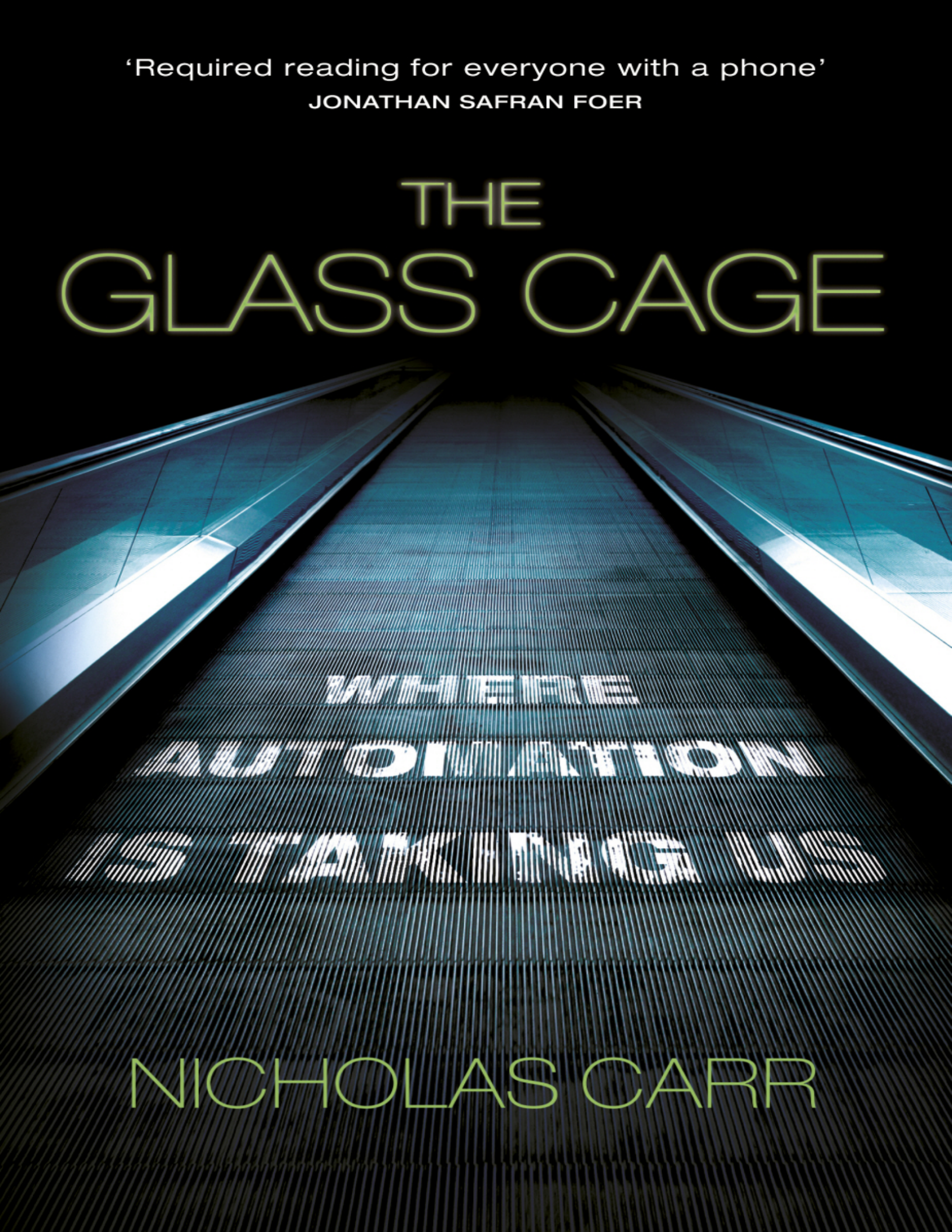
‘Required reading for everyone with a phone’
JONATHAN SAFRAN FOER

THE GLASS CAGE



NICHOLAS CARR

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ABOUT THE BOOK

In May 2009 an Airbus A330 passenger jet equipped with the latest ‘glass cockpit’ controls plummeted 30,000 feet into the Atlantic. The reason for the crash: the autopilot had routinely switched itself off. Faced with having to fly the plane themselves, the pilots ‘suffered a total loss of cognitive control’ and plunged all 228 passengers and crew to their deaths.

