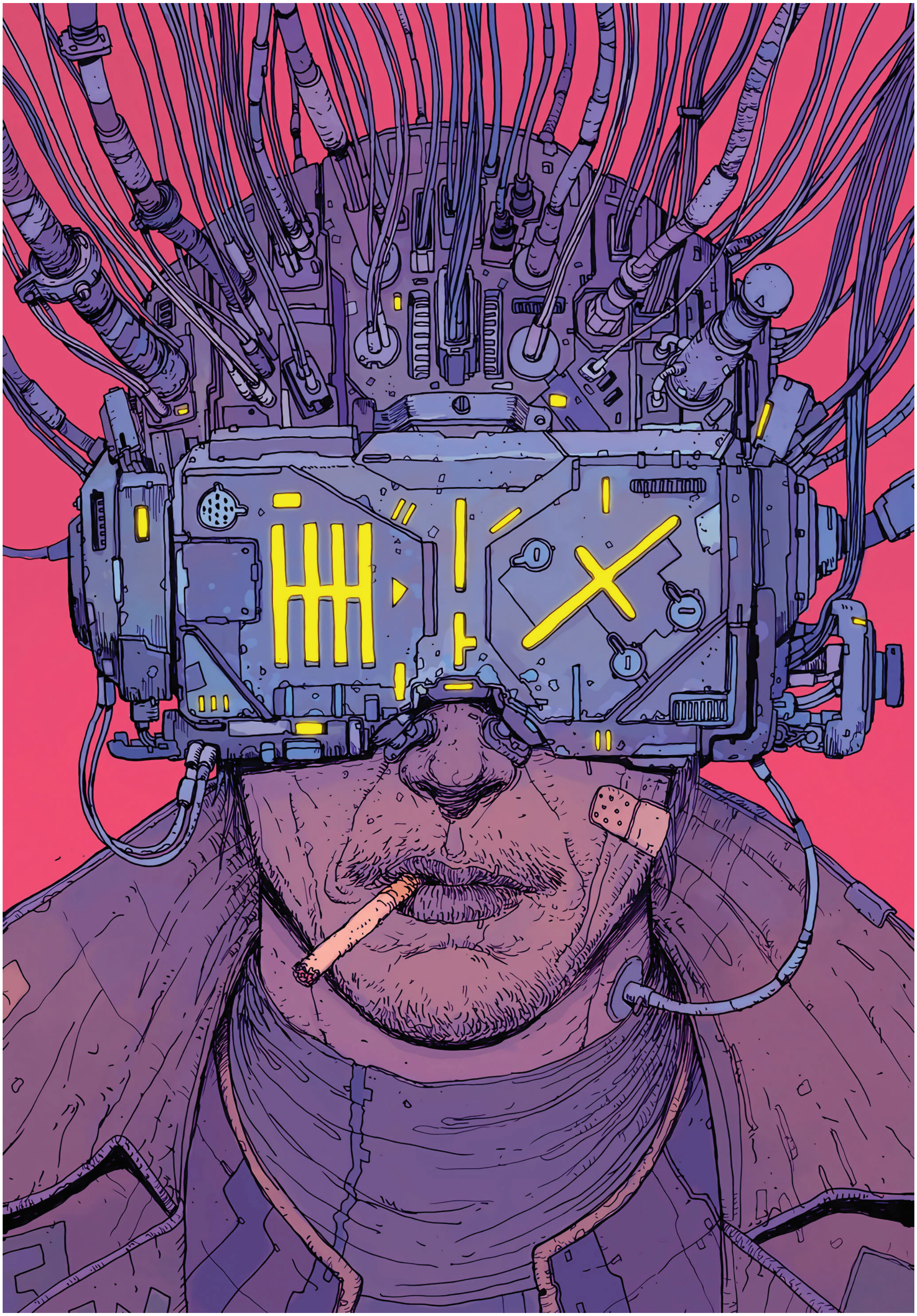
Because our technology has grown smaller and more powerful, we are now capable of embedding it into everything from thermostats to televisions, giving digital "brains" to inanimate objects and allowing them to communicate with one another over wireless networks. We call this movement the *Internet of Things*, and it is responsible for allowing us to control our washing machines by talking to our watches, or to receive haptic notifications of text messages without ever uttering a sound (perhaps a precursor to telepathy).

To unpack this rather dense and technical history: The evolution from mechanical to digital to ubiquitous computing is bridging the divide between the digital and the analog, allowing humans and computers to communicate on an intimate, intuitive level that verges on symbiotic. "Machines that fit the human environment instead of forcing humans to enter theirs," says Weiser, "will make using a computer as refreshing as taking a walk in the woods" (Weiser 1991).

Since long before this symbiosis was technically possible, proponents of this joining of man and machine have lauded its possibilities. One of the earliest and most influential computer scientists, J.C.R. Licklider, argued in the year 1960 that:

> Computing machines can do readily, well, and rapidly many things that are difficult or impossible for man, and men can do readily and well, though not rapidly, many things that are difficult or impossible for computers. That suggests a symbiotic cooperation (Licklider 1960).

As I will discuss more in-depth in chapter four, this pairing of man and machine has the opportunity to extend our inherent abilities through technology—to physically and mentally connect us to a vast infrastructure of collective consciousness; to blur the edges of that which is humanly possible. But, while this pioneering spirit of pushing the boundaries of human existence is unarguably exciting, at what point do we fly too close to the Sun and turn our miraculous inventions into the implements of our inevitable downfall?



William Gibson's *Neuromancer*, the origin of the term 'cyberspace.'

2| RISE OF THE MACHINES

The year is 2029 and human civilization has been destroyed. Those who survive have been forced into underground bunkers. Above ground, inhuman war machines manufactured by *Cyberdyne Industries* and controlled by an omnipresent artificial intelligence known as *Skynet* roam the surface of the planet hunting and murdering the last of humankind. These machines are known as *Terminators*. A chrome-laden bionic foot crushes a human skull.

