ALSO BY NICHOLAS CARR

Utopia Is Creepy

The Glass Cage: How Our Computers Are Changing Us

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

Does IT Matter?

THE SHALLOWS

What the Internet Is Doing to Our Brains

NICHOLAS CARR

Atlantic Books
London

Published by arrangement with W. W. Norton and Company, Inc., New York.

First published in hardback in Great Britain in 2010 by Atlantic Books,
an imprint of Atlantic Books Ltd.

This updated paperback edition first published in Great Britain in 2020 by
Atlantic Books, an imprint of Atlantic Books Ltd.

3 5 7 9 10 8 6 4 2

A CIP catalogue record for this book is available from the British Library.

Paperback ISBN: 978-1-83895-258-7
E-book ISBN: 978-1-84887-883-9

Printed in Great Britain

Atlantic Books
An imprint of Atlantic Books Ltd
Ormond House
26–27 Boswell Street
London
WC1N 3JZ

www.atlantic-books.co.uk

to my mother

and in memory of my father

Prologue

THE WATCHDOG AND THE THIEF

In 1964, just as the Beatles were launching their invasion of America's airwaves, Marshall McLuhan published *Understanding Media: The Extensions of Man* and transformed himself from an obscure academic into a star. Oracular, gnomic, and mind-bending, the book was a perfect product of the sixties, that now-distant decade of acid trips and moon shots, inner and outer voyaging. *Understanding Media* was at heart a prophecy, and what it prophesied was the dissolution of the linear mind. McLuhan declared that the "electric media" of the twentieth century—telephone, radio, movies, television—were breaking the tyranny of text over our thoughts and senses. Our isolated, fragmented selves, locked for centuries in the private reading of printed pages, were becoming whole again, merging into the global equivalent of a tribal village. We were approaching "the technological simulation of consciousness, when the creative process of knowing will be collectively and corporately extended to the whole of human society."[1]

Even at the crest of its fame, *Understanding Media* was a book more talked about than read. Today it has become a cultural relic, consigned to media studies courses in universities. But McLuhan, as

much a showman as a scholar, was a master at turning phrases, and one of them, sprung from the pages of the book, lives on as a popular saying: "The medium is the message." What's been forgotten in our repetition of this enigmatic aphorism is that McLuhan was not just acknowledging, and celebrating, the transformative power of new communication technologies. He was also sounding a warning about the threat the power poses—and the risk of being oblivious to that threat. "The electric technology is within the gates," he wrote, "and we are numb, deaf, blind and mute about its encounter with the Gutenberg technology, on and through which the American way of life was formed."[2]

McLuhan understood that whenever a new medium comes along, people naturally get caught up in the information—the "content"—it carries. They care about the news in the newspaper, the music on the radio, the shows on the TV, the words spoken by the person on the far end of the phone line. The technology of the medium, however astonishing it may be, disappears behind whatever flows through it—facts, entertainment, instruction, conversation. When people start debating (as they always do) whether the medium's effects are good or bad, it's the content they wrestle over. Enthusiasts celebrate it; skeptics decry it. The terms of the argument have been pretty much the same for every new informational medium, going back at least to the books that came off Gutenberg's press. Enthusiasts, with good reason, praise the torrent of new content that the technology uncorks, seeing it as signaling a "democratization" of culture. Skeptics, with equally good reason, condemn the crassness of the content, viewing it as signaling a "dumbing down" of culture. One side's abundant Eden is the other's vast wasteland.

The Internet is the latest medium to spur this debate. The clash between Net enthusiasts and Net skeptics, carried out over the last two decades through dozens of books and articles and thousands of blog posts, video clips, and podcasts, has become as polarized as ever, with the former heralding a new golden age of access and participation and the latter bemoaning a new dark age of mediocrity and narcissism. The debate has been important—content does matter—but because it hinges on personal ideology and taste, it has gone down a cul-de-sac. The views have become extreme, the attacks personal. "Luddite!" sneers the enthusiast. "Philistine!" scoffs the skeptic. "Cassandra!" "Pollyanna!"

What both enthusiast and skeptic miss is what McLuhan saw: that in the long run a medium's content matters less than the medium itself in influencing how we think and act. As our window onto the world, and onto ourselves, a popular medium molds what we see and how we see it—and eventually, if we use it enough, it changes who we are, as individuals and as a society. "The effects of technology do not occur at the level of opinions or concepts," wrote McLuhan. Rather, they alter "patterns of perception steadily and without any resistance."[3] The showman exaggerates to make his point, but the point stands. Media work their magic, or their mischief, on the nervous system itself.

Our focus on a medium's content can blind us to these deep effects. We're too busy being dazzled or disturbed by the programming to notice what's going on inside our heads. In the end, we come to pretend that the technology itself doesn't matter. It's how we use it that matters, we tell ourselves. The implication, comforting in its hubris, is that we're in control. The technology is just a tool, inert until we pick it up and inert again once we set it aside.

McLuhan quoted a self-serving pronouncement by David Sarnoff, the media mogul who pioneered radio at RCA and television at NBC. In a speech at the University of Notre Dame in 1955, Sarnoff dismissed criticism of the mass media on which he had built his empire and his fortune. He turned the blame for any ill effects away from the technologies and onto the listeners and viewers: "We are too prone to make technological instruments the scapegoats for the sins of those who wield them. The products of modern science are not in themselves good or bad; it is the way they are used that determines their value." McLuhan scoffed at the idea, chiding Sarnoff for speaking with "the voice of the current somnambulism."[4]

Every new medium, McLuhan understood, changes us. "Our conventional response to all media, namely that it is how they are used that counts, is the numb stance of the technological idiot," he wrote. The content of a medium is just "the juicy piece of meat carried by the burglar to distract the watchdog of the mind."[5]

Not even McLuhan could have foreseen the feast that the Internet has laid before us: one course after another, each juicier than the last, with hardly a moment to catch our breath between bites. As networked computers have shrunk to the size of iPhones and Androids, the feast has become a movable one, available anytime, anywhere. It's in our home, our office, our car, our classroom, our purse, our pocket. Even people who are wary of the Net's ever-expanding influence rarely allow their concerns to get in the way of their use and enjoyment of the technology. The movie critic David Thomson once observed that "doubts can be rendered feeble in the face of the certainty of the medium."[6] He was talking about the cinema and how it projects its sensations and sensibilities not only onto the movie screen but onto us, the engrossed and compliant audience. His comment applies with even greater force to the Net. The computer screen bulldozes our doubts with its bounties and conveniences. It is so much our servant that it would seem churlish to notice that it is also our master.

One

HAL AND ME

"Dave, stop. Stop, will you? Stop, Dave. Will you stop?" So the supercomputer HAL pleads with the implacable astronaut Dave Bowman in a famous and weirdly poignant scene toward the end of Stanley Kubrick's *2001: A Space Odyssey*. Bowman, having nearly been sent to a deep-space death by the malfunctioning machine, is calmly, coldly disconnecting the memory circuits that control its artificial brain. "Dave, my mind is going," HAL says, forlornly. "I can feel it. I can feel it."

I can feel it too. Over the last few years I've had an uncomfortable sense that someone, or something, has been tinkering with my brain, remapping the neural circuitry, reprogramming the memory. My mind isn't going—so far as I can tell—but it's changing. I'm not thinking the way I used to think. I feel it most strongly when I'm reading. I used to find it easy to immerse myself in a book or a lengthy article. My mind would get caught up in the twists of the narrative or the turns of the argument, and I'd spend hours strolling through long stretches of prose. That's rarely the case anymore. Now my concentration starts to drift after a page or two. I get fidgety, lose the thread, begin looking for something else to do. I feel like I'm

nology should be used to support that work." Whereas the Xerox researcher "was eager to juggle multiple threads of work simultaneously," the skeptical questioner viewed his own work "as an exercise in solitary, singleminded concentration."[30] In the choices we have made, consciously or not, about how we use our computers, we have rejected the intellectual tradition of solitary, singleminded concentration, the ethic that the book bestowed on us. We have cast our lot with the juggler.

Seven

THE JUGGLER'S BRAIN

It's been a while since the first-person singular was heard in these pages. This seems like a good time for me, your word-processing scribe, to make a brief reappearance. I realize that I've dragged you through a lot of space and time over the last few chapters, and I appreciate your fortitude in sticking with me. The journey you've been on is the same one I took in trying to figure out what's been going on inside my head. The deeper I dug into the science of neuroplasticity and the progress of intellectual technology, the clearer it became that the Internet's import and influence can be judged only when viewed in the fuller context of intellectual history. As revolutionary as it may be, the Net is best understood as the latest in a long series of tools that have helped mold the human mind.

Now comes the crucial question: What can science tell us about the actual effects that Internet use is having on the way our minds work? No doubt, this question will be the subject of a great deal of research in the years ahead. Already, though, there is much we know or can surmise. The news is even more disturbing than I had suspected. Dozens of studies by psychologists, neurobiologists, educators, and Web designers point to the same conclusion: when we

go online, we enter an environment that promotes cursory reading, hurried and distracted thinking, and superficial learning. It's possible to think deeply while surfing the Net, just as it's possible to think shallowly while reading a book, but that's not the type of thinking the technology encourages and rewards.

One thing is very clear: if, knowing what we know today about the brain's plasticity, you were to set out to invent a medium that would rewire our mental circuits as quickly and thoroughly as possible, you would probably end up designing something that looks and works a lot like the Internet. It's not just that we tend to use the Net regularly, even obsessively. It's that the Net delivers precisely the kind of sensory and cognitive stimuli—repetitive, intensive, interactive, addictive—that have been shown to result in strong and rapid alterations in brain circuits and functions. With the exception of alphabets and number systems, the Net may well be the single most powerful mind-altering technology that has ever come into general use. At the very least, it's the most powerful that has come along since the book.

During the course of a day, most of us with access to the Web spend at least a couple of hours online—sometimes much more—and during that time, we tend to repeat the same or similar actions over and over again, usually at a high rate of speed and often in response to cues delivered through a screen or a speaker. Some of the actions are physical ones. We tap the keys on our PC keyboard. We drag a mouse and click its left and right buttons and spin its scroll wheel. We draw the tips of our fingers across a trackpad. We use our thumbs to punch out text on the real or simulated keypads of our mobile phones. We rotate our iPhones and iPads to shift between "landscape" and "portrait" modes while manipulating the icons on their touch-sensitive screens.

As we go through these motions, the Net delivers a steady stream of inputs to our visual, somatosensory, and auditory cortices. There are the sensations that come through our hands and fingers as we click and scroll, type and touch. There are the many audio signals

delivered through our ears, such as the chime that announces the arrival of a new e-mail or instant message and the various ringtones that our mobile phones use to alert us to different events. And, of course, there are the myriad visual cues that flash across our retinas as we navigate the online world: not just the ever-changing arrays of text and pictures and videos but also the hyperlinks distinguished by underlining or colored text, the cursors that change shape depending on their function, the new e-mail subject lines highlighted in bold type, the virtual buttons that call out to be clicked, the icons and other screen elements that beg to be dragged and dropped, the forms that require filling out, the pop-up ads and windows that need to be read or dismissed. The Net engages all of our senses—except, so far, those of smell and taste—and it engages them simultaneously.

The Net also provides a high-speed system for delivering responses and rewards—"positive reinforcements," in psychological terms—which encourage the repetition of both physical and mental actions. When we click a link, we get something new to look at and evaluate. When we Google a keyword, we receive, in the blink of an eye, a list of interesting information to appraise. When we send a text or an instant message or an e-mail, we often get a reply in a matter of seconds or minutes. When we use Facebook, we attract new friends or form closer bonds with old ones. When we send a tweet through Twitter, we gain new followers. When we write a blog post, we get comments from readers or links from other bloggers. The Net's interactivity gives us powerful new tools for finding information, expressing ourselves, and conversing with others. It also turns us into lab rats constantly pressing levers to get tiny pellets of social or intellectual nourishment.

