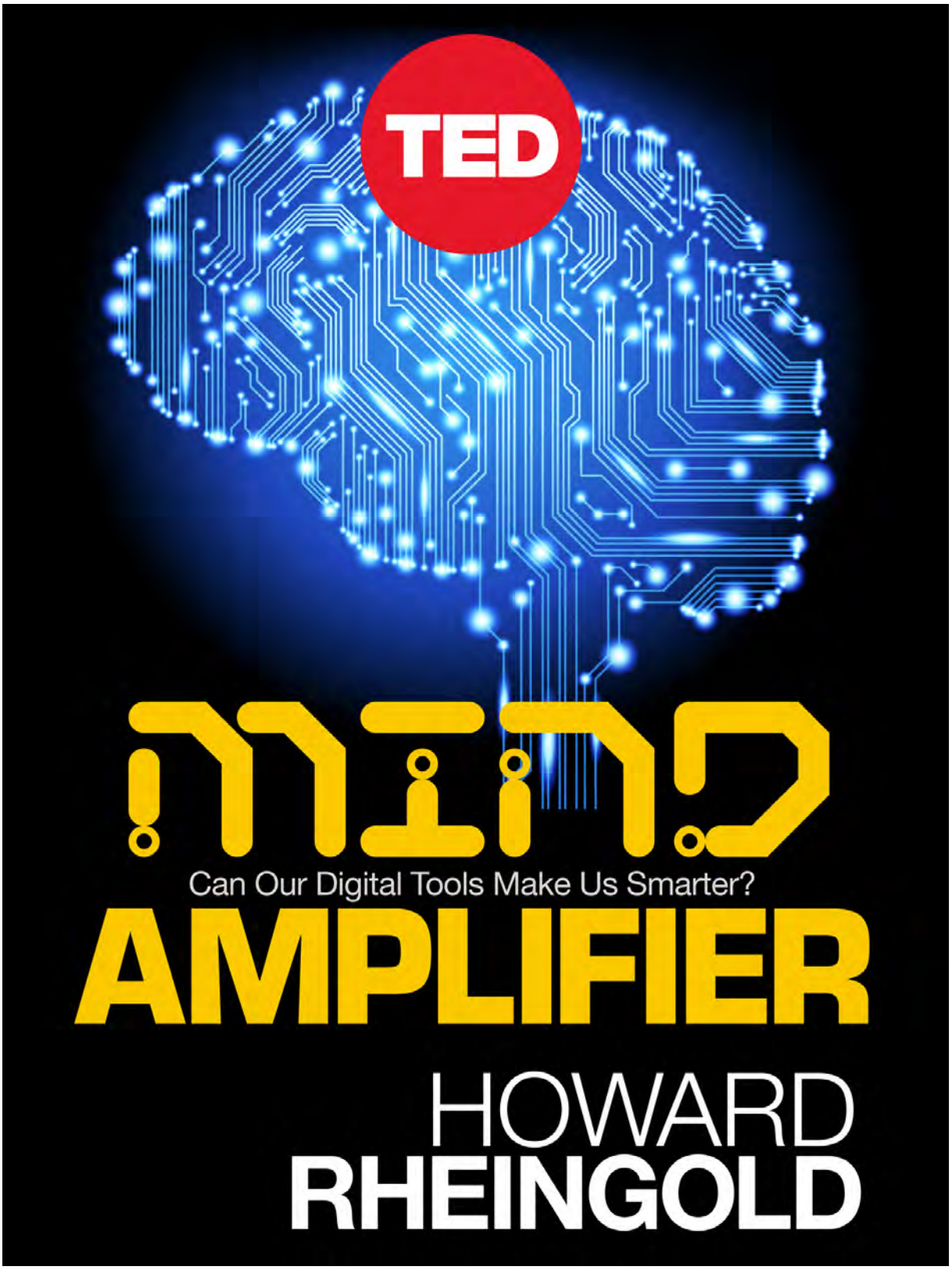
TED
Can Our Digital Tools Make Us Smarter?
AMPLIFIER
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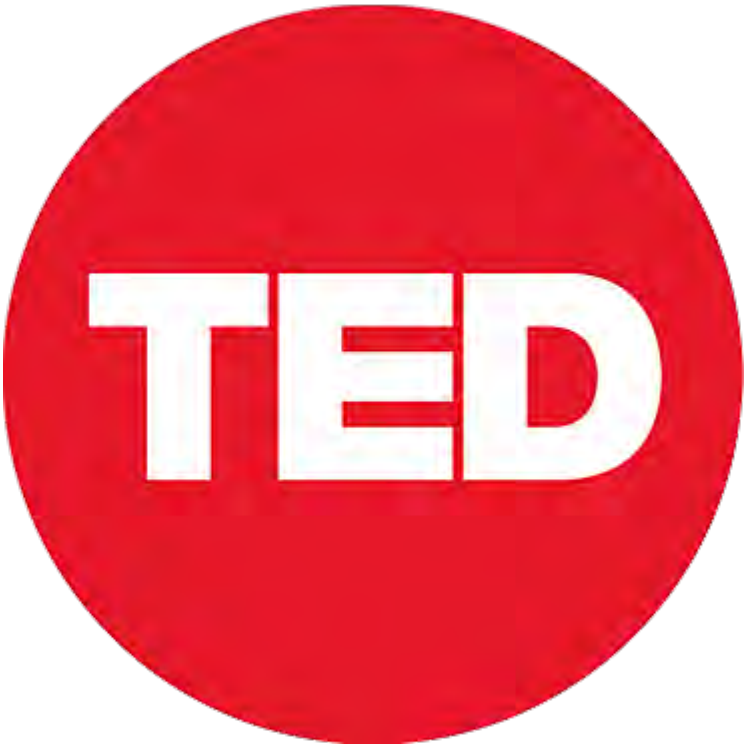