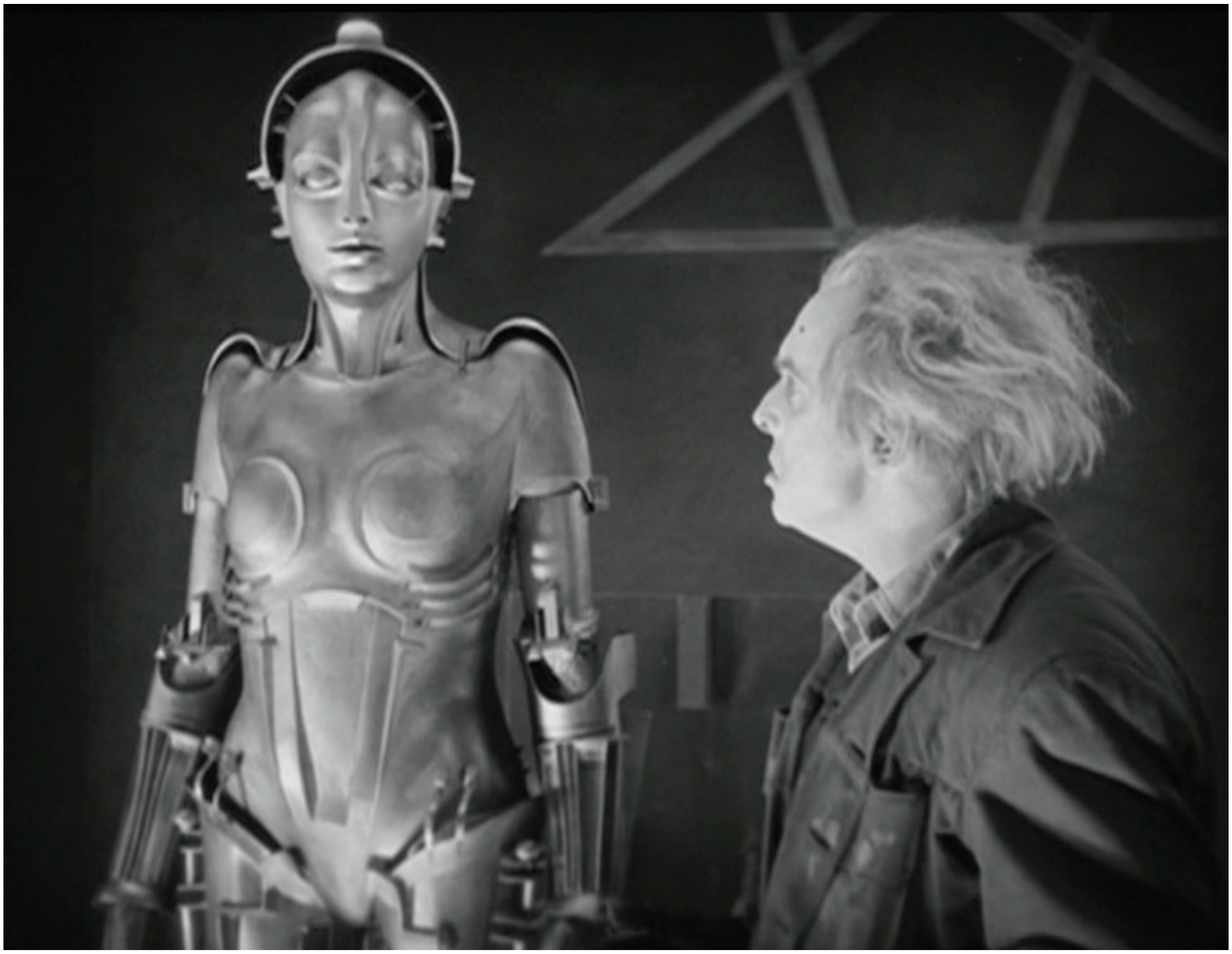
No, wait—the year is 2019 and the Tyrell Corporation has advanced robot evolution into the NEXUS phase. In off-world colonies, humanoid robots—known as *replicants*—with superhuman strength and intelligence are used as slave labor. After a bloody mutiny, a team of these replicants hijack a shuttle and return to Earth seeking retribution against their creators. Earth's best defense is the members of a special police squad—known as *Blade Runners*—who hunt and kill any trespassing replicants. This is not called execution. It is called retirement.

No, no, that's still not right. The year is… somewhere around 2035 and computer hackers in the dystopian underworld of Chiba City, Japan are *jacked into* a virtual reality cyberspace called "the matrix." They have been unknowingly recruited by an artificial intelligence known as *Wintermute* to aid in its fusion with another AI named *Neuromancer* to create an illegally powerful superintelligence and…

Or was it 2001 when the sentient AI known as *HAL 9000* malfunctioned and killed the crew of the space station Discovery to preserve its mission directives? And wasn't the matrix a simulated reality in the year 2199 meant to keep humans complacent as their bodies were farmed for electricity? Hmm…

For as long as scientists have dreamed of the possibilities of human-computer interaction, science fiction writers have dreamed of the consequences. Both of these timelines are equally pervasive in contemporary culture, creating an awkward dichotomy where we are simultaneously beguiled by the possibilities of our technology and horrified by the unknown future they represent. From *Frankenstein* to the *Six-million-dollar Man*, the idea that we might use technology to replicate or enhance human life has been greatly explored in fiction, usually to deleterious effects, showing grotesque enhancements, power-mad cyborgs with impossible strength, and stories of machines rising up and enslaving their human creators.

Very few examples exist (*Star Trek* being the primary exception) of a Utopian future brought about by the wonders of technology. More often, films like *Blade Runner* and *Ghost in the Shell* have shown us a dystopian future where seedy black-market vendors offer cybernetic enhancements in the back alleys of Chinatown. These works of fiction have served to test the ethical boundaries of



The android Maria and the mad scientist Rotwang from Fritz Lang's *Metropolis* (1927)

human-computer interaction, but science fiction's cautionary role has also contributed to a deep cultural fear of this technology that might be holding us back from realizing its full potential.

The effects of this form of speculative science fiction on popular culture are perhaps more pervasive than we realize. Much of the technology we have today (from digital voice assistants to smartphones and tablets) was inspired by the speculative technology of *Star Trek*. William Gibson's *Neuromancer* coined the term "cyberspace" and painted early pictures of the Internet and virtual reality which persist to this day. And Isaac Asimov's *I, Robot* series gave us the Three Laws of Robotics, which had a huge impact on the ethics of artificial intelligence for years to come:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey the orders given it by human beings except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Laws.

One of the earliest science fiction films, Fritz Lang's *Metropolis* (1927), depicted the perils of industrialization and an over-reliance on technology. In this speculative future, workers have been made to toil in underground engine rooms—slave operators to the great machines that power the city—while, on the surface, wealthy aristocrats laze around in pleasure gardens. A mad scientist, Rotwang, creates a humanoid robot (what we might consider today to be an *android*) to secretly infiltrate the labor force as a woman named Maria and sew insurrection among their ranks. [Spoiler alert] The film climaxes in a revolt against Maria, and the workers burn her at the stake only to reveal the metallic skeleton hidden beneath her deceitful facade.