Automation is everywhere – from the thermostat in our homes and the GPS in our phones to the algorithms of High Frequency Trading and self-driving cars. We now use it to diagnose patients, educate children, evaluate criminal evidence and fight wars. But psychological studies show that we perform best when fully involved in a task, while the principle of automation – that humans are inefficient – is self-fulfilling. As we become increasingly dependent on software to make decisions for us, the glass cockpit becomes a glass cage.

In this utterly engrossing exposé, bestselling writer Nicholas Carr uses remarkable case studies – from the navigation techniques of Inuit hunters to the errant trading of $7 billion on Wall Street by an algorithm gone rogue – to reveal how automation is changing us: our ability not just to read maps and drive cars but to solve problems, forge memories and acquire skills. Rather than rejecting technology, Carr argues that we must urgently rethink its role in our lives, using it to enhance rather than diminish the extraordinary abilities that make us human.

ABOUT THE AUTHOR

Nicholas Carr is a leading commentator on technology and culture. He is the author of *The Shallows: What the Internet Is Doing to Our Brains*, a 2011 Pulitzer Prize finalist and a *New York Times* bestseller, as well as two other influential books, *The Big Switch: Rewiring the World, from Edison to Google* (2008) and *Does IT Matter?* (2004). His books have been translated into more than 20 languages.

ALSO BY NICHOLAS CARR

The Shallows:
What the Internet Is Doing to Our Brains

The Big Switch:
Rewiring the World, from Edison to Google

Does IT Matter?
Information Technology and the Corrosion of Competitive Advantage

The Digital Enterprise
(editor)

To Ann

THE GLASS CAGE

WHERE AUTOMATION IS TAKING US

Nicholas Carr

THE BODLEY HEAD
LONDON

No one
to witness
and adjust, no one to drive the car

—*William Carlos Williams*

INTRODUCTION

ALERT FOR OPERATORS

On January 4, 2013, the first Friday of a new year, a dead day newswise, the Federal Aviation Administration released a one-page notice. It had no title. It was identified only as a "safety alert for operators," or SAFO. Its wording was terse and cryptic. In addition to being posted on the FAA's website, it was sent to all U.S. airlines and other commercial air carriers. "This SAFO," the document read, "encourages operators to promote manual flight operations when appropriate." The FAA had collected evidence, from crash investigations, incident reports, and cockpit studies, indicating that pilots had become too dependent on autopilots and other computerized systems. Overuse of flight automation, the agency warned, could "lead to degradation of the pilot's ability to quickly recover the aircraft from an undesired state." It could, in blunter terms, put a plane and its passengers in jeopardy. The alert concluded with a recommendation that airlines, as a matter of operational policy, instruct pilots to spend less time flying on autopilot and more time flying by hand.[1]

This is a book about automation, about the use of computers and software to do things we used to do ourselves. It's not about the technology or the economics of automation, nor is it about the future of robots and cyborgs and gadgetry, though all those things enter into the story. It's about automation's human consequences. Pilots have been out in front of a wave that is now engulfing us. We're

looking to computers to shoulder more of our work, on the job and off, and to guide us through more of our everyday routines. When we need to get something done today, more often than not we sit down in front of a monitor, or open a laptop, or pull out a smartphone, or strap a net-connected accessory to our forehead or wrist. We run apps. We consult screens. We take advice from digitally simulated voices. We defer to the wisdom of algorithms.

Computer automation makes our lives easier, our chores less burdensome. We're often able to accomplish more in less time—or to do things we simply couldn't do before. But automation also has deeper, hidden effects. As aviators have learned, not all of them are beneficial. Automation can take a toll on our work, our talents, and our lives. It can narrow our perspectives and limit our choices. It can open us to surveillance and manipulation. As computers become our constant companions, our familiar, obliging helpmates, it seems wise to take a closer look at exactly how they're changing what we do and who we are.

CHAPTER ONE

PASSENGERS

AMONG THE HUMILIATIONS OF MY TEENAGE YEARS WAS ONE that might be termed psycho-mechanical: my very public struggle to master a manual transmission. I got my driver's license early in 1975, not long after I turned sixteen. The previous fall, I had taken a driver's ed course with a group of my high-school classmates. The instructor's Oldsmobile, which we used for our on-the-road lessons and then for our driving tests at the dread Department of Motor Vehicles, was an automatic. You pressed the gas pedal, you turned the wheel, you hit the brakes. There were a few tricky maneuvers—making a three-point turn, backing up in a straight line, parallel parking—but with a little practice among pylons in the school parking lot, even they became routine.