Contents

Tools for the mind

Every day we see tremendous economic and cultural enthusiasm for an enormous range of networked electronic communication gadgets. At the same time, there is tremendous fear and uncertainty that these same devices which provide so much can also make people and culture shallow.

Instead of asking whether the Web and the various devices connected to it are making us stupid, what if we could mindfully design and use digital media to make us smarter? What if humans could build electronic tools that leverage our ability to think, communicate, and cooperate? I think we can. Humans invented social learning, speech, writing, alphabets, printing, computers, and the Internet. We should be systematically directing the evolution of intellectual augmentation.

Therefore, I want to look at this new assortment of networked devices that are so essential to our lives as the tools they really are, and examine how we may use those tools to, in turn, design more humane and effective technology. Ultimately, I will explore how we can use our machines and digital media to create an informed and socially conscious form of mind-extension. The root ideas are not my original creations. Rather, by linking together the work of media historians, cognitive psychologists, and

computer visionaries, I hope to provide a framework to guide our future use of machines-to-think-with. In our species' self-interest, we need to understand the human-computer symbiosis in which we've become enmeshed.

In this quest, we can certainly look to the past for guidance. Our unique ability to create thinking tools has paid off very well for *Homo sapiens* in many areas. Our primate ancestors probably became human by inventing ways to use their brains that no other species had been able to duplicate (such as foresight, language and social learning). The democratization of alphabetic literacy enabled by printing presses, for instance, laid the foundations for democracy and science as a collective enterprise.

Conversely, we are also now aware that building powerful machines before asking how they might change us can be destructive and even dangerous. The list of those negative consequences is long and spectacular — the widespread adoption of the automobile caused equally widespread air pollution that may be changing earth's climate; computers empower billions of people and form the infrastructure for unprecedented surveillance; nuclear weapons threaten the continued existence of human civilization.