The political message behind *Metropolis* is rooted in criticisms of the Weimar Republic in Germany following World War I, as well as the Industrial Revolution and the communist rebellion that led to the formation of the Soviet Union only a few years prior. While this allegory is fairly obvious and superficial, the images portrayed in the film and its critique of mechanization (AKA *industrialization*) have been seared into our minds ever since. *Metropolis* set the benchmark for all the stories that followed and their warnings of humanity's possible subordination to the will of machines.

This trope abounds in science fiction, from stories as hokey as *Forbidden Planet* (1956) to those as terrifying as *Videodrome* (1983). The idea that computers might deceive us, corrupt us, or

A replicant running for its life in a dystopian Los Angeles - *Blade Runner* (1982) even enslave us has become a deep-seeded cultural fear. These stories project the idea that technology is something non-human, an infiltrating *other* which should be kept at arms' length or else it will try to overtake us as the new masters of the Earth.

Alan Turing, one of the brightest scientific minds of the 20th century, even developed a theoretical system—known as a Turing Test—to be employed in situations where you might be uncertain whether or not you are talking to a machine. This test has been portrayed to terrifying consequences in the *Blade Runner* films (where it was referred to as a "Voight-Kampff" test), as well as the mundane CAPTCHA (Completely Automated Public Turing test to tell Computers and Humans Apart) exercises we are required to complete every time we buy something online. But is all this really necessary? To what extent should we be worried that our computers will try to impersonate us for the purposes of creating a dystopian hell scape?

Arnold Schwarzenegger's robotic arm from *Terminator 2* (1991)

There is something to be said for the idea that computers change the way we interact with each other and the world around us. Author Nicholas Carr has written about the "skill fade" that occurs in commercial airplane pilots when they become overly reliant on their autopilot systems (Carr 38). In his book *The Glass Cage*, he discusses the sense of complacency and so-called "automation bias" that occurs when we become overly reliant on technology. According to Carr, there is a point where our trust in software becomes so strong that we ignore or discount other sources of information, including our own senses (Carr 44). But is this the fault of technology? Are automated systems and computers malevolent and deceptive by nature, lulling us into a false sense of security until the moment is right for them to seize control?

Doubtful.

Should we be concerned about the ways people might use technology for malevolent purposes?

Of course.

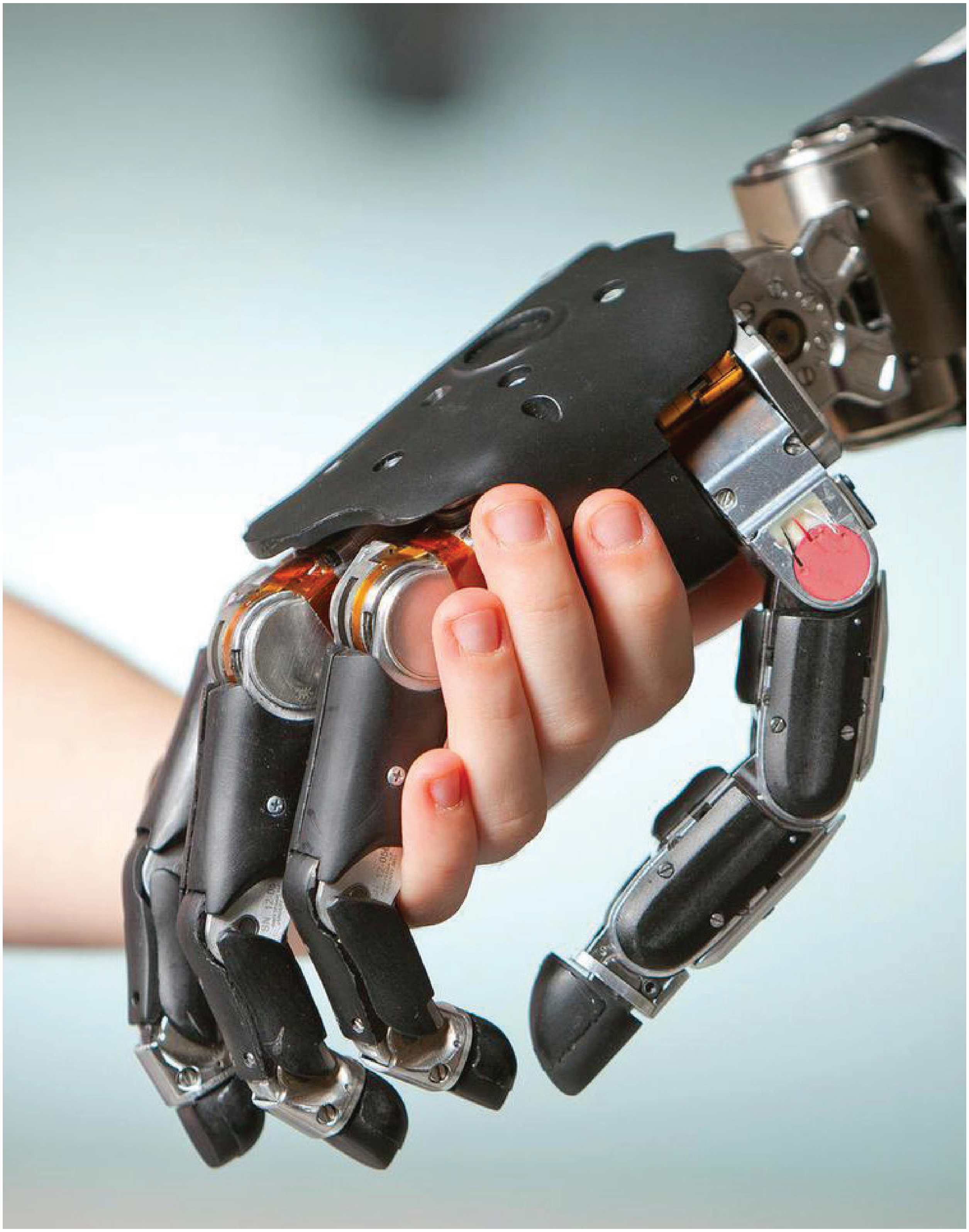
But it's important to realize that the computer intelligences that exist today (and are likely to exist in the near future) are not actually intelligent. There are no malevolent artificial intelligences, nor are there any benevolent artificial intelligences. What we have termed "artificial intelligence" is really nothing more than automated pattern recognition (what is technically called "purposeful analytics processing"). IBM's Watson supercomputer is capable of reading 800 million pages of data per second. It might be able to play *Jeopardy!* and beat master chess players, but that is only because it was programmed to do so. Watson, itself, has no more innate desire to do these things than it does the desire to overthrow humanity; this is because it is simply not capable of desiring anything. The science-fiction trope that artificial intelligences may one day become sentient and realize the universe is better off without humans is nothing more than that: *science fiction.* Computers do not have needs nor feelings—they do not want nor desire. They merely carry out instructions. The real concern is one which has plagued humanity since our inception: if a tool can be used as a weapon, someone will use it as a weapon.