The Net commands our attention with far greater insistency than our television or radio or morning newspaper ever did. Watch a kid texting his friends or a college student looking over the roll of new messages and requests on her Facebook page or a businessman scrolling through his e-mails on his phone—or consider yourself as you enter keywords into Google's search box and begin following

a trail of links. What you see is a mind consumed with a medium. When we're online, we're often oblivious to everything else going on around us. The real world recedes as we process the flood of symbols and stimuli coming through our devices.

The interactivity of the Net amplifies this effect as well. Because we're often using our computers in a social context, to converse with friends or colleagues, to create "profiles" of ourselves, to broadcast our thoughts through blog posts or Facebook updates, our social standing is, in one way or another, always in play, always at risk. The resulting self-consciousness—even, at times, fear—magnifies the intensity of our involvement with the medium. That's true for everyone, but it's particularly true for the young, who tend to be compulsive in using their phones and computers for texting and messaging. Today's teenagers typically send or receive a message every few minutes throughout their waking hours. As the psychotherapist Michael Hausauer notes, teens and other young adults have a "terrific interest in knowing what's going on in the lives of their peers, coupled with a terrific anxiety about being out of the loop."[1] If they stop sending messages, they risk becoming invisible.

Our use of the Internet involves many paradoxes, but the one that promises to have the greatest long-term influence over how we think is this one: the Net seizes our attention only to scatter it. We focus intensively on the medium itself, on the flickering screen, but we're distracted by the medium's rapid-fire delivery of competing messages and stimuli. Whenever and wherever we log on, the Net presents us with an incredibly seductive blur. Human beings "want more information, more impressions, and more complexity," writes Torkel Klingberg, the Swedish neuroscientist. We tend to "seek out situations that demand concurrent performance or situations in which [we] are overwhelmed with information."[2] If the slow progression of words across printed pages dampened our craving to be inundated by mental stimulation, the Net indulges it. It returns us to our native state of bottom-up distractedness, while presenting us with far more distractions than our ancestors ever had to contend with.

Not all distractions are bad. As most of us know from experience, if we concentrate too intensively on a tough problem, we can get stuck in a mental rut. Our thinking narrows, and we struggle vainly to come up with new ideas. But if we let the problem sit unattended for a time—if we "sleep on it"—we often return to it with a fresh perspective and a burst of creativity. Research by Ap Dijksterhuis, a Dutch psychologist who heads the Unconscious Lab at Radboud University in Nijmegen, indicates that such breaks in our attention give our unconscious mind time to grapple with a problem, bringing to bear information and cognitive processes unavailable to conscious deliberation. We usually make better decisions, his experiments reveal, if we shift our attention away from a difficult mental challenge for a time. But Dijksterhuis's work also shows that our unconscious thought processes don't engage with a problem until we've clearly and consciously defined the problem.[3] If we don't have a particular intellectual goal in mind, Dijksterhuis writes, "unconscious thought does not occur."[4]

The constant distractedness that the Net encourages—the state of being, to borrow another phrase from Eliot's *Four Quartets*, "distracted from distraction by distraction"—is very different from the kind of temporary, purposeful diversion of our mind that refreshes our thinking when we're weighing a decision. The Net's cacophony of stimuli short-circuits both conscious and unconscious thought, preventing our minds from thinking either deeply or creatively. Our brains turn into simple signal-processing units, quickly shepherding information into consciousness and then back out again.

In a 2005 interview, Michael Merzenich ruminated on the Internet's power to cause not just modest alterations but fundamental changes in our mental makeup. Noting that "our brain is modified on a substantial scale, physically and functionally, each time we learn a new skill or develop a new ability," he described the Net as the latest in a series of "modern cultural specializations" that "contemporary humans can spend millions of 'practice' events at [and that] the average human a thousand years ago had absolutely no exposure

to." He concluded that "our brains are massively remodeled by this exposure."[5] He returned to this theme in a post on his blog in 2008, resorting to capital letters to emphasize his points. "When culture drives changes in the ways that we engage our brains, it creates DIFFERENT brains," he wrote, noting that our minds "strengthen specific heavily-exercised processes." While acknowledging that it's now hard to imagine living without the Internet and online tools like the Google search engine, he stressed that "THEIR HEAVY USE HAS NEUROLOGICAL CONSEQUENCES."[6]

What we're *not* doing when we're online also has neurological consequences. Just as neurons that fire together wire together, neurons that don't fire together don't wire together. As the time we spend scanning Web pages crowds out the time we spend reading books, as the time we spend exchanging bite-sized text messages crowds out the time we spend composing sentences and paragraphs, as the time we spend hopping across links crowds out the time we devote to quiet reflection and contemplation, the circuits that support those old intellectual functions and pursuits weaken and begin to break apart. The brain recycles the disused neurons and synapses for other, more pressing work. We gain new skills and perspectives but lose old ones.

GARY SMALL, A professor of psychiatry at UCLA and the director of its Memory and Aging Center, has been studying the physiological and neurological effects of the use of digital media, and what he's discovered backs up Merzenich's belief that the Net causes extensive brain changes. "The current explosion of digital technology not only is changing the way we live and communicate but is rapidly and profoundly altering our brains," he says. The daily use of computers, smartphones, search engines, and other such tools "stimulates brain cell alteration and neurotransmitter release, gradually strengthening new neural pathways in our brains while weakening old ones."[7]

In 2008, Small and two of his colleagues carried out the first experiment that actually showed people's brains changing in response to Internet use.[8] The researchers recruited twenty-four volunteers—a dozen experienced Web surfers and a dozen novices—and scanned their brains as they performed searches on Google. (Since a computer won't fit inside a magnetic resonance imager, the subjects were equipped with goggles onto which were projected images of Web pages, along with a small handheld touchpad to navigate the pages.) The scans revealed that the brain activity of the experienced Googlers was much broader than that of the novices. In particular, "the computer-savvy subjects used a specific network in the left front part of the brain, known as the dorsolateral prefrontal cortex, [while] the Internet-naïve subjects showed minimal, if any, activity in this area." As a control for the test, the researchers also had the subjects read straight text in a simulation of book reading; in this case, scans revealed no significant difference in brain activity between the two groups. Clearly, the experienced Net users' distinctive neural pathways had developed through their Internet use.

The most remarkable part of the experiment came when the tests were repeated six days later. In the interim, the researchers had the novices spend an hour a day online, searching the Net. The new scans revealed that the area in their prefrontal cortex that had been largely dormant now showed extensive activity—just like the activity in the brains of the veteran surfers. "After just five days of practice, the exact same neural circuitry in the front part of the brain became active in the Internet-naïve subjects," reports Small. "Five hours on the Internet, and the naïve subjects had already rewired their brains." He goes on to ask, "If our brains are so sensitive to just an hour a day of computer exposure, what happens when we spend more time [online]?"[9]

One other finding of the study sheds light on the differences between reading Web pages and reading books. The researchers found that when people search the Net they exhibit a very different pattern of brain activity than they do when they read book-like text. Book readers have a lot of activity in regions associated with lan-

guage, memory, and visual processing, but they don't display much activity in the prefrontal regions associated with decision making and problem solving. Experienced Net users, by contrast, display extensive activity across all those brain regions when they scan and search Web pages. The good news here is that Web surfing, because it engages so many brain functions, may help keep older people's minds sharp. Searching and browsing seem to "exercise" the brain in a way similar to solving crossword puzzles, says Small.

But the extensive activity in the brains of surfers also points to why deep reading and other acts of sustained concentration become so difficult online. The need to evaluate links and make related navigational choices, while also processing a multiplicity of fleeting sensory stimuli, requires constant mental coordination and decision making, distracting the brain from the work of interpreting text or other information. Whenever we, as readers, come upon a link, we have to pause, for at least a split second, to allow our prefrontal cortex to evaluate whether or not we should click on it. The redirection of our mental resources, from reading words to making judgments, may be imperceptible to us—our brains are quick—but it's been shown to impede comprehension and retention, particularly when it's repeated frequently. As the executive functions of the prefrontal cortex kick in, our brains become not only exercised but overtaxed. In a very real way, the Web returns us to the time of *scriptura continua*, when reading was a cognitively strenuous act. In reading online, Maryanne Wolf says, we sacrifice the facility that makes deep reading possible. We revert to being "mere decoders of information."[10] Our ability to make the rich mental connections that form when we read deeply and without distraction remains largely disengaged.

Steven Johnson, in his 2005 book *Everything Bad Is Good for You*, contrasted the widespread, teeming neural activity seen in the brains of computer users with the much more muted activity evident in the brains of book readers. The comparison led him to suggest that computer use provides more intense mental stimulation than does book reading. The neural evidence could even, he wrote, lead a

person to conclude that "reading books chronically understimulates the senses."[11] But while Johnson's diagnosis is correct, his interpretation of the differing patterns of brain activity is misleading. It is the very fact that book reading "understimulates the senses" that makes the activity so intellectually rewarding. By allowing us to filter out distractions, to quiet the problem-solving functions of the frontal lobes, deep reading becomes a form of deep thinking. The mind of the experienced book reader is a calm mind, not a buzzing one. When it comes to the firing of our neurons, it's a mistake to assume that more is better.

John Sweller, an Australian educational psychologist, has spent three decades studying how our minds process information and, in particular, how we learn. His work illuminates how the Net and other media influence the style and the depth of our thinking. Our brains, he explains, incorporate two very different kinds of memory: short-term and long-term. We hold our immediate impressions, sensations, and thoughts as short-term memories, which tend to last only a matter of seconds. All the things we've learned about the world, whether consciously or unconsciously, are stored as long-term memories, which can remain in our brains for a few days, a few years, or even a lifetime. One particular type of short-term memory, called working memory, plays an instrumental role in the transfer of information into long-term memory and hence in the creation of our personal store of knowledge. Working memory forms, in a very real sense, the contents of our consciousness at any given moment. "We are conscious of what is in working memory and not conscious of anything else," says Sweller.[12]

If working memory is the mind's scratch pad, then long-term memory is its filing system. The contents of our long-term memory lie mainly outside of our consciousness. In order for us to think about something we've previously learned or experienced, our brain has to transfer the memory from long-term memory back into working memory. "We are only aware that something was stored in long-term memory when it is brought down into working memory,"

explains Sweller.[13] It was once assumed that long-term memory served merely as a big warehouse of facts, impressions, and events, that it "played little part in complex cognitive processes such as thinking and problem-solving."[14] But brain scientists have come to realize that long-term memory is actually the seat of understanding. It stores not just facts but complex concepts, or "schemas." By organizing scattered bits of information into patterns of knowledge, schemas give depth and richness to our thinking. "Our intellectual prowess is derived largely from the schemas we have acquired over long periods of time," says Sweller. "We are able to understand concepts in our areas of expertise because we have schemas associated with those concepts."[15]

The depth of our intelligence hinges on our ability to transfer information from working memory to long-term memory and weave it into conceptual schemas. But the passage from working memory to long-term memory also forms the major bottleneck in our brain. Unlike long-term memory, which has a vast capacity, working memory is able to hold only a very small amount of information. In a renowned 1956 paper, "The Magical Number Seven, Plus or Minus Two," Princeton psychologist George Miller observed that working memory could typically hold just seven pieces, or "elements," of information. Even that is now considered an overstatement. According to Sweller, current evidence suggests that "we can process no more than about two to four elements at any given time with the actual number probably being at the lower [rather] than the higher end of this scale." Those elements that we are able to hold in working memory will, moreover, quickly vanish "unless we are able to refresh them by rehearsal."[16]

Imagine filling a bathtub with a thimble; that's the challenge involved in transferring information from working memory into long-term memory. By regulating the velocity and intensity of information flow, media exert a strong influence on this process. When we read a book, the information faucet provides a steady drip, which we can control by the pace of our reading. Through our single-minded

concentration on the text, we can transfer all or most of the information, thimbleful by thimbleful, into long-term memory and forge the rich associations essential to the creation of schemas. With the Net, we face many information faucets, all going full blast. Our little thimble overflows as we rush from one faucet to the next. We're able to transfer only a small portion of the information to long-term memory, and what we do transfer is a jumble of drops from different faucets, not a continuous, coherent stream from one source.