License in hand, I was ready to roll. There was just one last roadblock. The only car available to me at home was a Subaru sedan with a stick shift. My dad, not the most hands-on of parents, granted me a single lesson. He led me out to the garage one Saturday morning, plopped himself down behind the wheel, and had me climb into the passenger seat beside him. He placed my left palm over the shift knob and guided my hand through the gears: "That's first." Brief pause. "Second." Brief pause. "Third." Brief pause. "Fourth." Brief pause. "Down over here"—a pain shot through my wrist as it twisted into an unnatural position—"is Reverse." He glanced at me to confirm I had it all down. I nodded helplessly. "And that"—wiggling my

hand back and forth—“that’s Neutral.” He gave me a few tips about the speed ranges of the four forward gears. Then he pointed to the clutch pedal he had pinned beneath his loafer. “Make sure you push that in while you shift.”

I proceeded to make a spectacle of myself on the roads of the small New England town where we lived. The car would buck as I tried to find the correct gear, then lurch forward as I mistimed the release of the clutch. I’d stall at every red light, then stall again halfway out into the intersection. Hills were a horror. I’d let the clutch out too quickly, or too slowly, and the car would roll backward until it came to rest against the bumper of the vehicle behind me. Horns were honked, curses cursed, birds flipped. What made the experience all the more excruciating was the Subaru’s yellow paint job—the kind of yellow you get with a kid’s rain slicker or a randy male goldfinch. The car was an eye magnet, my flailing impossible to miss.

From my putative friends, I received no sympathy. They found my struggles a source of endless, uproarious amusement. “Grind me a pound!” one of them would yell with glee from the backseat whenever I’d muff a shift and set off a metallic gnashing of gear teeth. “Smooth move,” another would snigger as the engine rattled to a stall. The word “spaz”—this was well before anyone had heard of political correctness—was frequently lobbed my way. I had a suspicion that my incompetence with the stick was something my buddies laughed about behind my back. The metaphorical implications were not lost on me. My manhood, such as it was at sixteen, felt deflated.

But I persisted—what choice did I have?—and after a week or two I began to get the hang of it. The gearbox loosened up and became more forgiving. My arms and legs stopped working at cross-purposes and started cooperating. Soon, I was shifting without thinking about it. It just happened. The car no longer stalled or bucked or lurched. I no longer had to sweat the hills or the

intersections. The transmission and I had become a team. We meshed. I took a quiet pride in my accomplishment.

Still, I coveted an automatic. Although stick shifts were fairly common back then, at least in the econoboxes and junkers that kids drove, they had already taken on a behind-the-times, hand-me-down quality. They seemed fusty, a little yesterday. Who wanted to be “manual” when you could be “automatic”? It was like the difference between scrubbing dishes by hand and sticking them in a dishwasher. As it turned out, I didn’t have to wait long for my wish to be granted. Two years after I got my license, I managed to total the Subaru during a late-night misadventure, and not long afterward I took stewardship of a used, cream-colored, two-door Ford Pinto. The car was a piece of crap—some now see the Pinto as marking the nadir of American manufacturing in the twentieth century—but to me it was redeemed by its automatic transmission.

I was a new man. My left foot, freed from the demands of the clutch, became an appendage of leisure. As I tooled around town, it would sometimes tap along jauntily to the thwacks of Charlie Watts or the thuds of John Bonham—the Pinto also had a built-in eight-track deck, another touch of modernity—but more often than not it just stretched out in its little nook under the left side of the dash and napped. My right hand became a beverage holder. I not only felt renewed and up-to-date. I felt liberated.

It didn’t last. The pleasures of having less to do were real, but they faded. A new emotion set in: boredom. I didn’t admit it to anyone, hardly to myself even, but I began to miss the gear stick and the clutch pedal. I missed the sense of control and involvement they had given me—the ability to rev the engine as high as I wanted, the feel of the clutch releasing and the gears grabbing, the tiny thrill that came with a downshift at speed. The automatic made me feel a little less like a driver and a little more like a passenger. I came to resent it.