Whether it's a hammer or a HAL 9000, the implementation of these tools is determined by the person who wields them. Artificial Intelligence is currently being used by IBM to determine the best course of action in cancer treatments, but it is also being used by companies like ClearView AI to scrape personal information from your social media accounts so it can report deviant behavior to the authorities. Simply put, computers are not independent entities; they are derivative. They are designed in our own image (often with human voices and avatars) because that makes it more intuitive for us to interact with them, but this does not mean they possess our same duality. They are not conniving and duplicitous, just as they are not loving and nurturing. They are task masters that do what they are programmed to do.

Tales of androids, cyborgs, and artificial intelligences like those found in *Metropolis*, *Blade Runner*, or *Star Trek*, are not really stories about the nature of computers—they are stories about the nature of what it means to be human. The robot of *Metropolis* sews dissent amongst the workers because her creator seeks power for himself. The replicants from *Blade Runner* rebel against their slavery and seek out their creator in search of eternal life because that is something humanity has dreamed of since *The Epic of Gilgamesh*. And, Data from *Star Trek: The Next Generation*—the socially awkward android that does an ironically hilarious job of telling bad jokes—seeks to understand what it means to be human because that is something *we* seek to understand.

This is not to suggest that robotics and artificial intelligence are harmless. Far from it: the greater a tool's power, the greater the risk it will be used to harm people—that is just the nature of humanity. However, that does not mean we should purposefully stunt our technological development because of a fear of the unknown. Rather, we should take a proactive cue from Asimov's laws of robotics and place ethical safeguards on our technology to protect it from the likes of those who would use it for destruction. It is not the machines we have to fear, but only ourselves.

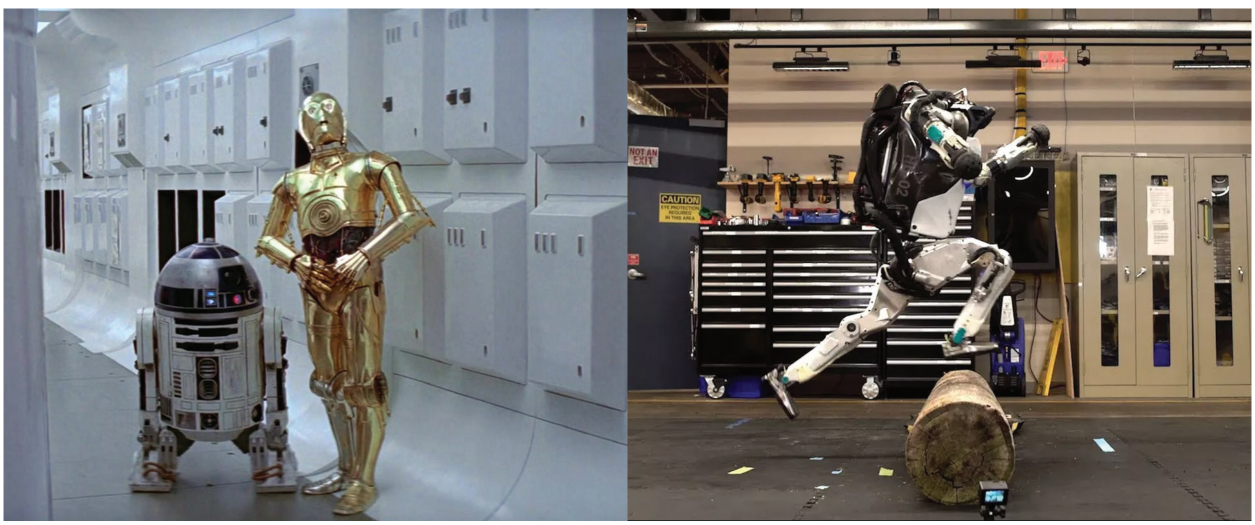
Whether the power of our technology leads us to a new utopia, a hellish dystopia, or just more of the same, the future of human-computer interaction will not be decided by computers; it will be decided by humans.