The information flowing into our working memory at any given moment is called our "cognitive load." When the load exceeds our mind's ability to store and process the information—when the water overflows the thimble—we're unable to retain the information or to draw connections with the information already stored in our long-term memory. We can't translate the new information into schemas. Our ability to learn suffers, and our understanding remains shallow. Because our ability to maintain our attention also depends on our working memory—"we have to remember what it is we are to concentrate on," as Torkel Klingberg says—a high cognitive load amplifies the distractedness we experience. When our brain is overtaxed, we find "distractions more distracting."[17] (Some studies link attention deficit disorder, or ADD, to the overloading of working memory.) Experiments indicate that as we reach the limits of our working memory, it becomes harder to distinguish relevant information from irrelevant information, signal from noise. We become mindless consumers of data.

Difficulties in developing an understanding of a subject or a concept appear to be "heavily determined by working memory load," writes Sweller, and the more complex the material we're trying to learn, the greater the penalty exacted by an overloaded mind.[18] There are many possible sources of cognitive overload, but two of the most important, according to Sweller, are "extraneous problem-solving" and "divided attention." Those also happen to be two of the central features of the Net as an informational medium. Using the Net may, as Gary Small suggests, exercise the brain the way solving crossword

puzzles does. But such intensive exercise, when it becomes our primary mode of thought, can impede deep learning and thinking. Try reading a book while doing a crossword puzzle; that's the intellectual environment of the Internet.

BACK IN THE 1980s, when schools began investing heavily in computers, there was much enthusiasm about the apparent advantages of digital documents over paper ones. Many educators were convinced that introducing hyperlinks into text displayed on computer screens would be a boon to learning. Hypertext would, they argued, strengthen students' critical thinking by enabling them to switch easily between different viewpoints. Freed from the lockstep reading demanded by printed pages, readers would make all sorts of new intellectual connections among diverse texts. The academic enthusiasm for hypertext was further kindled by the belief, in line with the fashionable postmodern theories of the day, that hypertext would overthrow the patriarchal authority of the author and shift power to the reader. It would be a technology of liberation. Hypertext, wrote the literary theorists George Landow and Paul Delany, can "provide a revelation" by freeing readers from the "stubborn materiality" of printed text. By "moving away from the constrictions of page-bound technology," it "provides a better model for the mind's ability to reorder the elements of experience by changing the links of association or determination between them."[19]

By the end of the decade, the enthusiasm had begun to subside. Research was painting a fuller, and very different, picture of the cognitive effects of hypertext. Evaluating links and navigating a path through them, it turned out, involves mentally demanding problem-solving tasks that are extraneous to the act of reading itself. Deciphering hypertext substantially increases readers' cognitive load and hence weakens their ability to comprehend and retain what they're reading. A 1989 study showed that readers of hypertext often ended up clicking distractedly "through pages instead of reading them

carefully." A 1990 experiment revealed that hypertext readers often "could not remember what they had and had not read." In another study that same year, researchers had two groups of people answer a series of questions by searching through a set of documents. One group searched through electronic hypertext documents, while the other searched through traditional paper documents. The group that used the paper documents outperformed the hypertext group in completing the assignment. In reviewing the results of these and other experiments, the editors of a 1996 book on hypertext and cognition wrote that, since hypertext "imposes a higher cognitive load on the reader," it's no surprise "that empirical comparisons between paper presentation (a familiar situation) and hypertext (a new, cognitively demanding situation) do not always favor hypertext." But they predicted that, as readers gained greater "hypertext literacy," the cognition problems would likely diminish.[20]

That hasn't happened. Even though the World Wide Web has made hypertext commonplace, indeed ubiquitous, research continues to show that people who read linear text comprehend more, remember more, and learn more than those who read text peppered with links. In a 2001 study, two Canadian scholars asked seventy people to read "The Demon Lover," a short story by the modernist writer Elizabeth Bowen. One group read the story in a traditional linear-text format; a second group read a version with links, as you'd find on a Web page. The hypertext readers took longer to read the story, yet in subsequent interviews they also reported more confusion and uncertainty about what they had read. Three-quarters of them said that they had difficulty following the text, while only one in ten of the linear-text readers reported such problems. One hypertext reader complained, "The story was very jumpy. I don't know if that was caused by the hypertext, but I made choices and all of a sudden it wasn't flowing properly, it just kind of jumped to a new idea I didn't really follow."

A second test by the same researchers, using a shorter and more simply written story, Sean O'Faolain's "The Trout," produced the same results. Hypertext readers again reported greater confu-

sion following the text, and their comments about the story's plot and imagery were less detailed and less precise than those of the linear-text readers. With hypertext, the researchers concluded, "the absorbed and personal mode of reading seems to be discouraged." The readers' attention "was directed toward the machinery of the hypertext and its functions rather than to the experience offered by the story."[21] The medium used to present the words obscured the meaning of the words.

In another experiment, researchers had people sit at computers and review two online articles describing opposing theories of learning. One article laid out an argument that "knowledge is objective"; the other made the case that "knowledge is relative." Each article was set up in the same way, with similar headings, and each had links to the other article, allowing a reader to jump quickly between the two to compare the theories. The researchers hypothesized that people who used the links would gain a richer understanding of the two theories and their differences than would people who read the pages sequentially, completing one before going on to the other. They were wrong. The test subjects who read the pages linearly actually scored considerably higher on a subsequent comprehension test than those who clicked back and forth between the pages. The links got in the way of learning, the researchers concluded.[22]

Another researcher, Erping Zhu, conducted a different kind of experiment that was also aimed at discerning the influence of hypertext on comprehension. She had groups of people read the same piece of online writing, but she varied the number of links included in the passage. She then tested the readers' comprehension by asking them to write a summary of what they had read and complete a multiple-choice test. She found that comprehension declined as the number of links increased. Readers were forced to devote more and more of their attention and brain power to evaluating the links and deciding whether to click on them. That left less attention and fewer cognitive resources to devote to understanding what they were reading. The experiment suggested a strong correlation

"between the number of links and disorientation or cognitive overload," wrote Zhu. "Reading and comprehension require establishing relationships between concepts, drawing inferences, activating prior knowledge, and synthesizing main ideas. Disorientation or cognitive overload may thus interfere with cognitive activities of reading and comprehension."[23]

In 2005, Diana DeStefano and Jo-Anne LeFevre, psychologists with the Centre for Applied Cognitive Research at Canada's Carleton University, undertook a comprehensive review of thirty-eight past experiments involving the reading of hypertext. Although not all the studies showed that hypertext diminished comprehension, they found "very little support" for the once-popular theory "that hypertext will lead to an enriched experience of the text." To the contrary, the preponderance of evidence indicated that "the increased demands of decision-making and visual processing in hypertext impaired reading performance," particularly when compared to "traditional linear presentation." They concluded that "many features of hypertext resulted in increased cognitive load and thus may have required working memory capacity that exceeded readers' capabilities."[24]

THE WEB COMBINES the technology of hypertext with the technology of multimedia to deliver what's called "hypermedia." It's not just words that are served up and electronically linked, but also images, sounds, and moving pictures. Just as the pioneers of hypertext once believed that links would provide a richer learning experience for readers, many educators also assumed that multimedia, or "rich media," as it's sometimes called, would deepen comprehension and strengthen learning. The more inputs, the better. But this assumption, long accepted without much evidence, has also been contradicted by research. The division of attention demanded by multimedia further strains our cognitive abilities, diminishing our learning and weakening our understanding. When

it comes to supplying the mind with the stuff of thought, more can be less.

In a study published in the journal *Media Psychology* in 2007, researchers recruited more than a hundred volunteers to watch a presentation about the country of Mali played through a Web browser on a computer. Some of the subjects watched a version of the presentation that included only a series of text pages. Another group watched a version that included, along with the pages of text, a window in which an audiovisual presentation of related material was streamed. The test subjects were able to stop and start the stream as they wished.

After viewing the presentation, the subjects took a ten-question quiz on the material. The text-only viewers answered an average of 7.04 of the questions correctly, while the multimedia viewers answered just 5.98 correctly—a significant difference, according to the researchers. The subjects were also asked a series of questions about their perceptions of the presentation. The text-only readers found it to be more interesting, more educational, more understandable, and more enjoyable than did the multimedia viewers, and the multimedia viewers were much more likely to agree with the statement "I did not learn anything from this presentation" than were the text-only readers. The multimedia technologies so common to the Web, the researchers concluded, "would seem to limit, rather than enhance, information acquisition."[25]

In another experiment, a pair of Cornell researchers divided a class of students into two groups. One group was allowed to surf the Web while listening to a lecture. A log of their activity showed that they looked at sites related to the lecture's content but also visited unrelated sites, checked their e-mail, went shopping, watched videos, and did all the other things that people do online. The second group heard the identical lecture but had to keep their laptops shut. Immediately afterward, both groups took a test measuring how well they could recall the information from the lecture. The surfers, the researchers report, "performed significantly poorer on immediate measures of memory for the to-be-learned content." It didn't matter, moreover, whether they surfed information related to the lecture or completely unrelated content—they all performed poorly. When the researchers repeated the experiment with another class, the results were the same.[26]

Kansas State University scholars conducted a similarly realistic study. They had a group of college students watch a typical CNN broadcast in which an anchor reported four news stories while various info-graphics flashed on the screen and a textual news crawl ran along the bottom. They had a second group watch the same programming but with the graphics and the news crawl stripped out. Subsequent tests found that the students who had watched the multimedia version remembered significantly fewer facts from the stories than those who had watched the simpler version. "It appears," wrote the researchers, "that this multimessage format exceeded viewers' attentional capacity."[27]

Supplying information in more than one form doesn't always take a toll on understanding. As we all know from reading illustrated textbooks and manuals, pictures can help clarify and reinforce written explanations. Education researchers have also found that carefully designed presentations that combine audio and visual explanations or instructions can enhance students' learning. The reason, current theories suggest, is that our brains use different channels for processing what we see and what we hear. As Sweller explains, "Auditory and visual working memory are separate, at least to some extent, and because they are separate, effective working memory may be increased by using both processors rather than one." As a result, in some cases "the negative effects of split attention might be ameliorated by using both auditory and visual modalities"—sounds and pictures, in other words.[28] The Internet, however, wasn't built by educators to optimize learning. It presents information not in a carefully balanced way but as a concentration-fragmenting mishmash.