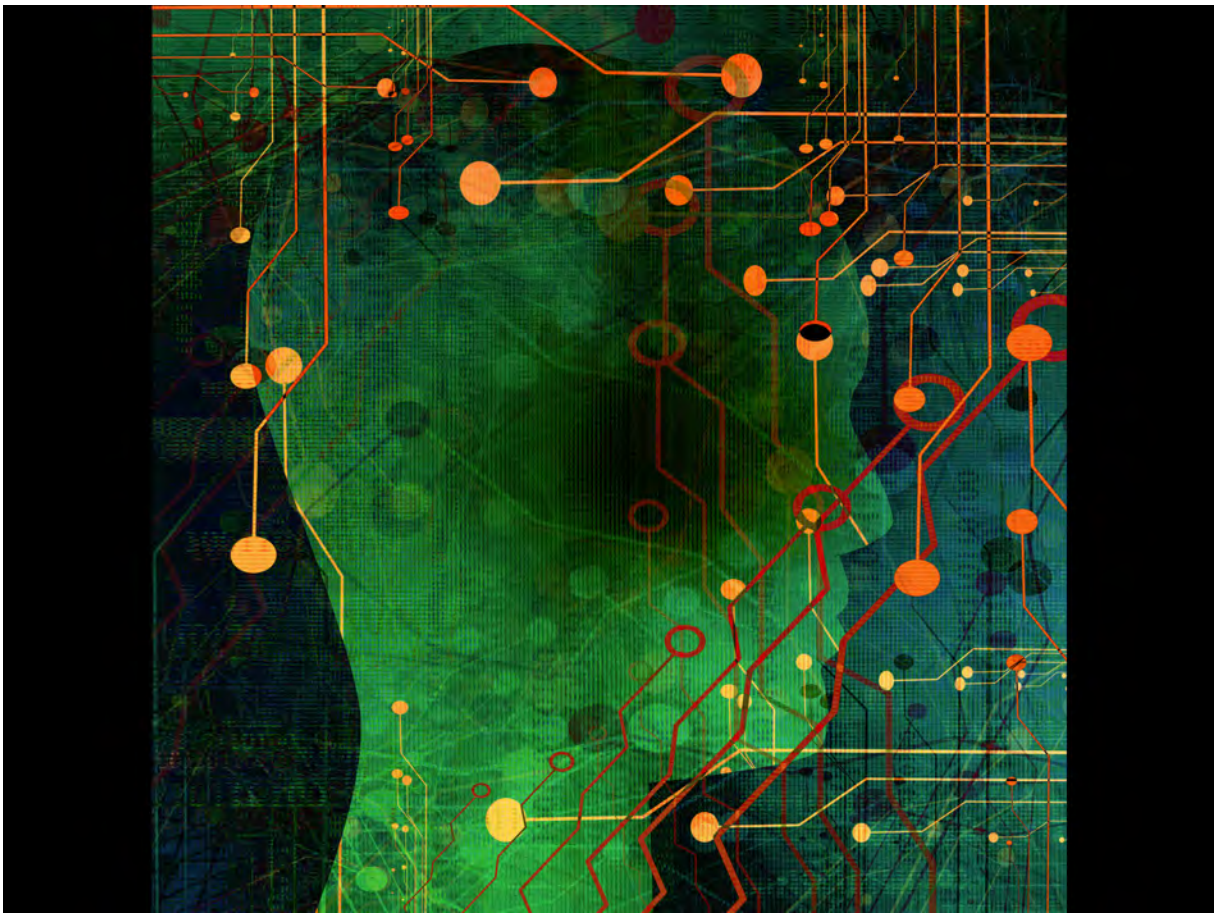
We humans have only recently begun to learn the consequences of using our thinking tools en masse. Technologies that empower individuals

can, when used by millions, exhibit emergent negative, even deadly side-effects. The democratization of air travel (lower ticket costs, multiple carriers, many routes to choose from) has also enabled the rapid spread of global epidemics, for instance. Likewise, texting while driving a car is becoming a major cause of highway fatalities.

It's not just the mind-tools that matter when creating civilization shifters. Knowing how to use mind-tools is what reshapes thinking and bends history. If you know how to use mathematics and the scientific method, it becomes possible for you to build both digital computers and thermonuclear weapons. Can we piece together what we know about designing extensions of the human mind — both cognitive and technological — and use what we learn to address the life-threatening impacts of our tool use? I do not want to ignore the possibility that using new technology to solve problems arising from the use of older tools is a self-destructive loop. Neither do I want to argue for or against the probability of a "singularity" in coming decades — a hypothesized evolutionary tipping point when intelligent machines might out-think humans at such velocity that we won't understand what our creations are up to.

Ultimately, though, I want to consider the question that motivated some of the pioneers of personal computing: How might we build media

that will enable people to think and collaborate in ways never before possible? What if using information media knowledgeably could make us smarter as individuals, as societies, as a species? This question was first posed decades ago by Vannevar Bush, J.C.R. Licklider, and Douglas Engelbart, and less successfully by Emanuel Goldberg and Paul Otlet before them.[1] [2] [3] [4] [5] Now that the technologies envisioned half a century ago have grown billions of times more powerful (and now that billions of people are using them), it's worth reconsidering these original ideas, and how to apply new tools to their originally intended purpose. The early tech visionaries who created personal computers and online networks pursued these inventions not to create industries but to enhance problem solving. It's time to revive the original quest that led to the development of personal digital media. It's time to extend our minds more mindfully.