■ ■ ■ ■

Motor ahead thirty-five years, to the morning of October 9, 2010. One of Google's in-house inventors, the German-born roboticist Sebastian Thrun, makes an extraordinary announcement in a blog post. The company has developed "cars that can drive themselves." These aren't some gawky, gearhead prototypes puttering around the Googleplex's parking lot. These are honest-to-goodness street-legal vehicles—Priuses, to be precise—and, Thrun reveals, they've already logged more than a hundred thousand miles on roads and highways in California and Nevada. They've cruised down Hollywood Boulevard and the Pacific Coast Highway, gone back and forth over the Golden Gate Bridge, circled Lake Tahoe. They've merged into freeway traffic, crossed busy intersections, and inched through rush-hour gridlock. They've swerved to avoid collisions. They've done all this by themselves. Without human help. "We think this is a first in robotics research," Thrun writes, with sly humility.[1]

Building a car that can drive itself is no big deal. Engineers and tinkerers have been constructing robotic and remote-controlled automobiles since at least the 1980s. But most of them were crude jalopies. Their use was restricted to test-drives on closed tracks or to races and rallies in deserts and other remote areas, far away from pedestrians and police. The Googlemobile, Thrun's announcement made clear, is different. What makes it such a breakthrough, in the history of both transport and automation, is its ability to navigate the real world in all its chaotic, turbulent complexity. Outfitted with laser range-finders, radar and sonar transmitters, motion detectors, video cameras, and GPS receivers, the car can sense its surroundings in minute detail. It can see where it's going. And by processing all the streams of incoming information

instantaneously—in “real time”—its onboard computers are able to work the accelerator, the steering wheel, and the brakes with the speed and sensitivity required to drive on actual roads and respond fluidly to the unexpected events that drivers always encounter. Google’s fleet of self-driving cars has now racked up close to a million miles, and the vehicles have caused just one serious accident. That was a five-car pileup near the company’s Silicon Valley headquarters in 2011, and it doesn’t really count. It happened, as Google was quick to announce, “while a person was manually driving the car.”[2]

Autonomous automobiles have a ways to go before they start chauffeuring us to work or ferrying our kids to soccer games. Although Google has said it expects commercial versions of its car to be on sale by the end of the decade, that’s probably wishful thinking. The vehicle’s sensor systems remain prohibitively expensive, with the roof-mounted laser apparatus alone going for eighty thousand dollars. Many technical challenges remain to be met, such as navigating snowy or leaf-covered roads, dealing with unexpected detours, and interpreting the hand signals of traffic cops and road workers. Even the most powerful computers still have a hard time distinguishing a bit of harmless road debris (a flattened cardboard box, say) from a dangerous obstacle (a nail-studded chunk of plywood). Most daunting of all are the many legal, cultural, and ethical hurdles a driverless car faces. Where, for instance, will culpability and liability reside should a computer-driven automobile cause an accident that kills or injures someone? With the car’s owner? With the manufacturer that installed the self-driving system? With the programmers who wrote the software? Until such thorny questions get sorted out, fully automated cars are unlikely to grace dealer showrooms.

Progress will sprint forward nonetheless. Much of the Google test cars' hardware and software will come to be incorporated into future generations of cars and trucks. Since the company went public with its autonomous vehicle program, most of the world's major carmakers have let it be known that they have similar efforts under way. The goal, for the time being, is not so much to create an immaculate robot-on-wheels as to continue to invent and refine automated features that enhance safety and convenience in ways that get people to buy new cars. Since I first turned the key in my Subaru's ignition, the automation of driving has already come a long way. Today's automobiles are stuffed with electronic gadgetry. Microchips and sensors govern the workings of the cruise control, the antilock brakes, the traction and stability mechanisms, and, in higher-end models, the variable-speed transmission, parking-assist system, collision-avoidance system, adaptive headlights, and dashboard displays. Software already provides a buffer between us and the road. We're not so much controlling our cars as sending electronic inputs to the computers that control them.

In coming years, we'll see responsibility for many more aspects of driving shift from people to software. Luxury-car makers like Infiniti, Mercedes, and Volvo are rolling out models that combine radar-assisted adaptive cruise control, which works even in stop-and-go traffic, with computerized steering systems that keep a car centered in its lane and brakes that slam themselves on in emergencies. Other manufacturers are rushing to introduce even more advanced controls. Tesla Motors, the electric car pioneer, is developing an automotive autopilot that "should be able to [handle] 90 percent of miles driven," according to the company's ambitious chief executive, Elon Musk.[3]