The Net is, by design, an interruption system, a machine geared for dividing attention. That's not only a result of its ability to display

many different kinds of media simultaneously. It's also a result of the ease with which it can be programmed to send and receive messages. Most e-mail applications, to take an obvious example, are set up to check automatically for new messages every five or ten minutes, and people routinely click the "check for new mail" button even more frequently than that. Studies of office workers who use computers reveal that they constantly stop what they're doing to read and respond to incoming e-mails. It's not unusual for them to glance at their in-box thirty or forty times an hour (though when asked how frequently they look, they'll often give a much lower figure).[29] Since each glance represents a small interruption of thought, a momentary redeployment of mental resources, the cognitive cost can be high. Psychological research long ago proved what most of us know from experience: frequent interruptions scatter our thoughts, weaken our memory, and make us tense and anxious. The more complex the train of thought we're involved in, the greater the impairment the distractions cause.[30]

Beyond the influx of personal messages—not only e-mail but also instant messages and text messages—the Web increasingly supplies us with all manner of other automated notifications. Feed readers and news aggregators let us know whenever a new story appears at a favorite publication or blog. Social networks alert us to what our friends are doing, often moment by moment. Twitter and other microblogging services tell us whenever one of the people we "follow" broadcasts a new message. We can also set up alerts to monitor shifts in the value of our investments, news reports about particular people or events, updates to the software we use, new videos uploaded to YouTube, and so forth. Depending on how many information streams we subscribe to and the frequency with which they send out updates, we may field a dozen alerts an hour, and for the most connected among us, the number can be much higher. Each of them is a distraction, another intrusion on our thoughts, another bit of information that takes up precious space in our working memory.

Navigating the Web requires a particularly intensive form of mental multitasking. In addition to flooding our working memory with information, the juggling imposes what brain scientists call "switching costs" on our cognition. Every time we shift our attention, our brain has to reorient itself, further taxing our mental resources. As Maggie Jackson explains in *Distracted*, her book on multitasking, "the brain takes time to change goals, remember the rules needed for the new task, and block out cognitive interference from the previous, still-vivid activity."[31] Many studies have shown that switching between just two tasks can add substantially to our cognitive load, impeding our thinking and increasing the likelihood that we'll overlook or misinterpret important information. In one simple experiment, a group of adults was shown a series of colored shapes and asked to make predictions based on what they saw. They had to perform the task while wearing headphones that played a series of beeps. In one trial, they were told to ignore the beeps and just concentrate on the shapes. In a second trial, using a different set of visual cues, they were told to keep track of the number of beeps. After each go-through, they completed a test that required them to interpret what they had just done. In both trials, the subjects made predictions with equal success. But after the multitasking trial, they had a much harder time drawing conclusions about their experience. Switching between the two tasks short-circuited their understanding; they got the job done, but they lost its meaning. "Our results suggest that learning facts and concepts will be worse if you learn them while you're distracted," said the lead researcher, UCLA psychologist Russell Poldrack.[32] On the Net, where we routinely juggle not just two but several mental tasks, the switching costs are all the higher.

It's important to emphasize that the Net's ability to monitor events and automatically send out messages and notifications is one of its great strengths as a communication technology. We rely on that capability to personalize the workings of the system, to program the vast database to respond to our particular needs, interests, and desires. We *want* to be interrupted, because each interruption brings us a valuable piece of information. To turn off these alerts

is to risk feeling out of touch, or even socially isolated. The near-continuous stream of new information pumped out by the Web also plays to our natural tendency to "vastly overvalue what happens to us *right now*," as Union College psychologist Christopher Chabris explains. We crave the new even when we know that "the new is more often trivial than essential."[33]

And so we ask the Internet to keep interrupting us, in ever more and different ways. We willingly accept the loss of concentration and focus, the division of our attention and the fragmentation of our thoughts, in return for the wealth of compelling or at least diverting information we receive. Tuning out is not an option many of us would consider.

IN 1879, A French ophthalmologist named Louis Émile Javal discovered that when people read, their eyes don't sweep across the words in a perfectly fluid way. Their visual focus advances in little jumps, called saccades, pausing briefly at different points along each line. One of Javal's colleagues at the University of Paris soon made another discovery: that the pattern of pauses, or "eye fixations," can vary greatly depending on what's being read and who's doing the reading. In the wake of these discoveries, brain researchers began to use eye-tracking experiments to learn more about how we read and how our minds work. Such studies have also proven valuable in providing further insights into the Net's effects on attention and cognition.

In 2006, Jakob Nielsen, a longtime consultant on the design of Web pages who has been studying online reading since the 1990s, conducted an eye-tracking study of Web users. He had 232 people wear a small camera that tracked their eye movements as they read pages of text and browsed other content. Nielsen found that hardly any of the participants read online text in a methodical, line-by-line way, as they'd typically read a page of text in a book. The vast majority skimmed the text quickly, their eyes skipping down the page in a pattern that resembled, roughly, the letter *F*. They'd start by glancing all the way across the first two or three lines of text. Then their eyes would drop down a bit, and they'd scan about halfway across a few more lines. Finally, they'd let their eyes cursorily drift a little farther down the left-hand side of the page. This pattern of online reading was confirmed by a subsequent eye-tracking study carried out at the Software Usability Research Laboratory at Wichita State University.[34]

"F," wrote Nielsen, in summing up the findings for his clients, is "for *fast*. That's how users read your precious content. In a few seconds, their eyes move at amazing speeds across your website's words in a pattern that's very different from what you learned in school."[35] As a complement to his eye-tracking study, Nielsen analyzed an extensive database on the behavior of Web users that had been compiled by a team of German researchers. They had monitored the computers of twenty-five people for an average of about a hundred days each, tracking the time the subjects spent looking at some fifty thousand Web pages. Parsing the data, Nielsen found that as the number of words on a page increases, the time a visitor spends looking at the page goes up, but only slightly. For every hundred additional words, the average viewer will spend just 4.4 more seconds perusing the page. Since even the most accomplished reader can read only about eighteen words in 4.4 seconds, Nielsen told his clients, "when you add verbiage to a page, you can assume that customers will read 18% of it." And that, he cautioned, is almost certainly an overstatement. It's unlikely that the people in the study were spending all their time reading; they were also probably glancing at pictures, videos, advertisements, and other types of content.[36]

Nielsen's analysis backed up the conclusions of the German researchers themselves. They had reported that most Web pages are viewed for ten seconds or less. Fewer than one in ten page views extend beyond two minutes, and a significant portion of those seem to involve "unattended browser windows . . . left open in the background of the desktop." The researchers observed that "even new pages with plentiful information and many links are regularly

viewed only for a brief period." The results, they said, "confirm that browsing is a rapidly interactive activity."[37] The results also reinforce something that Nielsen wrote in 1997 after his first study of online reading. "How do users read on the web?" he asked then. His succinct answer: "They don't."[38]

Web sites routinely collect detailed data on visitor behavior, and those statistics underscore just how quickly we leap between pages when we're online. Over a period of two months in 2008, an Israeli company named ClickTale, which supplies software for analyzing how people use corporate Web pages, collected data on the behavior of a million visitors to sites maintained by its clients around the world. It found that in most countries people spend, on average, between nineteen and twenty-seven seconds looking at a page before moving on to the next one, including the time required for the page to load into their browser's window. German and Canadian surfers spend about twenty seconds on each page, U.S. and U.K. surfers spend about twenty-one seconds, Indians and Australians spend about twenty-four seconds, and the French spend about twenty-five seconds.[39] On the Web, there is no such thing as leisurely browsing. We want to gather as much information as quickly as our eyes and fingers can move.

That's true even when it comes to academic research. As part of a five-year study that ended in early 2008, a group from University College London examined computer logs documenting the behavior of visitors to two popular research sites, one operated by the British Library and one by a U.K. educational consortium. Both sites provided users with access to journal articles, e-books, and other sources of written information. The scholars found that people using the sites exhibited a distinctive "form of skimming activity" in which they'd hop quickly from one source to another, rarely returning to any source they had already visited. They'd typically read, at most, one or two pages of an article or book before "bouncing out" to another site. "It is clear that users are not reading online in the traditional sense," the authors of the study reported; "indeed there

are signs that new forms of 'reading' are emerging as users 'power browse' horizontally through titles, contents pages and abstracts going for quick wins. It almost seems that they go online to avoid reading in the traditional sense."[40]

The shift in our approach to reading and research seems to be an inevitable consequence of our reliance on the technology of the Net, argues Merzenich, and it bespeaks a deeper change in our thinking. "There is absolutely no question that modern search engines and cross-referenced websites have powerfully enabled research and communication efficiencies," he says. "There is also absolutely no question that our brains are engaged less directly and more shallowly in the synthesis of information when we use research strategies that are all about 'efficiency,' 'secondary (and out-of-context) referencing,' and 'once over, lightly.'"[41]

The switch from reading to power-browsing is happening very quickly. Already, reports Ziming Liu, a library science professor at San José State University, "the advent of digital media and the growing collection of digital documents have had a profound impact on reading." In 2003, Liu surveyed 113 well-educated people—engineers, scientists, accountants, teachers, business managers, and graduate students, mainly between thirty and forty-five years old—to gauge how their reading habits had changed over the preceding ten years. Nearly eighty-five percent of the people reported that they were spending more time reading electronic documents. When asked to characterize how their reading practices have changed, eighty-one percent said that they were spending more time "browsing and scanning," and eighty-two percent reported that they were doing more "non-linear reading." Only twenty-seven percent said that the time they devoted to "in-depth reading" was on the rise, while forty-five percent said it was declining. Just sixteen percent said they were giving more "sustained attention" to reading; fifty percent said they were giving it less "sustained attention."

The findings, said Liu, indicate that "the digital environment tends to encourage people to explore many topics extensively, but at

a more superficial level," and that "hyperlinks distract people from reading and thinking deeply." One of the participants in the study told Liu, "I find that my patience with reading long documents is decreasing. I want to skip ahead to the end of long articles." Another said, "I skim much more [when reading] html pages than I do with printed materials." It's quite clear, Liu concluded, that with the flood of digital text pouring through our computers and phones, "people are spending more time on reading" than they used to. But it's equally clear that it's a very different kind of reading. A "screen-based reading behavior is emerging," he wrote, which is characterized by "browsing and scanning, keyword spotting, one-time reading, [and] non-linear reading." The time "spent on in-depth reading and concentrated reading" is, on the other hand, falling steadily.[42]

There's nothing wrong with browsing and scanning, or even power-browsing and power-scanning. We've always skimmed newspapers more than we've read them, and we routinely run our eyes over books and magazines in order to get the gist of a piece of writing and decide whether it warrants more thorough reading. The ability to skim text is every bit as important as the ability to read deeply. What is different, and troubling, is that skimming is becoming our dominant mode of reading. Once a means to an end, a way to identify information for deeper study, scanning is becoming an end in itself—our preferred way of gathering and making sense of information of all sorts. We've reached the point where a Rhodes Scholar like Florida State's Joe O'Shea—a philosophy major, no less—is comfortable admitting not only that he doesn't read books but that he doesn't see any particular need to read them. Why bother, when you can Google the bits and pieces you need in a fraction of a second? What we're experiencing is, in a metaphorical sense, a reversal of the early trajectory of civilization: we are evolving from being cultivators of personal knowledge to being hunters and gatherers in the electronic data forest.