Natural-born cyborgs

The human evolutionary process sped up dramatically when language emerged. Suddenly, *Homo sapiens* wasn't just accumulating new traits over long periods of time through biological mutation and selection. When we developed language we learned to create new capabilities very rapidly, rather than waiting millions of years for evolution to configure our biological equipment. Biology provided the workable parts for thinking tools, but early humans learned to innovate by repurposing their brains and thought patterns in ways that neuroscientist Stanislas Dahaene calls "neuronal recycling." [6] Biological evolution would favor mutations that changed brains over many generations to make them more fit for their environment. But through neuronal recycling human brains learned how to use existing biological parts to perform new functions. Further, they could teach other human brains to do this as well.

Our ancestors learned to reprogram their brains to deal with the more complex social world they were creating, and the tools our forebears used for reprogramming their thinking capabilities in turn enabled them to make the social world more complex and to make even more powerful thinking tools. Thought and language created the basis for writing, which was perfected into alphabetic writing, automated through print, and amplified

by digital media.

In recent decades, neuroscientists have discovered that the human brain is even more malleable than was previously believed, possessing a capacity now known as "neuroplasticity." In other words, life experience allows the brain to rewire its neural pathways and synapses. Because our brains are self-reprogrammable ("neuroplastic") and we can use language to pass our knowledge to others, mind-tools can boost our individual thinking power. The right cognitive tools can repurpose our brains, have done so repeatedly, and are at the root of what it means to be human. Mechanical aids like writing and computation take advantage of our brains' architecture. Our brains are wired not only to learn, but to socialize in complex ways. The increasingly complex forms of social organization that our aggregate brainpower makes possible for human groups, and the talent for tool-making that our brains, eyes and hands make possible have been co-evolving since our ancestors invented culture. And culture — everything we teach and learn from one another — was the lever by which our biological capabilities bootstrapped themselves. Culture assembled the brain's cognitive building blocks, such as abstraction, prediction and sequencing, into new intellectual capabilities, such as reading and writing.

As Andy Clark, who is a professor of philosophy and metaphysics at the University of Edinburgh, claims, humans appear to be "natural-born

cyborgs," biologically equipped to reprogram each other's thinking machinery through culture. That's where today's 2 billion Internet users come into play. Developing a mutualistic relationship with computing machinery — becoming networks of cyborgs — is taking this older process of human-tool co-evolution to a whole new level. Thinkers from cyberneticist Norbert Wiener to post-humanist Donna Haraway have noted that our cyborg powers affect our humanity, both positively and negatively.[7] [8] The question "What does it mean to be human?" is no longer an exercise for just philosophers and theologians; it is now a bioethics and engineering issue.

Augment, amplify, extend

The term "cyborg," introduced by Manfred Clyne and Nathan Klines in 1960, originally referred to the inclusion of technology in bodies ("CYBernetic ORGanisms"). More recently, media theorists extended the term to describe people whose brains are not physically jacked in to a computer (yet) but whose nervous systems are (already) attuned — through the personal computer's (and smartphone's) point-and-click visual interface — to a kind of "thinking" possible only with computers.[9] Chips implanted in skulls may indeed become commonplace in the future, but the literacies needed to empower smartphone-carrying individuals already exist. Priests who inscribed language on clay tablets in ancient Sumeria were cyborgs, just as your Bluetooth earphone makes you one.

When I talk about "cyborg literacy," I mean a set of skills and social practices that optimize the ability to use physical and cognitive technologies to augment, amplify or extend human thinking and communication capabilities. This not only includes an ability to enhance problem solving but also to include a balance of individual autonomy and collective interdependence; networks of trust; and norms of reciprocity, empathy, compassion and conviviality that are absent from strictly engineering-oriented or purely market-based approaches.

While my initial enthusiasm for digital media as powerful tools for my professional pursuits of writing and teaching has not waned, I cannot help observing the ways in which the world is NOT a better place for the past 30 years of cybernetic innovation. The pitfalls and the hidden prices of technology are more visible, and industries that sprouted from the dreams of engineer-utopians can, in hindsight, lack an essential ethical dimension. Facebook has redefined privacy (and not always for the better), pilotless drones with face-recognition technology target individuals, students play online games during lectures, and exploited labor and conflict minerals are part of the smartphone ecosystem.