The arrival of Google's self-driving car shakes up more than our conception of driving. It forces us to change our

thinking about what computers and robots can and can't do. Up until that fateful October day, it was taken for granted that many important skills lay beyond the reach of automation. Computers could do a lot of things, but they couldn't do everything. In an influential 2004 book, *The New Division of Labor: How Computers Are Creating the Next Job Market*, economists Frank Levy and Richard Murnane argued, convincingly, that there were practical limits to the ability of software programmers to replicate human talents, particularly those involving sensory perception, pattern recognition, and conceptual knowledge. They pointed specifically to the example of driving a car on the open road, a talent that requires the instantaneous interpretation of a welter of visual signals and an ability to adapt seamlessly to shifting and often unanticipated situations. We hardly know how we pull off such a feat ourselves, so the idea that programmers could reduce all of driving's intricacies, intangibilities, and contingencies to a set of instructions, to lines of software code, seemed ludicrous. "Executing a left turn across oncoming traffic," Levy and Murnane wrote, "involves so many factors that it is hard to imagine the set of rules that can replicate a driver's behavior." It seemed a sure bet, to them and to pretty much everyone else, that steering wheels would remain firmly in the grip of human hands.[4]

In assessing computers' capabilities, economists and psychologists have long drawn on a basic distinction between two kinds of knowledge: *tacit* and *explicit*. Tacit knowledge, which is also sometimes called procedural knowledge, refers to all the stuff we do without thinking about it: riding a bike, snagging a fly ball, reading a book, driving a car. These aren't innate skills—we have to learn them, and some people are better at them than others—but they can't be expressed as a simple recipe. When you make a turn through a busy intersection in your car, neurological

studies show, many areas of your brain are hard at work, processing sensory stimuli, making estimates of time and distance, and coordinating your arms and legs.[5] But if someone asked you to document everything involved in making that turn, you wouldn't be able to, at least not without resorting to generalizations and abstractions. The ability resides deep in your nervous system, outside the ambit of your conscious mind. The mental processing goes on without your awareness.

Much of our ability to size up situations and make quick judgments about them stems from the fuzzy realm of tacit knowledge. Most of our creative and artistic skills reside there too. Explicit knowledge, which is also known as declarative knowledge, is the stuff you can actually write down: how to change a flat tire, how to fold an origami crane, how to solve a quadratic equation. These are processes that can be broken down into well-defined steps. One person can explain them to another person through written or oral instructions: do this, then this, then this.

Because a software program is essentially a set of precise, written instructions—do this, then this, then this—we've assumed that while computers can replicate skills that depend on explicit knowledge, they're not so good when it comes to skills that flow from tacit knowledge. How do you translate the ineffable into lines of code, into the rigid, step-by-step instructions of an algorithm? The boundary between the explicit and the tacit has always been a rough one—a lot of our talents straddle the line—but it seemed to offer a good way to define the limits of automation and, in turn, to mark out the exclusive precincts of the human. The sophisticated jobs Levy and Murnane identified as lying beyond the reach of computers—in addition to driving, they pointed to teaching and medical diagnosis—were a mix of the mental and the manual, but they all drew on tacit knowledge.

Google's car resets the boundary between human and computer, and it does so more dramatically, more decisively, than have earlier breakthroughs in programming. It tells us that our idea of the limits of automation has always been something of a fiction. We're not as special as we think we are. While the distinction between tacit and explicit knowledge remains a useful one in the realm of human psychology, it has lost much of its relevance to discussions of automation.

■ ■ ■ ■

THAT DOESN'T mean that computers now have tacit knowledge, or that they've started to think the way we think, or that they'll soon be able to do everything people can do. They don't, they haven't, and they won't. Artificial intelligence is not human intelligence. People are mindful; computers are mindless. But when it comes to performing demanding tasks, whether with the brain or the body, computers are able to replicate our ends without replicating our means. When a driverless car makes a left turn in traffic, it's not tapping into a well of intuition and skill; it's following a program. But while the strategies are different, the outcomes, for practical purposes, are the same. The superhuman speed with which computers can follow instructions, calculate probabilities, and receive and send data means that they can use explicit knowledge to perform many of the complicated tasks that we do with tacit knowledge. In some cases, the unique strengths of computers allow them to perform what we consider to be tacit skills better than we can perform them ourselves. In a world of computer-controlled cars, you wouldn't need traffic lights or stop signs. Through the continuous, high-speed exchange of data, vehicles would seamlessly coordinate their passage through even the busiest of

intersections—just as computers today regulate the flow of inconceivable numbers of data packets along the highways and byways of the internet. What's ineffable in our own minds becomes altogether effable in the circuits of a microchip.