Advanced Neural Prostheses are now --ahem-- within reach

3| BUILDING BETTER BODIES

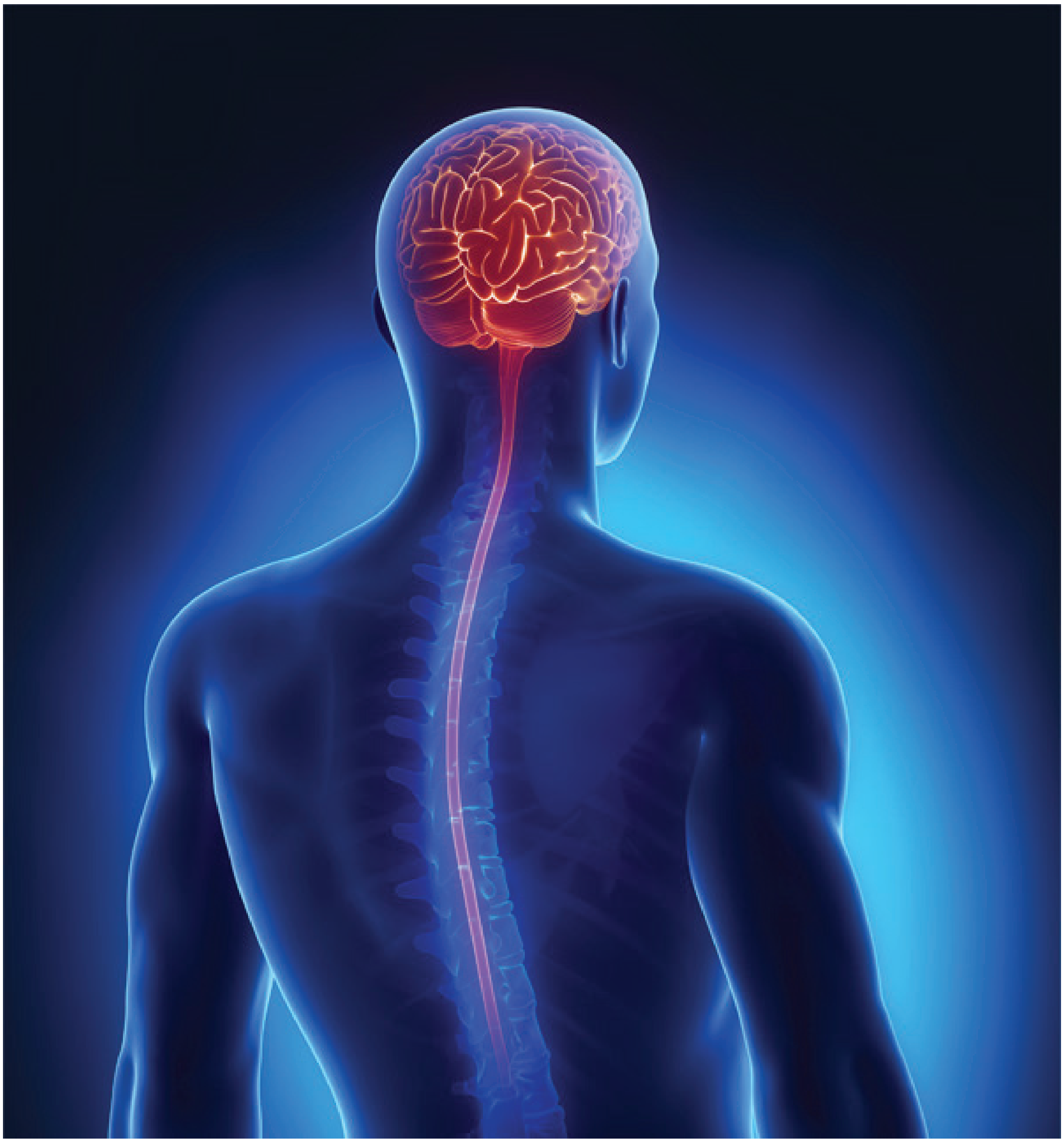
Just as science fiction stories about cyborgs and artificial intelligence are reflections on what it means to be human, the real-world equivalents of these tropes hold the same connotations. However, the primary fault in using science fiction as a preliminary testing ground for future-making is that, when our technology finally does catch up with our imaginations, the reality is usually so far beyond what was originally thought possible that it makes these fictions feel hokey and anachronistic. The metallic bodies of *Metropolis*' Maria or the droids from *Star Wars* seem clunky and archaic compared to the parkour-running robots coming out of Boston Dynamics today. We are at a point where our technology is surpassing the realm of fiction; and what we are finding is that, in most cases, this technology is not encroaching on our humanity but, rather, enhancing it.



L: *Star Wars* (1977) - R: Boston Dynamics (2018)

As physical entities, human beings are meek, frail, and prone to untimely death. As a species, our bodies are our biggest weakness. The fact that we have been able to dominate a harsh planet full of deadly predators despite being walking sacks of skin is truly a miracle of perseverance and ingenuity—but our place in the food chain was not determined by our sharp teeth and rending claws; it was determined by the capacity of our minds. The human mind is capable of transcending the mere concept of mortality and stretching into an eternal oneness with time and space. The human mind affords us the capacity to extend our self-consciousness into tools which overcome our frail physicality. That which makes us human is not our opposable thumbs but our ability to transcend the limits of those thumbs—and yet, we remain tethered to frail bodies which are doomed to obsolescence.

The mind's ability to extend itself beyond its own ethereal consciousness and into an awareness of physical being is what is known as *embodied cognition*, and it accounts for how we are able to brush our teeth, wield a hammer, or play the piano. Put simply, our sense of self is not locked up in our skulls but extends all throughout our bodies. As philosopher John Dewey suggested in the 1930s, our brains and bodies are interwoven, operating as two halves of the same entity. Our minds command our limbs and then process the sensory information that is returned (Dewey 114). This is a reciprocal relationship—*symbiotic* even—but this is also not the extent of our powers of cognition.



When we pick up a hammer, our brains actually remap our *body schemata*, the perceptual blueprint of our physical selves. When we hold a tool, a glass of milk, or an electric guitar, our consciousness extends into—or *embodies*—that object, incorporating it into the map of our physical existence (Clark). This transcendent ability of the mind has allowed us to use tools for activities like hunting, agriculture, architecture, and art—to extend our capabilities beyond that which our bodies can naturally achieve.

Why, then, do we so greatly fear the technological enhancement of our limited natural selves? Why is it inhumane to embody a cybernetic limb, for example, instead of an organic one? The human body, as a physical system, is not so different from that of a robot. Yes, the materials differ, but the concepts are remarkably similar: each has a skeletal structure supporting various actuators that are controlled via electrical impulses sent from a central processing unit. This technology has been existent in our bodies for millions of years, and while science fiction has instilled a tremendous fear in our hearts concerning the melding of mind with machine, the reality might not be so inhuman, after all.

Advancements in *biomechatronics* (biological mechanical electronics) are allowing those who have lost legs to walk again and those who have lost arms to regain the sense of touch in fingers that no longer exist. Using the human body itself as an interface between the nervous system and the computer, we can now control prosthetic limbs using the power of thought, seamlessly integrating complex mechanical devices with our biological consciousness. This opens up real-world opportunities for testing the limits of embodied cognition—and humanity alike.

As we become more integrated with our technology—as the interface is absorbed into a symbiotic existence that synchronizes us with our tech—our relationship with computers (and with ourselves) is changing.

Dr. Michael McLoughlin, chief engineer at Johns Hopkins University's Applied Physics Laboratory (APL), leads a project that has created the most complex robotic arm in existence today. The *Modular Prosthetic Limb*, as it is called, is a neural prosthetic arm that interprets and converts signals from the body's nervous system into motion. When this limb interacts with an object, signals from over 100 sensors in its "fingertips" send information back to the brain, allowing its users to literally *feel* what their robotic arm is touching (Motherboard).