THERE ARE COMPENSATIONS. Research shows that certain cognitive skills are strengthened, sometimes substantially, by our use of computers and the Net. These tend to involve lower-level, or more primitive, mental functions such as hand-eye coordination, reflex response, and the processing of visual cues. One much-cited study of video gaming, published in *Nature* in 2003, revealed that after just ten days of playing action games on computers, a group of young people had significantly increased the speed with which they could shift their visual focus among different images and tasks. Veteran game players were also found to be able to identify more items in their visual field than novices could. The authors of the study concluded that "although video-game playing may seem to be rather mindless, it is capable of radically altering visual attentional processing."[43]

While experimental evidence is sparse, it seems only logical that Web searching and browsing would also strengthen brain functions related to certain kinds of fast-paced problem solving, particularly those involving the recognition of patterns in a welter of data. Through the repetitive evaluation of links, headlines, text snippets, and images, we should become more adept at quickly distinguishing among competing informational cues, analyzing their salient characteristics, and judging whether they'll have practical benefit for whatever task we're engaged in or goal we're pursuing. One British study of the way women search for medical information online indicated that the speed with which they were able to assess the probable value of a Web page increased as they gained familiarity with the Net.[44] It took an experienced browser only a few seconds to make an accurate judgment about whether a page was likely to have trustworthy information.

Other studies suggest that the kind of mental calisthenics we engage in online may lead to a small expansion in the capacity of our working memory.[45] That, too, would help us to become more adept at juggling data. Such research "indicates that our brains learn to swiftly focus attention, analyze information, and almost instantaneously decide on a go or no-go decision," says Gary Small. He believes that

as we spend more time navigating the vast quantity of information available online, "many of us are developing neural circuitry that is customized for rapid and incisive spurts of directed attention."[46] As we practice browsing, surfing, scanning, and multitasking, our plastic brains may well become more facile at those tasks.

The importance of such skills shouldn't be taken lightly. As our work and social lives come to center on the use of electronic media, the faster we're able to navigate those media and the more adroitly we're able to shift our attention among online tasks, the more valuable we're likely to become as employees and even as friends and colleagues. As the writer Sam Anderson put it in "In Defense of Distraction," a 2009 article in *New York* magazine, "Our jobs depend on connectivity" and "our pleasure-cycles—no trivial matter—are increasingly tied to it." The practical benefits of Web use are many, which is one of the main reasons we spend so much time online. "It's too late," argues Anderson, "to just retreat to a quieter time."[47]

He's right, but it would be a serious mistake to look narrowly at the Net's benefits and conclude that the technology is making us more intelligent. Jordan Grafman, head of the cognitive neuroscience unit at the National Institute of Neurological Disorders and Stroke, explains that the constant shifting of our attention when we're online may make our brains more nimble when it comes to multitasking, but improving our ability to multitask actually hampers our ability to think deeply and creatively. "Does optimizing for multitasking result in better functioning—that is, creativity, inventiveness, productiveness? The answer is, in more cases than not, no," says Grafman. "The more you multitask, the less deliberative you become; the less able to think and reason out a problem." You become, he argues, more likely to rely on conventional ideas and solutions rather than challenging them with original lines of thought.[48] David Meyer, a University of Michigan neuroscientist and one of the leading experts on multitasking, makes a similar point. As we gain more experience in rapidly shifting our attention, we may "overcome some of the inefficiencies" inherent in multitasking,

he says, "but except in rare circumstances, you can train until you're blue in the face and you'd never be as good as if you just focused on one thing at a time."[49] What we're doing when we multitask "is learning to be skillful at a superficial level."[50] The Roman philosopher Seneca may have put it best two thousand years ago: "To be everywhere is to be nowhere."[51]

In an article published in *Science* in early 2009, Patricia Greenfield, a prominent developmental psychologist who teaches at UCLA, reviewed more than fifty studies of the effects of different types of media on people's intelligence and learning ability. She concluded that "every medium develops some cognitive skills at the expense of others." Our growing use of the Net and other screen-based technologies has led to the "widespread and sophisticated development of visual-spatial skills." We can, for example, rotate objects in our minds better than we used to be able to. But our "new strengths in visual-spatial intelligence" go hand in hand with a weakening of our capacities for the kind of "deep processing" that underpins "mindful knowledge acquisition, inductive analysis, critical thinking, imagination, and reflection."[52] The Net is making us smarter, in other words, only if we define intelligence by the Net's own standards. If we take a broader and more traditional view of intelligence—if we think about the depth of our thought rather than just its speed—we have to come to a different and considerably darker conclusion.

Given our brain's plasticity, we know that our online habits continue to reverberate in the workings of our synapses when we're not online. We can assume that the neural circuits devoted to scanning, skimming, and multitasking are expanding and strengthening, while those used for reading and thinking deeply, with sustained concentration, are weakening or eroding. In 2009, researchers from Stanford University found signs that this shift may already be well under way. They gave a battery of cognitive tests to a group of heavy media multitaskers as well as a group of relatively light multitaskers. They found that the heavy multitaskers were much more easily distracted by "irrelevant environmental stimuli," had significantly less

control over the contents of their working memory, and were in general much less able to maintain their concentration on a particular task. Whereas the infrequent multitaskers exhibited relatively strong "top-down attentional control," the habitual multitaskers showed "a greater tendency for bottom-up attentional control," suggesting that "they may be sacrificing performance on the primary task to let in other sources of information." Intensive multitaskers are "suckers for irrelevancy," commented Clifford Nass, the Stanford professor who led the research. "Everything distracts them."[53] Michael Merzenich offers an even bleaker assessment. As we multitask online, he says, we are "training our brains to pay attention to the crap." The consequences for our intellectual lives may prove "deadly."[54]

The mental functions that are losing the "survival of the busiest" brain cell battle are those that support calm, linear thought—the ones we use in traversing a lengthy narrative or an involved argument, the ones we draw on when we reflect on our experiences or contemplate an outward or inward phenomenon. The winners are those functions that help us speedily locate, categorize, and assess disparate bits of information in a variety of forms, that let us maintain our mental bearings while being bombarded by stimuli. These functions are, not coincidentally, very similar to the ones performed by computers, which are programmed for the high-speed transfer of data in and out of memory. Once again, we seem to be taking on the characteristics of a popular new intellectual technology.

ON THE EVENING of April 18, 1775, Samuel Johnson accompanied his friends James Boswell and Joshua Reynolds on a visit to Richard Owen Cambridge's grand villa on the banks of the Thames outside London. They were shown into the library, where Cambridge was waiting to meet them, and after a brief greeting Johnson darted to the shelves and began silently reading the spines of the volumes arrayed there. "Dr. Johnson," said Cambridge, "it seems odd that one should have such a desire to look at the backs of books." Johnson, Boswell would later recall, "instantly started from his reverie, wheeled about, and replied, 'Sir, the reason is very plain. Knowledge is of two kinds. We know a subject ourselves, or we know where we can find information upon it.'"[55]

The Net grants us instant access to a library of information unprecedented in its size and scope, and it makes it easy for us to sort through that library—to find, if not exactly what we were looking for, at least something sufficient for our immediate purposes. What the Net diminishes is Johnson's primary kind of knowledge: the ability to know, in depth, a subject for ourselves, to construct within our own minds the rich and idiosyncratic set of connections that give rise to a singular intelligence.

how prescient Weizenbaum had been when, decades ago, he warned that as we grow more accustomed to and dependent on our computers we will be tempted to entrust to them "tasks that demand wisdom." And once we do that, there will be no turning back. The software will become indispensable to those tasks.

The seductions of technology are hard to resist, and in our age of instant information the benefits of speed and efficiency can seem unalloyed, their desirability beyond debate. But I continue to hold out hope that we won't go gently into the future our computer engineers and software programmers are scripting for us. Even if we don't heed Weizenbaum's words, we owe it to ourselves to consider them, to be attentive to what we stand to lose. How sad it would be, particularly when it comes to the nurturing of our children's minds, if we were to accept without question the idea that "human elements" are outmoded and dispensable.

The Edexcel story also stirred, once again, my memory of that scene at the end of *2001*. It's a scene that has haunted me ever since I first saw the film as a teenager back in the 1970s, in the midst of my analogue youth. What makes it so poignant, and so weird, is the computer's emotional response to the disassembly of its mind: its despair as one circuit after another goes dark, its childlike pleading with the astronaut—"I can feel it. I can feel it. I'm afraid"—and its final reversion to what can only be called a state of innocence. HAL's outpouring of feeling contrasts with the emotionlessness that characterizes the human figures in the film, who go about their business with an almost robotic efficiency. Their thoughts and actions feel scripted, as if they're following the steps of an algorithm. In the world of *2001*, people have become so machinelike that the most human character turns out to be a machine. That's the essence of Kubrick's dark prophecy: as we come to rely on computers to mediate our understanding of the world, it is our own intelligence that flattens into artificial intelligence.

Afterword to the Second Edition

THE MOST INTERESTING THING IN THE WORLD

Marketing slogans don't normally assume the power of prophecy, but the one beamed onto a screen behind Steve Jobs the morning of January 9, 2007, was an exception. The Apple CEO, ebullient despite his long struggle with pancreatic cancer, was more than an hour into his keynote address at the annual Macworld trade show in San Francisco's Moscone Convention Center. He had reached the talk's climax—the unveiling of Apple's latest gadget, a sleek handheld computer called the iPhone. It's "a revolutionary product," he told the rapt audience. It "changes everything." And then a slide appeared with a striking, twenty-foot-tall image of the new phone. Wrapped around the picture was the prescient tagline: "Your life in your pocket."

Not even Jobs grasped how thoroughly the iPhone would recast our daily routines. "What's the killer app?" he asked the crowd. "The killer app is making calls!" To Jobs, the iPhone was a sexy, tricked-out version of the commonplace cell phone. But making calls would turn out to be the least consequential of its features. What really mattered were its powerful operating system, its versatile touch-

screen, and its always-available network connection, the combination of which enabled it to run a much greater variety of software than had been possible with earlier mobile devices. The iPhone did turn out to be the future of the cell phone, but it also turned out to be the future of the personal computer. Within a few years, the smartphone had replaced the desktop and the laptop as the general public's preferred data-processing machine. By delivering a never-ending stream of information into the hands of the masses, the iPhone and its kin completed what the Internet had begun: the consolidation of communications, computing, and media into a single industry—and onto a single device.

The original iPhone went on sale in June of 2007, a few months after Jobs's speech. That was also, by happenstance, when I began the research that would culminate, three years later, with the publication of this book. Although the first edition of *The Shallows* includes several references to the iPhone and other smartphones, the story it tells is set in a time when desktops and laptops still defined people's conception of computing and framed their experience of the Internet. Even social networks like Facebook, LinkedIn, and Twitter were accessed almost exclusively through Web sites ten years ago. The apps we now download by the billions had yet to take hold.

That world feels distant now. To the young, who have grown up with phones in their hands, it must seem utterly foreign—like a world without cars or indoor plumbing. Jobs may not have anticipated the full extent of the iPhone's impact, but he got the "revolutionary" part right. Along with the attendant growth of social media, the proliferation of smartphones—more than 10 billion have been sold—has had a sweeping influence on almost every aspect of life and culture. It has given a new texture and tempo to our days. It has upset social norms and relations. It has reshaped the public square and the political arena. And it has allowed a handful of companies to hold sway over what we see, what we do, and how we express ourselves.

Jobs was mistaken, though, to suggest that the iPhone would

change everything. When it comes to how we think—the central subject of this book—smartphones and their apps have reinforced the status quo of the digital age, not upended it. They have amplified and accelerated all the psychological and cognitive trends I described in the preceding pages. A review of the sociological and scientific research that has appeared over the last decade—some of it inspired by *The Shallows*—makes that clear.

PEOPLE WERE SPENDING a lot of time looking at screens in 2010. Today, they're spending a lot more. According to the latest installment of the Nielsen Company's long-running media-use survey, the average American adult can now be found gazing into an electronic screen—television, computer, or phone—a whopping nine hours and forty-five minutes a day. That's up more than an hour and a half from five years ago.[1] Astounding as they are, the Nielsen figures appear to understate actual screen time considerably, as the company excludes from its survey "non-media" computer activities—pretty much anything that doesn't involve a Web browser or a social-media app. Once those tasks are taken into account, it becomes evident that Americans now spend at least half their waking hours looking at screens.