Many of the cognitive talents we've considered uniquely human, it turns out, are anything but. Once computers get quick enough, they can begin to mimic our ability to spot patterns, make judgments, and learn from experience. We were first taught that lesson back in 1997 when IBM's Deep Blue chess-playing supercomputer, which could evaluate a billion possible moves every five seconds, beat the world champion Garry Kasparov. With Google's intelligent car, which can process a million environmental readings a second, we're learning the lesson again. A lot of the very smart things that people do don't actually require a brain. The intellectual talents of highly trained professionals are no more protected from automation than is the driver's left turn. We see the evidence everywhere. Creative and analytical work of all sorts is being mediated by software. Doctors use computers to diagnose diseases. Architects use them to design buildings. Attorneys use them to evaluate evidence. Musicians use them to simulate instruments and correct bum notes. Teachers use them to tutor students and grade papers. Computers aren't taking over these professions entirely, but they are taking over many aspects of them. And they're certainly changing the way the work is performed.

It's not only vocations that are being computerized. Avocations are too. Thanks to the proliferation of smartphones, tablets, and other small, affordable, and even wearable computers, we now depend on software to carry out many of our daily chores and pastimes. We launch apps to aid us in shopping, cooking, exercising, even finding a mate and raising a child. We follow turn-by-turn GPS instructions to get from one place to the next. We use social

networks to maintain friendships and express our feelings. We seek advice from recommendation engines on what to watch, read, and listen to. We look to Google, or to Apple's Siri, to answer our questions and solve our problems. The computer is becoming our all-purpose tool for navigating, manipulating, and understanding the world, in both its physical and its social manifestations. Just think what happens these days when people misplace their smartphones or lose their connections to the net. Without their digital assistants, they feel helpless. As Katherine Hayles, a literature professor at Duke University, observed in her 2012 book *How We Think*, "When my computer goes down or my Internet connection fails, I feel lost, disoriented, unable to work—in fact, I feel as if my hands have been amputated."[6]

Our dependency on computers may be disconcerting at times, but in general we welcome it. We're eager to celebrate and show off our whizzy new gadgets and apps—and not only because they're so useful and so stylish. There's something magical about computer automation. To watch an iPhone identify an obscure song playing over the sound system in a bar is to experience something that would have been inconceivable to any previous generation. To see a crew of brightly painted factory robots effortlessly assemble a solar panel or a jet engine is to view an exquisite heavy-metal ballet, each movement choreographed to a fraction of a millimeter and a sliver of a second. The people who have taken rides in Google's car report that the thrill is almost otherworldly; their earth-bound brain has a tough time processing the experience. Today, we really do seem to be entering a brave new world, a Tomorrowland where computers and automatons will be at our service, relieving us of our burdens, granting our wishes, and sometimes just keeping us company. Very soon now, our Silicon Valley wizards assure us, we'll have robot

maids as well as robot chauffeurs. Sundries will be fabricated by 3-D printers and delivered to our doors by drones. The world of the *Jetsons*, or at least of *Knight Rider*, beckons.

It's hard not to feel awestruck. It's also hard not to feel apprehensive. An automatic transmission may seem a paltry thing beside Google's tricked-out, look-ma-no-humans Prius, but the former was a precursor to the latter, a small step along the path to total automation, and I can't help but remember the letdown I felt after the gear stick was taken from my hand—or, to put responsibility where it belongs, after I begged to have the gear stick taken from my hand. If the convenience of an automatic transmission left me feeling a little lacking, a little *underutilized*, as a labor economist might say, how will it feel to become, truly, a passenger in my own car?

■ ■ ■ ■

THE TROUBLE with automation is that it often gives us what we don't need at the cost of what we do. To understand why that's so, and why we're eager to accept the bargain, we need to take a look at how certain cognitive biases—flaws in the way we think—can distort our perceptions. When it comes to assessing the value of labor and leisure, the mind's eye can't see straight.

Mihaly Csikszentmihalyi, a psychology professor and author of the popular 1990 book *Flow*, has described a phenomenon that he calls "the paradox of work." He first observed it in a study he conducted in the 1980s with his University of Chicago colleague Judith LeFevre. They recruited a hundred workers, blue-collar and white-collar, skilled and unskilled, from five businesses around Chicago. They gave each an electronic pager (this was when cell phones were still luxury goods) that they had programmed

to beep at seven random moments a day over the course of a week. At each beep, the subjects would fill out a short questionnaire. They'd describe the activity they were engaged in at that moment, the challenges they were facing, the skills they were deploying, and the psychological state they were in, as indicated by their sense of motivation, satisfaction, engagement, creativity, and so forth. The intent of this "experience sampling," as Csikszentmihalyi termed the technique, was to see how people spend their time, on the job and off, and how their activities influence their "quality of experience."