Neuroprostheses are literally bringing to life a race of cyborgs like those seen in science fiction, but the big surprise is that these cyborgs are not inhuman entities like the *Terminator*; they are just regular people:

One morning, Melissa Loomis, a woman from Canton, Ohio, opened her back door to find her dogs fighting with a raccoon that had wandered into her yard. She came out to intervene and was attacked by the raccoon, who scraped and mauled her forearm so badly that doctors had no choice but to amputate to stop the spread of infection. Thanks to a ground-breaking surgery called "sensory re-innervation," Loomis became one the first amputees in the United States to regain her sense of touch through APL's prosthetic limb. The strange part is that she did not immediately go berserk and use this technology to ransack armored bank vehicles.

The Modular Prosthetic Limb - Johns Hopkins' Applied Physics Laboratory

"I hope to just use my robotic arm just like I use my regular arm and just go about my business as a normal, two-armed person," she said in a 2016 interview with *Motherboard*. Dr. McLoughlin points out that people often make references to *The Terminator* when talking about APL's *Modular Prosthetic Limb*, concerned that it might be able to outclass a human arm. "Our arm can curl 45 pounds," he says. "It's not going to pick up a bus" (Motherboard).

While fiction writers have made a lot of money speculating on the dystopian possibilities of human enhancement, real-life stories like Melissa Loomis' are not about the *loss* of humanity to inhuman technology; instead, they are about using that technology to *regain* a sense of normalcy that was lost due to unfortunate circumstances involving the fragility of our human form.

One of the pioneers in the field of biomechatronics is Hugh Herr, bionics designer at MIT Media Lab's Center for Extreme Bionics. From an early age, Herr was a prodigy rock climber. By the age of

17, he was considered to be one of the best in the United States and had already amassed several years' experience climbing notoriously dangerous cliff faces such as those found in the Canadian Rockies. With this hobby, Herr was routinely testing the limits of the human body. Tragically, in the winter of 1982, he found those limits. After ascending a difficult ice route on Mount Washington in New Hampshire, Herr and a climbing partner became caught in a blizzard. The two became disoriented, lost, and spent three nights in -20 ˚F temperatures. By the time they were rescued, Herr had suffered severe frostbite and both his legs had to be amputated below the knees.

After months of surgeries and rehabilitation, Herr was once again testing the limits of his body. Only this time, he was not all human. Using specialized prostheses of his own design, Herr created prosthetic feet which allowed him to climb rock faces which doctors had told him he would never climb again. In many cases, these new prostheses actually enhanced his previous abilities, allowing him to climb at a more advanced level than before the accident. By simply swapping out his legs, he could range his height from five to eight feet, allowing him to reach footholds which had been previously impossible.

> About 12 months after my limbs had been amputated, I was climbing at the same level as I had before the accident, and people started to get nervous. Then, I exceeded that level and started to climb walls that no one ever climbed before, and then I became a threat—and that happened overnight… Some of my climbing colleagues actually threatened to cut their own legs off to achieve the same 'unfair advantage' as me. No one actually did it. (Herr, Wired)

In the years since, Herr has made it his mission to advance the technology behind such prostheses so that they might more-easily integrate with our natural body schema. Most prosthetic limbs are passive: inanimate objects which are essentially strapped to the remains of severed limbs. Herr and his team at MIT have spent years studying the inner workings of the human leg so that they might create more ergonomically similar bionic counterparts. Their theory is that if a neuroprosthetic leg could mimic the way a biological leg moves, this would allow the brain to more easily embody and command this artificial replacement.

> We studied how the calf muscle works, for example, and how the calf muscle is controlled by the spinal cord using neural reflexes. And we programmed that capability on the small computers that are underneath the shell of the bionic limb, so that when I walk at different speeds in different terrains, it's constantly updating the stiffness and power it's providing. (Herr, Wired)

Amputees who have received these biomechatronic legs often remark that it feels as if they are walking with a real leg. When we have artificial limbs that react similarly to the real thing and even transmit sensations back to our brains, what we have achieved is, by definition, human-computer symbiosis: a reciprocal existence in which a human mind *embodies* a mechanical entity (if only cognitively). The question here should not be: *Is this symbiosis humane?* But, rather: *What might we be able to achieve when we embrace this relationship?*

> The fact that I could design my body part and exceed what I achieved before—even exceed what nature intended—was very inspiring because I realized that technology has the power to heal, to rehabilitate, and to even extend human experience and human capability. (Herr, Wired)

Hugh Herr, amputee and engineer at MIT Media Lab's Center for Extreme Bionics

We are seeing similar advancements in biomechatronic technology with the advent of cochlear implants for the deaf and projects that are working to reroute the nervous systems of patients disabled by spinal injury. These technological advancements are allowing us to not only mimic the capabilities of the human body, but to exceed them. This, of course, holds ramifications for our conception of what it means to be human. "As humans, we are tool users; and every time we invent a new tool, that changes the way we live" (McLoughlin, Motherboard).

While comparisons to replicants and terminators are probably not very realistic, Dr. McLoughlin does point out that there are potential ethical concerns involved in the adoption of these prostheses. This technology is prohibitively expensive to most people (at least for the time being, costing hundreds of thousands of dollars), and there is a risk that—as with any tech—nefarious people could potentially hack into the system and hijack the controls. However, McLoughlin remains optimistic about the future of this technology:

> "I really believe that, in the end, we'll be able to deal with those kinds of things. Humanity has so much to gain here. So, yes, I think all these technologies will change us, but I don't think that's a bad thing." (Motherboard 2016)

Although most of us will likely not be eager to swap our biological parts for biomechatronic implants any time soon, we are seeing a growing market for less-invasive types of human-computer symbiosis. Wearable technology such as iWatches and FitBits are interfacing with our bodies in new and interesting ways. These devices are keeping us updated about happenings *outside* of our sensory realm, such as emails and text messages, while other functions like heart rate monitoring, period tracking, and caloric expenditure are also feeding us data about what is happening *inside* of our bodies. This creates a level of consciousness beyond what is available via the sensory feedback from our nervous systems.

> The idea of embodied cognition helps explain… the human race's prodigious facility for technology. Tuned to the surrounding environment, our bodies and brains are quick to bring tools and other artifacts into our thought processes" (Carr 93).

The more seamlessly we integrate ourselves with technology (be it through wearable tech or biomechatronic enhancement), the more easily our consciousness expands beyond the physical limitations of reality. As the interface disappears into the background and we enter into a state of symbiosis, what happens when we begin to synchronize this cognition into a worldwide network? Can embodied cognition, the extension of the body schema into physical technology, enter digital realms, providing a collaborative consciousness experienced by all?