As screens command more of our attention, less remains for everything else. Quieter, more solitary pastimes—reading for pleasure, notably— continue to be the most vulnerable to being crowded out by digital diversions. The time Americans devote to leisure reading dropped to sixteen minutes a day in 2018 from an already paltry twenty minutes in 2008, according to the Bureau of Labor Statistics' annual time-use survey.[2] Remove the elderly from the picture, and daily reading time drops to about six minutes—less than three-quarters of an hour a week. There are still plenty of readers around, but curling up with a book is losing its place in the general culture.[3] It's becoming a quaint pursuit, like ballroom dancing or darts.

The recent rise in screen time is the direct result of the explosion in smartphone use. People who own smartphones—around

eighty percent of adults and more than ninety-five percent of young adults—use their phones between four and six hours a day on average, according to the latest statistics. In one study, conducted in 2015 at the University of Lincoln in England, psychologists installed tracking software on the smartphones of twenty-three students and staff members and monitored all activity over two weeks.[4] The study participants were on their phones an average of 5.05 hours a day. That's a large amount of time, but how those hours were divided up is even more revealing. The participants used their phone eighty-five times a day on average—a number in line with data that Apple has released on iPhone use[5]—and most of those interactions were brief, the majority lasting less than thirty seconds. Phone owners tend to check their devices impulsively throughout the day, the activity logs showed, from the moment they wake up to the moment they go to bed. Smartphone use has become so "habitual," the researchers wrote, that "people have little awareness of the frequency with which they check their phone."

None of this comes as a surprise. It confirms what most of us know from experience. But the study and others like it are revelatory nonetheless. They throw into high relief the fact that the smartphone is something new in the world. Never before has a media gadget, or any other piece of technology, been so entangled with our day-to-day and even minute-by-minute existence. Contrast the smartphone with the TV. People always spent a lot of time watching television (and still do), but traditional TV viewing was concentrated at particular times—evenings, especially. It didn't extend throughout the day. People weren't carrying TVs in their pockets and pulling them out every few minutes. With smartphones, all time is prime time. Because the gadgets are always at hand—whether we're at home, at work, at school, or walking down the street—they are always intruding on our thoughts.

As smartphone use intensified after 2010, many scientists began to study the cognitive and emotional effects. Their initial findings reinforced what had already been discovered about the Internet's

power to distract the mind, scatter attention, and breed anxiety. If you use your phone while doing something else—driving a car, say, or studying for an exam—your performance will suffer. But the research also revealed that our phones routinely disrupt our thinking even when we're not using them, when they're tucked away in a pocket or a purse. That's a consequence of the dozens of alerts and notifications a typical smartphone emits over the course of a day. In a 2015 Florida State University study, psychologists found that when people's phones beep or buzz while they're in the middle of a challenging task, their focus wavers and their work gets sloppier—whether they check the phone or not.[6] Another 2015 study, published in the *Journal of Computer-Mediated Communication*, showed that when people hear their phone ring but are unable to answer it, their blood pressure spikes, their pulse quickens, and their problem-solving skills weaken.[7] A 2016 experiment by a University of Virginia psychologist and two colleagues revealed that phone notifications produce symptoms of hyperactivity and absentmindedness similar to those that afflict people with attention deficit disorders.[8]

The early findings were troubling, but they only hinted at the fraught symbiosis that was developing between minds and phones. In 2017, we got a fuller picture. A team of four cognitive and behavioral psychologists, led by Adrian Ward of the University of Texas at Austin and including Kristen Duke and Ayelet Gneezy of the University of California at San Diego and Harvard's Maarten Bos, published an article called "Brain Drain" in the April issue of the *Journal of the Association for Consumer Research*.[9] It described the results of an ingenious experiment involving more than 500 undergraduates at UCSD. The students were given two standard tests of intellectual acuity. One gauged "working memory capacity," the mind's ability to focus its cognitive power on a task. The second assessed "fluid intelligence," the mind's ability to interpret and solve an unfamiliar problem. The only variable in the experiment was the location of the subjects' smartphones. Some of the students were asked to place their phones on their desks, screen side down; others were told

to stow their phones in their pockets or handbags; still others were required to leave their phones in a different room. In all cases, the phones were put into do-not-disturb mode, so they would neither ring nor vibrate during the exercise.

The results were striking. In both tests, the subjects whose phones were in view posted the worst scores, while those who left their phones in a different room did the best. The students who kept their phones in their pockets or bags came out in the middle. As the phone's proximity increased, brainpower decreased. It was as if the smartphones had force fields that sapped their owners' intelligence. In subsequent interviews, nearly all the students said that their phones hadn't been a distraction—that they hadn't even thought about the devices during the experiment. They remained oblivious even as the phones muddled their thinking. A follow-up experiment, with nearly 300 participants, produced similar results. It also revealed that the more heavily the students relied on their phones in their everyday lives, the greater the cognitive penalty they suffered when their phones were nearby.

In summing up the findings, Ward and his coauthors wrote that the "integration of smartphones into daily life" appears to cause a "brain drain" that diminishes such vital mental skills as "learning, logical reasoning, abstract thought, problem solving, and creativity." Smartphones have become so tied up in our lives that, even when we're not peering or pawing at them, they tug at our attention, diverting precious cognitive resources. Just suppressing the desire to check a phone, which we do routinely and subconsciously throughout the day, can debilitate our thinking, the authors noted. The fact that most of us now habitually keep our phones "nearby and in sight" only magnifies the toll.

The "Brain Drain" study's findings are consistent with other published research. In a similar but smaller 2014 study, psychologists at the University of Southern Maine found that people who had their phones in view, albeit turned off, during two demanding tests of attention and cognition made significantly more errors than

did a control group whose phones remained out of sight.[10] When the researchers gave the participants a set of easier tests, however, they found that the two groups performed about the same. That makes sense. If our minds aren't being taxed, we can spare the cognitive capacity that our phones siphon off. It's when we need to be smart that our phones dumb us down.

Because learning requires strong mental focus and exertion, students are especially susceptible to the brain-depleting effects of smartphones. A 2017 experiment at the University of Arkansas at Monticello examined how phones affected undergraduates' understanding and retention of information in a large lecture class.[11] The researchers found that students who didn't bring their phones to the classroom scored a full letter grade higher on a test of the material presented than those who had their phones with them. It didn't matter whether the students who had their phones used them or not: All of them scored equally poorly. A 2016 survey of nearly a hundred high schools in Britain found that when schools ban smartphones, students' examination scores go up substantially, with the weakest students benefiting the most.[12]

It isn't just our reasoning that takes a hit when phones are around. Our social skills and relationships appear to suffer as well. Because smartphones serve as constant reminders of all the friends we could be exchanging messages with electronically, they pull at our minds when we're talking with someone in person. Conversations become shallower and less satisfying. In a 2013 study conducted at Britain's University of Essex, 142 people were divided into pairs and asked to converse in private for ten minutes. Half talked with a phone in the room, half without. The participants were then given tests of affinity, trust, and empathy. "The mere presence of mobile phones," the researchers reported, "inhibited the development of interpersonal closeness and trust" and diminished "the extent to which individuals felt empathy and understanding from their partners." The effects were strongest when "a personally meaningful topic" was being discussed.[13] The findings were validated in a subsequent and more

realistic experiment, conducted by Virginia Tech professors, that involved observing 200 people chatting in coffee shops and cafes.[14]

THE EVIDENCE THAT our phones get inside our heads with such disruptive force is unsettling. It suggests that our thoughts and feelings, far from being sheltered in our skulls, can be skewed by outside forces we're not even aware of. But however uncanny, the findings fit with what neuroscientists have discovered about the way the mind accomplishes one of its central functions: deciding what to pay attention to.

At every instant of the day, our nervous system is bombarded by stimuli that may be worthy of our attention—objects in our field of view, sounds and scents, people we know and people we don't know, ideas and memories, emotions, bodily sensations. From the near-infinite welter of possibilities, the mind has to choose a target. This enormously complicated, enormously important task—nothing so determines our thoughts and behavior as the distribution of our attention—is accomplished through a neural system called the salience network. Spanning many areas of the brain, from the subcortical limbic system that regulates basic drives and feelings to the frontal cortex that guides conscious decision-making, the salience network is, in the words of Stanford behavioral scientist Vinod Menon, "the interface of the cognitive, homeostatic, motivational, and affective systems of the human brain."[15] It is, to put it another way, the orchestrator of the self.

In selecting targets of attention, the network gives priority to four types of stimuli: those that are novel or unexpected, those that are pleasurable or otherwise rewarding, those that are personally relevant, and those that are emotionally engaging.[16] These are exactly the kinds of stimuli our smartphones supply—all the time and in abundance. Refreshing their contents continuously, our phones are fonts of new and surprising information. Our phones give us stimulation and gratification whenever we check them, triggering releases of the

pleasure-producing neurotransmitter dopamine.[17] Because they are deeply personal repositories of photos and messages, our phones are always of immediate relevance to us. And our phones are emotionally charged. They send and receive signals of our social status, and they flood us with information on the people, events, and subjects we care most about. Imagine combining a mailbox, a newspaper, a TV, a radio, a photo album, a public library, a personal diary, and a boisterous party attended by everyone you know, and then compressing them all into a single, small, radiant object. That's what a smartphone represents to us.

Media and communication devices, from telephones to television sets, have always been captivating. Whether turned on or switched off, in use or idle, they promise an unending supply of interesting information and diverting experiences. By design, they seize and hold our attention in ways natural objects never could. But even in the long history of mesmerizing media, the smartphone stands out. It's an attention magnet unlike any our minds have had to grapple with before. It acts as what Ward calls a "supernormal stimulus" that is able to "hijack" attention whenever it's part of the surroundings—and it's always part of the surroundings.[18] With the smartphone, the human race has succeeded in creating the most interesting thing in the world. No wonder we can't take our minds off it.

Facebook and other social media companies have been adept at extending and exploiting the smartphone's colonization of the salience network. Building on Google's practice of exhaustive, clandestine behavioral testing, they have designed their apps to be as addictive as possible. The seemingly innocuous features we now take for granted on social media—the "like" and "heart" buttons that signal appreciation and affection, the swipe gestures that refresh the screen with new information, the "streak" counts that tally exchanges with friends, the infinite scrolls of stuff—are variations on psychological-conditioning techniques pioneered by slot-machine makers.[19] They promise emotional and social rewards, and they deliver those rewards in an unpredictable fashion. We're never

sure exactly what will happen when we touch the screen, but we know we might like it. So, like compulsive gamblers, we keep coming back for more.

Social networks, Facebook's first president, Sean Parker, now admits, were designed from the start to exploit "a vulnerability in human psychology." He, his colleague Mark Zuckerberg, and other architects of the systems "understood this consciously, and we did it anyway."[20] "You don't realize it," another former Facebook executive, Chamath Palihapitiya, says, "but you are being programmed."[21] The goal of the programming is to maximize "time-on-device"—a term common to both Las Vegas and Silicon Valley. The Internet industry may have begun in idealism, but it's now powered by a manipulative and very lucrative feedback loop. The more we use our phones, the more data social-media companies amass on the way our minds respond to stimuli. They use that information to make their apps even more addictive. And the money rolls in.

Given recent advances in artificial intelligence, it doesn't take the mind of a HAL to see where this is heading. Assuming their ambitions remain unchecked, social media companies will begin using machine-learning algorithms to, as Adrian Ward puts it, "optimize for salience."[22] Through the statistical analysis of people's responses to online content, computers will be able to pinpoint the triggers of attention with a precision far beyond what Silicon Valley's army of marketers, programmers, and behavioral scientists has achieved to date. Mind control will be automated.