The results were surprising. People were happier, felt more fulfilled by what they were doing, while they were at work than during their leisure hours. In their free time, they tended to feel bored and anxious. And yet they didn't like to be at work. When they were on the job, they expressed a strong desire to be off the job, and when they were off the job, the last thing they wanted was to go back to work. "We have," reported Csikszentmihalyi and LeFevre, "the paradoxical situation of people having many more positive feelings at work than in leisure, yet saying that they 'wish to be doing something else' when they are at work, not when they are in leisure."[7] We're terrible, the experiment revealed, at anticipating which activities will satisfy us and which will leave us discontented. Even when we're in the midst of doing something, we don't seem able to judge its psychic consequences accurately.

Those are symptoms of a more general affliction, on which psychologists have bestowed the poetic name *miswanting*. We're inclined to desire things we don't like and to like things we don't desire. "When the things we want to happen do not improve our happiness, and when the things we want not to happen do," the cognitive psychologists Daniel Gilbert and Timothy Wilson have observed, "it seems fair to say we have wanted badly."[8] And

as slews of gloomy studies show, we're forever wanting badly. There's also a social angle to our tendency to misjudge work and leisure. As Csikszentmihalyi and LeFevre discovered in their experiments, and as most of us know from our own experience, people allow themselves to be guided by social conventions—in this case, the deep-seated idea that being "at leisure" is more desirable, and carries more status, than being "at work"—rather than by their true feelings. "Needless to say," the researchers concluded, "such a blindness to the real state of affairs is likely to have unfortunate consequences for both individual well-being and the health of society." As people act on their skewed perceptions, they will "try to do more of those activities that provide the least positive experiences and avoid the activities that are the source of their most positive and intense feelings."[9] That's hardly a recipe for the good life.

It's not that the work we do for pay is intrinsically superior to the activities we engage in for diversion or entertainment. Far from it. Plenty of jobs are dull and even demeaning, and plenty of hobbies and pastimes are stimulating and fulfilling. But a job imposes a structure on our time that we lose when we're left to our own devices. At work, we're pushed to engage in the kinds of activities that human beings find most satisfying. We're happiest when we're absorbed in a difficult task, a task that has clear goals and that challenges us not only to exercise our talents but to stretch them. We become so immersed in the flow of our work, to use Csikszentmihalyi's term, that we tune out distractions and transcend the anxieties and worries that plague our everyday lives. Our usually wayward attention becomes fixed on what we're doing. "Every action, movement, and thought follows inevitably from the previous one," explains Csikszentmihalyi. "Your whole being is involved, and you're using your skills to the

utmost."[10] Such states of deep absorption can be produced by all manner of effort, from laying tile to singing in a choir to racing a dirt bike. You don't have to be earning a wage to enjoy the transports of flow.

More often than not, though, our discipline flags and our mind wanders when we're not on the job. We may yearn for the workday to be over so we can start spending our pay and having some fun, but most of us fritter away our leisure hours. We shun hard work and only rarely engage in challenging hobbies. Instead, we watch TV or go to the mall or log on to Facebook. We get lazy. And then we get bored and fretful. Disengaged from any outward focus, our attention turns inward, and we end up locked in what Emerson called the jail of self-consciousness. Jobs, even crummy ones, are "actually easier to enjoy than free time," says Csikszentmihalyi, because they have the "built-in" goals and challenges that "encourage one to become involved in one's work, to concentrate and lose oneself in it."[11] But that's not what our deceiving minds want us to believe. Given the opportunity, we'll eagerly relieve ourselves of the rigors of labor. We'll sentence ourselves to idleness.

■ ■ ■ ■

Is it any wonder we're enamored of automation? By offering to reduce the amount of work we have to do, by promising to imbue our lives with greater ease, comfort, and convenience, computers and other labor-saving technologies appeal to our eager but misguided desire for release from what we perceive as toil. In the workplace, automation's focus on enhancing speed and efficiency—a focus determined by the profit motive rather than by any particular concern for people's well-being—often has the effect of removing complexity from jobs, diminishing the

challenge they present and hence the engagement they promote. Automation can narrow people's responsibilities to the point that their jobs consist largely of monitoring a computer screen or entering data into prescribed fields. Even highly trained analysts and other so-called knowledge workers are seeing their work circumscribed by decision-support systems that turn the making of judgments into a data-processing routine. The apps and other programs we use in our private lives have similar effects. By taking over difficult or time-consuming tasks, or simply rendering those tasks less onerous, the software makes it even less likely that we'll engage in efforts that test our skills and give us a sense of accomplishment and satisfaction. All too often, automation frees us from that which makes us feel free.