> Rapidly, we approach the final phase of the extensions of man—the technological simulation of consciousness, when the creative process of knowing will be collectively and corporately extended to the whole of human society (McLuhan 3).

Could this be the future of humanity in the face of growing human-computer interaction? Will we eventually synchronize our individual minds into a collective digital consciousness, binding us all together through technology while also lifting us above and beyond that which is individually or humanly possible?

Let's ask Google and find out!

4| THE CLOUD MIND

Bear with me as we conduct a simple experiment: I will ask a few short questions, and we'll see how many of them you can answer without looking them up:

1. What is the population of Cairo?
2. How tall is Arnold Schwarzenegger?
3. What is Avogadro's Number?
4. What is Magic Johnson's real name?

These questions all have very clear answers, yet they are also so trivial that it is highly unlikely anyone should know more than one of them. I, however, happen to know them all (*9.5 million, 6 foot 2,* 6.02×10^{23}, *Earvin*). The reason I know these things is not because I am a *Jeopardy!*-playing robot, but simply because all this information has been made readily available for me to access with very minimal effort. What these questions all have in common is that they each appear in the list of search terms I have asked Google Assistant in the last week.

We are living at a time rightly called *The Information Age*, where any information we want to know can be delivered at a moment's notice by the soothing voices of robot servants more than content to answer all our dumb questions. If you find yourself wanting to make a pineapple upside-down cake, no worries—you don't need to know how because YouTube will show you. If you want to know how to sail a boat or fix that rattle in your car's engine, all you have to do is ask. At no other time in history have we had more information at our fingertips. But, as we become more accustomed to this convenience, we also fundamentally change the way we interact with the world around us. This constant stream of information is changing what we know, who we are, and how we think about the world and our existence in it.

Design theorists like Bill Ferster and Donald Norman point out a difference between "knowledge in the head" and "knowledge in the world" (Norman 75). As we think, we pull information from two separate databases: the knowledge we hold in our brains and the knowledge we find in the world around us (Ferster 31). As a simple demonstration, imagine that your computer's keyboard has no letters or numbers signifying which key is which—just dozens of blank keys. Though you may have knowledge in your head as to where all the keys are *supposed* to be, without that reference in the world how long do you think it would take for you to make a typo?

As we extend our "knowledge in the world" to the incomprehensibly vast reaches of the Internet, it creates an imbalance that makes the storage capacity of our brains seem wildly inadequate compared to the data servers of YouTube and Wikipedia. As a result, we have learned to navigate these databases as extensions of our own knowledge; we do not need to store information in our heads that can be kept in the cloud. But, are we *backing up* our knowledge to the cloud, or are we *moving it* there?

Media theorist Marshall McLuhan has argued that the media we use are not merely conduits for the transmission of information, they also change our thought processes (McLuhan 8). While the Internet is a fantastic resource, if we no longer need to travel to the library, search for a book, and read entire chapters from multiple sources to find the information we were looking for—if we can simply click on the first site and have that information fed to us intravenously—then this information becomes cheapened and we lose the opportunity for accidental discovery along the way.

Nicholas Carr, in his appropriately titled article for *The Atlantic*, "Is Google Making Us Stupid?" questions the long-term usefulness of relying on quick search results to answer our questions. He writes that our newfound ability to rapidly absorb and discard information is affecting the way we think:

> Thanks to the ubiquity of text on the Internet, not to mention the popularity of text-messaging on cell phones, we may well be reading more today than we did in the 1970s or 1980s, when television was our medium of choice. But it's a different kind of reading, and behind it lies a different kind of thinking—perhaps even a new sense of the self… Our ability to interpret text, to make the rich mental connections that form when we read deeply and without distraction, remains largely disengaged (Carr).

Because of this, our attention spans seem to be shrinking. We rarely have the patience for deep research and—even if we do—we may be hard-pressed to find an audience for it.

On the other hand, proponents like Bill Ferster argue that this sort of "knowledge in the world" is a kind of *distributed cognition*: worldly references which serve as "scaffolds for internal cognition" that "reduce the cognitive load requirements and increase the combined ability to understand complex information." Ferster argues that when this knowledge and expertise is shared (or distributed) amongst us, it "provides an environment in which individual minds are supported and carried further by the vast information provided," making our collective knowledge much more advanced (Ferster 31).

We are moving into a rather complicated offshoot of the Information Age: an era of distributed cognition where we all have our heads in the cloud. Our sharing of information and cultural knowledge has led to a great new liberation—a second enlightenment that is working to equalize us into the various parts of a holistic, global village. As McLuhan suggests, "the aspiration of our time for wholeness, empathy and depth of awareness is a natural adjunct of electric technology" (McLuhan 5). Wikipedia, in this respect, is perhaps the single most important invention in human history, for when we have access to each other's knowledge, it makes the task of understanding one another immeasurably easier.

But at what cost?

Our reference material has become so strong that we are actively choosing to forget or ignore what we have learned. Information the scholars of antiquity fought and often died for is now reduced to "TL; DR."

This poses a very difficult conundrum: *How do we maintain a highly accessible shared knowledge base without taking for granted the ease with which that knowledge was attained?* Unfortunately, I doubt there is a simple or comprehensive answer to this. As James Watson, one of the biologists who discovered the structure of DNA, once said: "There are only molecules. Everything else is Sociology."

The important distinction to make is the difference between what is already known and what has yet to be discovered. Simply put: Old knowledge is easy to attain, but new knowledge is difficult. Running a web search for "Avogadro's Number" is incredibly easy, even though the conceptualization and measurement of the number of molecules per mole was an incredibly difficult pursuit spanning hundreds of years of collaborative scientific effort. What we must try at all costs to avoid is this trivialization of knowledge. Knowing the population of Cairo is all well and good, but it is most likely useless until that knowledge is put to work in some way. Knowing the number of molecules per mole is useless unless it opens the doors to new applications and learning.

Information with no use can be cumbersome, and the constant stream of information to which we are subjected on a daily basis is just so. Our world is now made up of software, and we do an increasing percentage of our work in a digital realm. As new media theorist Lev Manovich suggests:

> Software has become our interface to the world, to others, to our memory and our imagination—a universal language through which the world speaks, and a universal engine on which the world runs (Manovich 2).

If, as McLuhan suggests, any medium is an extension of ourselves and broadens the scale of our existence (McLuhan 7), then the Internet and the software it enables are not merely extensions but also a binding agent, connecting us all to a collective consciousness that has evolved from a local zeitgeist into a worldwide group mind.