Steve Jobs told us we'd have our lives in our pockets. He didn't warn us about the pickpockets.

IN THE PROLOGUE to his 2000 book *From Dawn to Decadence*, the historian and social critic Jacques Barzun bemoaned the debasement of the word "culture." Through years of loose and lazy usage, it had been turned into "a piece of all-purpose jargon that covers a hodge-podge of overlapping things." Lost along the way was the

term's essential meaning, which Barzun defined, simply, as "the well-furnished mind." Information of all sorts, he granted, was easier to come by in our media-saturated world, but "it may be doubted whether this bonanza will by itself cultivate the fallow mind, lift it out of day-to-day interests, and scrape it free of provincialism."[23]

It's common today, even more so than ten years ago, to think of knowledge as something that surrounds us, something we swim through and consume, like sea creatures in plankton-filled waters. The ideal of knowledge as something self-created, something woven of the facts, ideas, and experiences gathered in the individual mind, continues to recede. In the first edition of *The Shallows*, I suggested that our use of the Internet as a substitute for personal memory was misguided and dangerous. At the time, the evidence was mainly circumstantial; little research had been done. That's changed. Rigorous studies of the Web's effects on memory have been completed, and while the findings aren't definitive, they strongly suggest that our ability to form and connect memories has already been compromised.

In a 2011 study, now considered a landmark in the field, a team of researchers led by Columbia psychology professor Betsy Sparrow and including the late Harvard memory expert Daniel Wegner had people read forty brief, factual statements—"the space shuttle Columbia disintegrated during re-entry over Texas in Feb. 2003" was a typical one—then type the statements into a computer. Half the participants were told that the machine would save what they typed, and the rest were told that the statements would be erased immediately.

Afterward, the researchers asked the subjects to write down as many of the statements as they could remember. Those who believed the facts had been recorded in the computer demonstrated much weaker recall than did those who assumed the facts would not be stored. Anticipating that information will be readily available in digital form, the researchers concluded, appears to reduce the mental effort people make to remember it. Digital recording encourages

neurological erasing. They dubbed this phenomenon the "Google effect," and in an article in the journal *Science* they noted its broad implications: "Since search engines are continually available to us, we may often be in a state of not feeling we need to encode the information internally. When we need it, we will look it up."[24]

People were able to look up facts long before the Internet came along—there were books, there were libraries—but it required much more time and effort. Now that it's easy to shift responsibility for memory storage and retrieval to data banks and search engines, our brains have less incentive to take on the work of remembering. Human beings are "cognitive misers," a half century of research has shown.[25] If we can offload or otherwise avoid mental work, we generally will, even when it's not in our best interest. Our phones, by giving us immediate access to pretty much every fact ever recorded, allow us to indulge our mental miserliness as never before.

Memories of facts aren't the only things that go missing. It's also memories of events. In 2014, Linda Henkel, a professor at Fairfield University in Connecticut, published the results of an experiment which revealed that when people record their experiences in digital form, they end up with foggier memories of the experiences. Henkel took a group of undergraduates into the Bellarmine Museum of Art on the Fairfield campus. She gave them digital cameras, then led them, one by one, on a tour of the museum. Along the way, she had them stop and look closely at thirty works of art—paintings, sculptures, handicrafts. In some cases, she would have a student take a photograph of an object after observing it. In other cases, she'd tell the student to set the camera aside and just look. The next day, Henkel tested the students' memories of what they had seen. She discovered they had a much tougher time recalling the works they had photographed than those they had simply observed. Even when they did remember a photographed item, they had a hazier sense of its details.[26] If prints of snapshots glued to the pages of photo albums served as aides-memoire, digital pictures stored as intangible data appear to have the opposite effect, rendering the mind less absorbent. The popular expression "pics or it didn't happen" gets it backward.

Subsequent studies have confirmed Henkel's discovery. In a series of experiments involving hundreds of subjects, Princeton psychologist Diana Tamir and three colleagues examined how people's recording of their experiences, through online comments or digital photographs, influenced memory formation in three different scenarios: watching a lecture on a computer, taking a self-guided tour of a historic building alone, and taking the same tour in the company of another person. "Media use impaired memory for both computer-based and real-world experiences, in both solo and social contexts," the researchers reported in the *Journal of Experimental Psychology*. "Creating a hard copy of an experience through media leaves only a diminished copy in our own heads."[27] With social media allowing and encouraging us to upload accounts of pretty much everything we do, this effect is now widespread. A 2017 *Frontiers in Psychology* survey of peer-reviewed research on how smartphones affect memory concluded that "when we turn to these devices, we generally learn and remember less from our experiences."[28]

There's a twist to this story. It turns out that we're not very good at distinguishing the knowledge we keep in our heads from the information we find online. As Daniel Wegner and Adrian Ward explained in a 2013 *Scientific American* article, when people call up information through their phones or other computers, they often end up suffering delusions of intelligence. They feel as though "their *own* mental capacities" had generated the information, not their devices.[29] Several studies, including an extensive series of experiments at Yale, have documented this "misattribution" phenomenon, revealing that as people gather information online, they come to believe they're smarter and more knowledgeable than they actually are.[30] "The advent of the 'information age' seems to have created a generation of people who feel they know more than ever before," Wegner and Ward concluded, even though "they may know ever less about the world around them."

That unhappy insight probably helps explain society's current gullibility crisis, with its attendant plague of propaganda, dogma, and venom. If your phone has blunted your powers of discernment, you'll believe anything it tells you. And you won't hesitate to share deceptive information with others. A 2018 MIT study of message threads on Twitter, spanning more than 4.5 million tweets posted over ten years, found that fabricated or otherwise misleading stories are 70 percent more likely to be retweeted than factual ones. While accurate stories rarely reach more than a thousand people, fake reports routinely reach tens of thousands. We want to blame algorithms and bots for the circulation of lies online, but the real culprits, the researchers discovered, are people: "False news spreads farther, faster, deeper, and more broadly than the truth because humans, not robots, are more likely to spread it."[31] The technology we assumed would enlarge us has made us smaller.

Data, the novelist and critic Cynthia Ozick once wrote, is "memory without history."[32] Her observation points to the fundamental problem with allowing smartphones and the companies that program them to commandeer our brains. When we constrict our capacity for reasoning and recall, or transfer those skills to a machine or a corporation, we sacrifice the ability to turn information into knowledge. We get the data but lose the meaning. Barring a cultural course correction, that may be the Internet's most enduring legacy.

Notes

Introduction to the Second Edition

1. Janna Quitney Anderson and Lee Rainie, *The Future of the Internet* (Washington, DC: Pew Research Center, 2010), 6.

Prologue THE WATCHDOG AND THE THIEF

1. Marshall McLuhan, *Understanding Media: The Extensions of Man*, critical ed., ed. W. Terrence Gordon (Corte Madera, CA: Gingko, 2003), 5.
2. Ibid., 30.
3. Ibid., 31.
4. Ibid., 23.
5. Ibid., 31.
6. David Thomson, *Have You Seen?: A Personal Introduction to 1,000 Films* (New York: Knopf, 2008), 149.

One HAL AND ME

1. Heather Pringle, "Is Google Making Archaeologists Smarter?," *Beyond Stone & Bone* blog (Archaeological Institute of America), February 27, 2009, http://archaeology.org/blog/?p=332.
2. Clive Thompson, "Your Outboard Brain Knows All," *Wired*, October 2007.
3. Scott Karp, "The Evolution from Linear Thought to Networked Thought," *Publishing* 2.0 blog, February 9, 2008, http://publishing2.com/2008/02/09/the-evolution-from-linear-thought-to-networked-thought.
4. Bruce Friedman, "How Google Is Changing Our Information-Seeking Behavior," *Lab Soft News* blog, February 6, 2008, http://labsoftnews.typepad.com/lab_soft_news/2008/02/how-google-is-c.html.

4. Charles McGrath, "By-the-Book Reader Meets the Kindle," *New York Times*, May 29, 2009.
5. L. Gordon Crovitz, "The Digital Future of Books," *Wall Street Journal*, May 19, 2008.
6. Debbie Stier, "Are We Having the Wrong Conversation about EBook Pricing?," HarperStudio blog, February 26, 2009, http://theharperstudio.com/2009/02/are-we-having-the-wrong-conversation-about-ebook-pricing.
7. Steven Johnson, "How the E-Book Will Change the Way We Read and Write," *Wall Street Journal*, April 20, 2009.
8. Christine Rosen, "People of the Screen," *New Atlantis*, Fall 2008.
9. David A. Bell, "The Bookless Future: What the Internet Is Doing to Scholarship," *New Republic*, May 2, 2005.
10. John Updike, "The End of Authorship," *New York Times Sunday Book Review*, June 25, 2006.
11. Norimitsu Onishi, "Thumbs Race as Japan's Best Sellers Go Cellular," *New York Times*, January 20, 2008. See also Dana Goodyear, "I ♥ Novels," *New Yorker*, December 22, 2008.
12. Tim O'Reilly, "Reinventing the Book in the Age of the Web," *O'Reilly Radar* blog, April 29, 2009, http://radar.oreilly.com/2009/04/reinventing-the-book-age-of-web.html.
13. Motoko Rich, "Curling Up with Hybrid Books, Videos Included," *New York Times*, September 30, 2009.
14. Johnson, "How the E-Book Will Change."
15. Andrew Richard Albanese, "Q&A: The Social Life of Books," *Library Journal*, May 15, 2006.
16. Kevin Kelly, "Scan this Book!" *New York Times Magazine*, May 14, 2006.
17. Caleb Crain, "How Is the Internet Changing Literary Style?," *Steamboats Are Ruining Everything* blog, June 17, 2008, www.steamthing.com/2008/06/how-is-the-inte.html.
18. Some Kindle owners received a startling lesson in the ephemerality of digital text when, on the morning of July 17, 2009, they awoke to find that the e-book versions of George Orwell's *1984* and *Animal Farm* they had purchased from Amazon.com had disappeared from their devices. It turned out that Amazon had erased the books from customers' Kindles after discovering that the editions were unauthorized.
19. Up to now, concerns about the influence of digital media on language have centered on the abbreviations and emoticons that kids use in instant messaging and texting. But such affectations will probably prove benign, just the latest twist in the long history of slang. Adults would be wiser to pay attention to how their own facility with writing is changing. Is their vocabulary shrinking or becoming more hackneyed? Is their syntax becoming less flexible and more formulaic? Those are the types of questions that matter in judging the Net's long-run effects on the range and expressiveness of language.
20. Wendy Griswold, Terry McDonnell, and Nathan Wright, "Reading and the Reading Class in the Twenty-First Century," *Annual Review of Sociology*, 31 (2005): 127–41. See also Caleb Crain, "Twilight of the Books," *New Yorker*, December 24, 2007.
21. Steven Levy, "The Future of Reading," *Newsweek*, November 26, 2007.
22. Alphonse de Lamartine, *Ouvres Diverses* (Brussels: Louis Hauman, 1836), 106–7. Translation by the author.
23. Philip G. Hubert, "The New Talking Machines," *Atlantic Monthly*, February 1889.
24. Edward Bellamy, "With the Eyes Shut," *Harper's*, October 1889.
25. Octave Uzanne, "The End of Books," *Scribner's Magazine*, August 1894.
26. George Steiner, "Ex Libris," *New Yorker*, March 17, 1997.
27. Mark Federman, "Why Johnny and Janey Can't Read, and Why Mr. and Mrs. Smith Can't Teach: The Challenge of Multiple Media Literacies in a Tumultuous Time," undated, http://individual.utoronto.ca/markfederman/WhyJohnnyandJaneyCantRead.pdf.
28. Clay Shirky, "Why Abundance Is Good: A Reply to Nick Carr," *Encyclopaedia Britannica Blog*, July 17, 2008, www.britannica.com/blogs/2008/07/why-abundance-is-good-a-reply-to-nick-carr.
29. Alberto Manguel, *The Library at Night* (New Haven, CT: Yale University Press, 2008), 218.
30. David M. Levy, *Scrolling Forward: Making Sense of Documents in the Digital Age* (New York: Arcade, 2001), 101–2.