The point is not that automation is bad. Automation and its precursor, mechanization, have been marching forward for centuries, and by and large our circumstances have improved greatly as a result. Deployed wisely, automation can relieve of us drudge work and spur us on to more challenging and fulfilling endeavors. The point is that we're not very good at thinking rationally about automation or understanding its implications. We don't know when to say "enough" or even "hold on a second." The deck is stacked, economically and emotionally, in automation's favor. The benefits of transferring work from people to machines and computers are easy to identify and measure. Businesses can run the numbers on capital investments and calculate automation's benefits in hard currency: reduced labor costs, improved productivity, faster throughputs and turnarounds, higher profits. In our personal lives, we can point to all sorts of ways that computers allow us to save time and avoid hassles. And thanks to our bias for leisure over work, ease over effort, we overestimate automation's benefits.

The costs are harder to pin down. We know computers make certain jobs obsolete and put some people out of

work, but history suggests, and most economists assume, that any declines in employment will prove temporary and that over the long haul productivity-boosting technology will create attractive new occupations and raise standards of living. The personal costs are even hazier. How do you measure the expense of an erosion of effort and engagement, or a waning of agency and autonomy, or a subtle deterioration of skill? You can't. Those are the kinds of shadowy, intangible things that we rarely appreciate until after they're gone, and even then we may have trouble expressing the losses in concrete terms. But the costs are real. The choices we make, or fail to make, about which tasks we hand off to computers and which we keep for ourselves are not just practical or economic choices. They're ethical choices. They shape the substance of our lives and the place we make for ourselves in the world. Automation confronts us with the most important question of all: What does *human being* mean?

Csikszentmihalyi and LeFevre discovered something else in their study of people's daily routines. Among all the leisure activities reported by their test subjects, the one that generated the greatest sense of flow was driving a car.

CHAPTER TWO

THE ROBOT AT THE GATE

In the early 1950s, Leslie Illingworth, a much-admired political cartoonist at the British satirical magazine *Punch*, drew a dark and foreboding sketch. Set at dusk on what appears to be a stormy autumn day, it shows a worker peering anxiously from the doorway of an anonymous manufacturing plant. One of his hands grips a small tool; the other is balled into a fist. He looks out across the muddy factory yard to the plant's main gate. There, standing beside a sign reading "Hands Wanted," looms a giant, broad-shouldered robot. Across its chest, emblazoned in block letters, is the word "Automation."

The illustration was a sign of its times, a reflection of a new anxiety seeping through Western society. In 1956, it was reprinted as the frontispiece of a slender but influential book called *Automation: Friend or Foe?* by Robert Hugh Macmillan, an engineering professor at Cambridge University. On the first page, Macmillan posed an unsettling question: "Are we in danger of being destroyed by our own creations?" He was not, he explained, referring to the well-known "perils of unrestricted 'push-button' warfare." He was talking about a less discussed but more insidious threat: "the rapidly increasing part that automatic devices are playing in the peace-time industrial life of all civilized countries."[1] Just as earlier machines "had replaced man's muscles," these new devices seemed likely to "replace his brains." By taking over many good,

well-paying jobs, they threatened to create widespread unemployment, leading to social strife and upheaval—of just the sort Karl Marx had foreseen a century earlier.[2]

But, Macmillan continued, it didn't have to be that way. If "*rightly* applied," automation could bring economic stability, spread prosperity, and relieve the human race of its toils. "My hope is that this new branch of technology may eventually enable us to lift the curse of Adam from the shoulders of man, for machines could indeed become men's slaves rather than their masters, now that practical techniques have been devised for controlling them automatically."[3] Whether technologies of automation ultimately proved boon or bane, Macmillan warned, one thing was certain: they would play an ever greater role in industry and society. The economic imperatives of "a highly competitive world" made that inevitable.[4] If a robot could work faster, cheaper, or better than its human counterpart, the robot would get the job.

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"WE ARE brothers and sisters of our machines," the technology historian George Dyson once remarked.[5] Sibling relations are notoriously fraught, and so it is with our technological kin. We love our machines—not just because they're useful to us, but because we find them companionable and even beautiful. In a well-built machine, we see some of our deepest aspirations take form: the desire to understand the world and its workings, the desire to turn nature's power to our own purposes, the desire to add something new and of our own fashioning to the cosmos, the desire to be awed and amazed. An ingenious machine is a source of wonder and of pride.

But machines are ugly too, and we sense in them a threat to things we hold dear. Machines may be a conduit of