It would benefit all of us to learn how to use our ubiquitous gadgets for our own good. To that end, a pattern of thought and theory and possible practical design advice is emerging around mind-extension. The ideas worth spreading include arguments about where human fascination with making machines came from, and where we, and our machines, ought to go next:

- *The human mind is a self-evolving organ. The invention of speech, writing, mathematics, logic, algorithms, computation and human-computer interfaces has been an ongoing process of cyborg co-evolution for hundreds of thousands of years.*
- *Our species' unique capability to learn and teach brought Darwinian dynamics to cultural evolution — survival-enhancing tools and ideas spread quickly, upgrading the capabilities of all humans within communication range.*
- *Literacies made possible by these thought-tools have shifted the course of civilizations,*

necessitating the creation of new intellectual tools to deal with the complexities that older tools enabled.

• *The automation of external symbol-manipulation by computational media and the interconnection of minds and information afforded by many-to-many networks has made it possible for people to more deliberately design powerful cognitive tools. The Internet made the Web possible, and the Web made Wikipedia possible. We're beginning to see how the process of using old tools to create new tools works. This means we can influence or exert control over the process of evolution of the extended mind rather than simply coping with it.*

Co-evolving with our tools

Those who hope to influence the future of the extended mind should consider its origins. Not only can humans reprogram our mental toolkit in ways no other creature is known to do — we call it "social learning" — the human brain's self-reprogramming capabilities seem to have arisen from, and remain coupled to, a co-evolutionary upward spiral. The benefits of this are many, including evolved biological capabilities such as bipedalism, opposable thumbs, big forebrains, sociality and inventiveness; artificially created tools such as chipped arrowheads, clay tablets and microprocessors; and symbolic communication media such as speech, the alphabet and the point-and-click human-computer interface. Each factor drives each other factor to grow more powerful.

One of the first people I met when I started exploring the budding online culture in the late 1980s was a scientist named William Calvin. His research combined paleontology, evolutionary biology, and neuroscience. He has since written several books presenting evidence that the large brains and unique capacities of *Homo sapiens* were shaped by sudden climate change tens of thousands and hundreds of thousands of years ago.[10] When I met him, Calvin was in the process of elaborating his theories. I had the opportunity to engage him online and directly at the face-to-face parties

held by our early virtual community (the Whole Earth Lectronic Link — the WELL — for which I popularized the term "virtual community.")

Calvin's first book, which I read a couple of years before I met him, was evocatively named *The Throwing Madonna*, because it presented the argument that brain mechanisms for speech are closely connected with brain mechanisms used for ballistic calculations — like throwing a rock at a moving rabbit.[11] In order to hit a moving target, different neural computation networks are required to make predictions and sequence actions. These brain mechanisms, Calvin hypothesized, were later adapted to form sentences in the brain and coordinate the muscular actions required to speak them — estimating where a running rabbit is likely to be when your stone reaches that location turns out also to be useful for modeling the future, planning actions, and putting words together into meaningful sequences. Think about the way some invisible mind mechanism seems to fetch the right words to finish your sentences, even if you weren't sure where they were going when the sentences started.

Language encourages generative thinking — not just learning and remembering, but inventing. Even the least creative person invents new sentences every day. Invention and learning by searching for what might turn out to be useful, testing it, and adopting the experiments that work is another uniquely human capability that might have grown out of the need

for rapid ballistic estimates.

The way living organisms can adopt biological organs for new purposes forms the basis for what Calvin and others claim to be our species' talent for "exaptation." This gradual repurposing of previously evolved organs to create new organs, requiring random mutations and millions of years, explains how small bones in the jaws of ancient reptiles turned into auditory organs. Human exaptation is uniquely powerful because of our ability to repurpose in real time the way we use our innate information-processing hardware — and to teach others how to do it. We don't have to wait for mutations to enable us to read and write; we can use parts of our brains to quickly read and understand tracks in the mud and to throw rocks more accurately. Likewise, we can recognize groups of visual symbols as words and then sequence those words into sentences.

"Co-evolution" is another term that characterizes the way humans, tools and culture bootstrap each other. In biology, species co-evolve when they trigger changes in each other over time that increase their fitness to the environment. Faster and faster predators co-evolve with increasingly smarter prey. Oxygen-producing organisms co-evolve with oxygen-consuming organisms. That same form of co-evolution occurs with humans and our tools, both mental and physical.