Seven THE JUGGLER'S BRAIN

1. Katie Hafner, "Texting May Be Taking a Toll," *New York Times*, May 25, 2009.
2. Torkel Klingberg, *The Overflowing Brain: Information Overload and the Limits of Working Memory*, trans. Neil Betteridge (Oxford: Oxford University Press, 2009), 166–67.
3. Ap Dijksterhuis, "Think Different: The Merits of Unconscious Thought in Preference Development and Decision Making," *Journal of Personality and Social Psychology*, 87, no. 5 (2004): 586–98.

4. Marten W. Bos, Ap Dijksterhuis, and Rick B. van Baaren, "On the Goal-Dependency of Unconscious Thought," *Journal of Experimental Social Psychology*, 44 (2008): 1114–20.
5. Stefanie Olsen, "Are We Getting Smarter or Dumber?," CNET News, September 21, 2005, http://news.cnet.com/Are-we-getting-smarter-or-dumber/2008-1008_3-5875404.html.
6. Michael Merzenich, "Going Googly," *On the Brain* blog, August 11, 2008, http://merzenich.positscience.com/?p=177.
7. Gary Small and Gigi Vorgan, *iBrain: Surviving the Technological Alteration of the Modern Mind* (New York: Collins, 2008), 1.
8. G. W. Small, T. D. Moody, P. Siddarth, and S. Y. Bookheimer, "Your Brain on Google: Patterns of Cerebral Activation during Internet Searching," *American Journal of Geriatric Psychiatry*, 17, no. 2 (February 2009): 116–26. See also Rachel Champeau, "UCLA Study Finds That Searching the Internet Increases Brain Function," UCLA Newsroom, October 14, 2008, http://newsroom.ucla.edu/portal/ucla/ucla-study-finds-that-searching-64348.aspx.
9. Small and Vorgan, *iBrain*, 16–17.
10. Maryanne Wolf, interview with the author, March 28, 2008.
11. Steven Johnson, *Everything Bad Is Good for You: How Today's Popular Culture Is Actually Making Us Smarter* (New York: Riverhead Books, 2005), 19.
12. John Sweller, *Instructional Design in Technical Areas* (Camberwell, Australia: Australian Council for Educational Research, 1999), 4.
13. Ibid., 7.
14. Ibid.
15. Ibid., 11.
16. Ibid., 4–5. For a broad review of current thinking on the limits of working memory, see Nelson Cowan, *Working Memory Capacity* (New York: Psychology Press, 2005).
17. Klingberg, *Overflowing Brain*, 39 and 72–75.
18. Sweller, *Instructional Design*, 22.
19. George Landow and Paul Delany, "Hypertext, Hypermedia and Literary Studies: The State of the Art," in *Multimedia: From Wagner to Virtual Reality*, ed. Randall Packer and Ken Jordan (New York: Norton, 2001), 206–16.
20. Jean-Francois Rouet and Jarmo J. Levonen, "Studying and Learning with Hypertext: Empirical Studies and Their Implications," in *Hypertext and Cognition*, ed. Jean-Francois Rouet, Jarmo J. Levonen, Andrew Dillon, and Rand J. Spiro (Mahwah, NJ: Erlbaum, 1996), 16–20.
21. David S. Miall and Teresa Dobson, "Reading Hypertext and the Experience of Literature," *Journal of Digital Information*, 2, no. 1 (August 13, 2001).

22. D. S. Niederhauser, R. E. Reynolds, D. J. Salmen, and P. Skolmoski, "The Influence of Cognitive Load on Learning from Hypertext," *Journal of Educational Computing Research*, 23, no. 3 (2000): 237–55.
23. Erping Zhu, "Hypermedia Interface Design: The Effects of Number of Links and Granularity of Nodes," *Journal of Educational Multimedia and Hypermedia*, 8, no. 3 (1999): 331–58.
24. Diana DeStefano and Jo-Anne LeFevre, "Cognitive Load in Hypertext Reading: A Review," *Computers in Human Behavior*, 23, no. 3 (May 2007): 1616–41. The paper was originally published online on September 30, 2005.
25. Steven C. Rockwell and Loy A. Singleton, "The Effect of the Modality of Presentation of Streaming Multimedia on Information Acquisition," *Media Psychology*, 9 (2007): 179–91.
26. Helene Hembrooke and Geri Gay, "The Laptop and the Lecture: The Effects of Multitasking in Learning Environments," *Journal of Computing in Higher Education*, 15, no. 1 (September 2003): 46–64.
27. Lori Bergen, Tom Grimes, and Deborah Potter, "How Attention Partitions Itself during Simultaneous Message Presentations," *Human Communication Research*, 31, no. 3 (July 2005): 311–36.
28. Sweller, *Instructional Design*, 137–47.
29. K. Renaud, J. Ramsay, and M. Hair, "'You've Got Email!' Shall I Deal with It Now?," *International Journal of Human-Computer Interaction*, 21, no. 3 (2006): 313–32.
30. See, for example, J. Gregory Trafton and Christopher A. Monk, "Task Interruptions," *Reviews of Human Factors and Ergonomics*, 3 (2008): 111–26. Researchers believe that frequent interruptions lead to cognitive overload and impair the formation of memories.
31. Maggie Jackson, *Distracted: The Erosion of Attention and the Coming Dark Age* (Amherst, NY: Prometheus, 2008), 79.
32. Karin Foerde, Barbara J. Knowlton, and Russell A. Poldrack, "Modulation of Competing Memory Systems by Distraction," *Proceedings of the National Academy of Sciences*, 103, no. 31 (August 1, 2006): 11778–83; and "Multi-Tasking Adversely Affects Brain's Learning," University of California press release, July 7, 2005.
33. Christopher F. Chabris, "You Have Too Much Mail," *Wall Street Journal*, December 15, 2008. The italics are Chabris's.
34. Sav Shrestha and Kelsi Lenz, "Eye Gaze Patterns While Searching vs. Browsing a Website," *Usability News*, 9, no. 1 (January 2007), www.surl.org/usabilitynews/91/eyegaze.asp.

35. Jakob Nielsen, "F-Shaped Pattern for Reading Web Content," *Alertbox*, April 17, 2006, www.useit.com/alertbox/reading_pattern.html.
36. Jakob Nielsen, "How Little Do Users Read?," *Alertbox*, May 6, 2008, www.useit.com/alertbox/percent-text-read.html.
37. Harald Weinreich, Hartmut Obendorf, Eelco Herder, and Matthias Mayer, "Not Quite the Average: An Empirical Study of Web Use," *ACM Transactions on the Web*, 2, no. 1 (2008).
38. Jakob Nielsen, "How Users Read on the Web," *Alertbox*, October 1, 1997, www.useit.com/alertbox/9710a.html.
39. "Puzzling Web Habits across the Globe," *ClickTale* blog, July 31, 2008, www.clicktale.com/2008/07/31/puzzling-web-habits-across-the-globe-part-1/.
40. University College London, "Information Behaviour of the Researcher of the Future," January 11, 2008, www.ucl.ac.uk/slais/research/ciber/downloads/ggexecutive.pdf.
41. Merzenich, "Going Googly."
42. Ziming Liu, "Reading Behavior in the Digital Environment," *Journal of Documentation*, 61, no. 6 (2005): 700–712.
43. Shawn Green and Daphne Bavelier, "Action Video Game Modifies Visual Selective Attention," *Nature*, 423 (May 29, 2003): 534–37.
44. Elizabeth Sillence, Pam Briggs, Peter Richard Harris, and Lesley Fishwick, "How Do Patients Evaluate and Make Use of Online Health Information?," *Social Science and Medicine*, 64, no. 9 (May 2007): 1853–62.
45. Klingberg, *Overflowing Brain*, 115–24.
46. Small and Vorgan, *iBrain*, 21.
47. Sam Anderson, "In Defense of Distraction," *New York*, May 25, 2009.
48. Quoted in Don Tapscott, *Grown Up Digital* (New York: McGraw-Hill, 2009), 108–9.
49. Quoted in Jackson, *Distracted*, 79–80.
50. Quoted in Sharon Begley and Janeen Interlandi, "The Dumbest Generation? Don't Be Dumb," *Newsweek*, June 2, 2008.
51. Lucius Annaeus Seneca, *Letters from a Stoic* (New York: Penguin Classics, 1969), 33.
52. Patricia M. Greenfield, "Technology and Informal Education: What Is Taught, What Is Learned," *Science*, 323, no. 5910 (January 2, 2009): 69–71.
53. Eyal Ophir, Clifford Nass, and Anthony D. Wagner, "Cognitive Control in Media Multitaskers," *Proceedings of the National Academy of Sciences*, August 24, 2009, www.pnas.org/content/early/2009/08/21/0903620106.full.pdf. See also Adam Gorlick, "Media Multitaskers Pay Mental Price, Stanford Study Shows," *Stanford Report*, August 24, 2009, http://news.stanford.edu/news/2009/august24/multitask-research-study-082409.html.
54. Michael Merzenich, interview with the author, September 11, 2009.
55. James Boswell, *The Life of Samuel Johnson, LL. D.* (London: Bell, 1889), 331–32.

a digression ON THE BUOYANCY OF IQ SCORES

1. Don Tapscott, *Grown Up Digital* (New York: McGraw-Hill, 2009), 291.
2. College Board, "PSAT/NMSQT Data & Reports," http://professionals.collegeboard.com/data-reports-research/psat.
3. Naomi S. Baron, *Always On: Language in an Online and Mobile World* (Oxford: Oxford University Press, 2008), 202.
4. David Schneider, "Smart as We Can Get?," *American Scientist*, July–August 2006.
5. James R. Flynn, "Requiem for Nutrition as the Cause of IQ Gains: Raven's Gains in Britain 1938–2008," *Economics and Human Biology*, 7, no. 1 (March 2009): 18–27.
6. Some contemporary readers may find Flynn's choice of words insensitive. He explains, "We are in a transitional period in which the term 'mentally retarded' is being replaced by the term 'mentally disabled' in the hope of finding words with a less negative connotation. I have retained the old term for clarity and because history has shown that negative connotations are simply passed on from one label to another." James R. Flynn, *What Is Intelligence? Beyond the Flynn Effect* (Cambridge: Cambridge University Press, 2007), 9–10.
7. Ibid., 9.
8. Ibid., 172–73.
9. "The World Is Getting Smarter," *Intelligent Life*, December 2007. See also Matt Nipert, "Eureka!" *New Zealand Listener*, October 6–12, 2007.
10. Patricia M. Greenfield, "Technology and Informal Education: What Is Taught, What Is Learned," *Science*, 323, no. 5910 (January 2, 2009): 69–71.
11. Denise Gellene, "IQs Rise, but Are We Brighter?," *Los Angeles Times*, October 27, 2007.

Eight THE CHURCH OF GOOGLE

1. For an account of Taylor's life, see Robert Kanigel, *One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency* (New York: Viking, 1997).