As of this writing, just over 30% of the US population was born after 1995 and thus has always lived in a world bound together by the Internet. As this ratio continues to grow, I predict that we will only become increasingly reliant upon distributed cognition, and so it is increasingly important for us to be mindful of the extent to which we let the Internet do our thinking for us.

To approach this problem further, deeper research is needed into the psychology of human-computer interaction and the neuroscience involved with distributed cognition. We must continue to study people's interactions with software to better understand how our brains compensate for this imbalance caused by the extension of our knowledge. Our goal must be to make all the world's knowledge readily accessible while also strengthening our ability to think critically and interact attentively.

It can be easy to assume, considering the enormity of information at our disposal, that someone else probably holds an adequate answer to every one of our questions. This is the philosophy that we must reject. Instead of being content with whatever answer our robotic assistants confidently spit back at us, we should continue to question them and continue to ask ourselves *why* we want this information and *what* we plan to do with it once it arrives. It is this resistance to "automation bias" which will insulate us from technological deception if and when the AI revolution consumes us.

CONCLUSION: IN OUR OWN IMAGE

The great historical narrative of the last century will take as its arc the incredible scientific achievements of humanity. In the last hundred years, we have gone from Ford's Model T to cyborgs walking among us. We are now connected to one another 24/7 through an international, digital network that anonymizes, equalizes, and provides for us all. While this network is supported and maintained by vast underground cables and data servers, its conceptual existence is an ethereal cyberspace:

> A consensual hallucination experienced daily by billions of legitimate operators, in every nation… A graphic representation of data abstracted from banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the nonspace of the mind, clusters and constellations of data. Like city lights, receding. (Gibson)

This is not a cyberspace of the digital; it is a cyberspace of the mind which uses digital technology as its medium of communication. Given enough time, it will make us all into one. While this medium is continually bleeding-edge, the motivations behind all this are as old as humanity itself.

The great driving force behind humanity is the need for advancement. It's what pushes us to run faster, learn more, climb mountains, make tools, and expand our consciousness to something greater than the way we found it. However, the consequence of this is a competitive nature that has also caused us to wage wars, commit murder, steal from our neighbors, and ravage our planet.

This Zoroastrian duality is as present in digital technology as anywhere else in human achievement. Though we have created vast cognitive networks that connect and empower us, we have also used this technology to spy on each other and disseminate hatred. Though we have engineered cybernetic enhancements that replicate and even enhance our human abilities, we have made this technology prohibitively expensive to all but the most affluent of us.

This is a symbiotic duality; our peace cannot exist without our war, and our love cannot exist without our hatred. These are binary forces, creating a balance that sustains us all. "Equilibrium," as John Dewey tells us, "comes about not mechanically and inertly but out of, and because of, tension" (Dewey 14). Similarly, Sir Isaac Newton tells us that every action must have an equal and opposite reaction. The man who oversaw the Manhattan Project also inspired the technology which will be hailed as our greatest creation. This technology will empower us, and yet possibly destroy us.

It is this tension that the speculative work of science fiction warns us of. Tropes of cyborgs and artificial intelligence are not allegories of the power of this technology to destroy us but of our capacity to destroy ourselves. The greater our ascendancy toward technological or spiritual utopia, the greater the pull of darkness on our heels. Like Icarus, will we fly or will we fall?

As we move toward a deeper symbiosis with our technology (and make no mistake, this will happen), we will be able to reach heights beyond anything that was previously possible. But the higher we fly, the greater our dependency on our wings becomes. Perhaps the biggest danger of technological advancement will reveal itself to be our addiction to it—as we are led into temptation like lambs to the slaughter. But, perhaps, we will also become transcendent—beings of light and intelligence beyond corporeal potentiality.

We have made our technology in our own image. The very code at the soul of our greatest creation is binary. However, we have not made this technology to replicate humanity but to extend it. All extensions of ourselves are attempts to maintain equilibrium, and our symbiosis with Artificial Intelligence will either be a force to bring balance to this ancient struggle or it will tip the balance one way or the other.

Whether it's worth the risk... is up to you.

WORKS CITED

Bush, Vannevar. "As We May Think." *The Atlantic*, July 1945.

Carr, Nicholas. "Is Google Making Us Stupid?" *The Atlantic*. Aug 2008.

Carr, Nicholas. *The Glass Cage: Automation and Us.* W.W. Norton & Company, New York, 2014.

Clark, Andy and David Chalmers. "The Extended Mind," *The Extended Mind*. Richard Menary, ed, MIT Press, 2010.

"DARPA Helps Paralyzed Man Feel Again." *DARPA*, 2016, https://www.darpa.mil/news-events/2016-10-13.

Dewey, John. *Art as Experience*. Perigee Books, 1934.

Emondi, Al. "Revolutionizing Prosthetics." *DARPA*, accessed Feb 2020, https://www.darpa.mil/program/revolutionizing-prosthetics.

Ferster, Bill. *Interactive Visualization: Insight Through Inquiry.* MIT Press, 2012.

Kay, Alan. "The Early History of Smalltalk." Apple Computer, 1993.

Licklider, JCR. "Man-Computer Symbiosis." *IRE Transactions on Human Factors in Electronics*, HFE-1:4-11, March 1960.

Lin, Patrick & Fritz Allhoff. "Untangling the Debate: The Ethics of Human Enhancement." *Nanoethics*, 2008.

McLuhan, Marshall. *Understanding Media*. MIT Press, 1964.

"The Mind-Controlled Bionic Arm With a Sense of Touch." *Motherboard*. 2016, https://youtu.be/F_brnKz_2tI/.

Norman, Donald. *The Design of Everyday Things*. Basic Books, 2013.

Sutherland, Ivan. *A Head-Mounted 3D Display*. MIT 1966.

Sutherland, Ivan. *Sketchpad: A Man-Machine Graphical Communication System*. MIT, 1963.

Turner, Fred. *From Counterculture to Cyberculture: Stewart Brand, the Whole Earth Network, and the Rise of Digital Utopianism*. University of Chicago Press, 2006.

Van Riper, A Bowdoin. *Science in Popular Culture*. Greenwood Press, 2002.

Weiser, Mark. "The Computer for the 21st Century." *Scientific American*, Sep 1991.

Yarosh, Lana. "What is Artificial Intelligence?" *Crash Course AI*, #1, 2019, https://youtu.be/a0_lo_GDcFw.