Just as other predators evolved claws, wings or venom, our predecessors

developed abilities to make complex tools, forecast the future, learn by watching others of our species, and coordinate action among ourselves by communicating with linguistic symbols. Once the biological machinery for our self-reprogramming brains evolved, the collection of practices we now call "culture" shifted human evolution into hyperdrive.

In the beginning, the ability to walk on two feet freed the hands of our primate division to grasp and use external objects as extensions of their muscles. Many of the proto-traits that led to language were about the use of our brains as well as about the capabilities of our vocal cords, tongues, and lips.

Our mastery of attention, for example, is foremost among the traits that enabled humans to invent and evolve culture. We share with other primates the existence of "mirror neurons" that fire not only when we perform a task, but also when we see others performing a task — the basis for internal models of others' behavior.[12] Uniquely among primates, our species will look where another member of our species points, and baby humans quickly learn to pay attention to what their mothers focus on.[13] We are the only primates with large white areas in our eyes, enabling other humans to discern the attentional focus of others.[14] Mindfulness and metacognition — thinking more effectively by becoming more aware of our thinking — are both useful consequences of our attentional capabilities and

clues to designing better mind-tools.

Inventing literacy

Learning from others requires not just the capacity to pay attention and to model the intentions and beliefs of others, but a set of social skills as well. Anthropologist Robin Dunbar and others have argued that the need for complex neural computations such as facial recognition and memory for past behavior — required by the need to keep track of reputation, reciprocity and cooperation — drove the growth and exaptation of the evolutionarily youngest part of the human brain, the neocortex. "The principal function of language was (and is!) to enable the exchange of social information ('gossip') in order to facilitate bonding in larger, more dispersed social groups," Dunbar wrote in a famous paper about co-evolution of neocortical size, group size, and language in humans.[15]

As our ancestors learned to capture fire and to alter the environment to their benefit, make more complicated tools, divide labor, cook, share food, and organize collective defense against predators, they were able to create more socially complex ways of life that enhanced their chances of surviving and reproducing. Extreme, sudden changes in climate killed off those proto-human groups that were not able to respond to changing conditions. The emergence of new levels of social complexity around 100,000 years ago, media ecologist and physicist Robert Logan argues, stimulated thought and

language.[16]

I traveled to Toronto to talk with Logan about extended minds, their origins and their future. Logan reasserted the claims in his books that stone tool-making interacted with control of fire, coordinated hunting, and mimetic communication using gestures and primitive vocalizations, to create the conditions for the emergence of language when severe environmental changes necessitated radical innovation.

"When we gained words as containers for ideas, humans started to think in concepts instead of percepts," Logan reminded me.

The road to microchips started when humans began growing food instead of hunting for it. About 10,000 years ago, agriculture arose, nomads started to live in stationary settlements, big cities grew, kings became emperors, large-scale irrigation projects required hierarchical social organizations, and the conditions ripened for another autocatalytic bootstrapping of our intellectual capabilities. About halfway between then and now, around 5,000 years ago, writing emerged as a cultural exaptation. Its history is now more clearly understood: Clay figurines used by Sumerians to account for economic transactions evolved into *representations* of figurines, impressed on clay tablets, after which the transaction system was further appropriated to encode and transport knowledge of all kinds across time and space.

The invention of writing bootstrapped human knowledge-generating capabilities in stages, beginning with economic transactions, evolving into a general-purpose tool for encoding and transmitting knowledge, and later being reinvented in a highly abstracted and far more learnable form, alphabetic literacy.

The discovery of hundreds of identical small, clay objects in Sumerian excavations posed a mystery to archaeologists for decades until Denise Schmandt-Besserat traveled to museums in the Near East, North Africa, Europe and North America and pieced together the physical evidence of how a writing system emerged.[17] She identified the objects as tokens representing transactions — "calculi." Although the use of tokens has been traced back to 8000 B.C.E., around 3300 B.C.E. these tiny symbolic representations of sheep or bushels of wheat began to be baked into clay envelopes as a kind of tangible contract (for example, "I contributed four bushels of wheat to the royal granary"). Impressions of the tokens were made on the outside of the envelope, so it wouldn't be necessary to break open the baked clay to count the number of tokens inside. Eventually, the accountants for Sumerian emperors — the first literate class — abandoned the use of tokens inside baked containers and used tokens to stamp the outside of the containers. Later, they started inscribing abstractions of the stamped figurines by using a reed to incise lines on wet clay. Inventions build on previous inventions; abstractions encapsulate previous abstractions.