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Engelbart's Theory of Technical Evolution

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Introduction

To any self-respecting geek, Doug Engelbart needs no introduction. He is best known for inventing the mouse and the Windows-Interactive-Menus-Pointing device (WIMP) user interface in the 1960s.¹ He also demonstrated the world's first networked computing environment in 1968, the oN-Line System (NLS), and pioneered video conferencing, hypertext and team-based software development. The interface and mouse from NLS were taken to Xerox with one of Engelbart's team, and moved on to Apple and Microsoft to become the modern computing environment we know today.

Due to these contributions, Engelbart has entered the annals of computing history. His 1968 demonstration is remembered as computing history's 'foundational tribal tale' (Bardini, [2000](#), p. 139), 'the mother of all demonstrations' (Wardrip-Fruin, 2003, p. 231), and a 'landmark ... in the annals of interactive computing' (Ceruzzi, [1998](#), p. 260). He tends to inspire historians to superlatives:

If a computing Hall of Fame is ever built, Engelbart will be among the first half-dozen honorees ... [he] demonstrated the future of interactive computing.
(Segaller, [1998](#), p. 125)

The social influence of Engelbart's inventions from the 1960s is beyond debate, and his influence on the history of computer engineering is also well known. What is not so well known is that he has his own theory of technical evolution, a theory which mobilizes technology as its own milieu that evolves in tandem with human socio-cultural and language practices (he terms this 'co-evolution'). I will be exploring this theory here, based on an interview conducted with Engelbart in 1999 and on some of his technical papers from the 1960s and 1970s. I will be situating his theory alongside contemporary theories of technical evolution which explore technology as its own milieu, focusing on the work of archeologist Andre Leroi-Gourhan and philosopher Bernard Stiegler. It is not my intention to give a history of Engelbart's inventions—this has already been written, many times over (e.g. Bardini, [2000](#); Rheingold, [1985](#); Goldberg, [1988](#); and also Engelbart, [1988](#)). I will be interested in how Engelbart views technical evolution, and what he calls the 'co-evolution' of humans and their tools.

Introduction to Technical Evolution

There is a long tradition within philosophy that investigates the relationship between human beings and technology, extending at least as far back as Aristotle. In this tradition, the instrumental relation between means and ends is usually stressed (Rammert, [1999](#)), and human beings affirmed against *techne*. From this perspective, the factors governing change in technology over time are external to technology itself—human society is the driving force behind change. Technical artefacts are created; they do not create us in return. In the mid-twentieth century a tradition developed which explored technology from a different perspective; the rules governing change are part of the technical milieu and technical discourse itself (Simondon, [1958](#); Gille, 1986; Leroi-Gourhan, 1993; Stiegler, [1998](#)). From this perspective, technological change moves faster than human societies; we are constantly playing catch-up. When we are born, we are born *into* a particular technical system, and we take it on as our own; it shapes us as a species.

In 1964 French anthropologist Leroi-Gourhan proposed that technology has its own evolutionary dynamic, and this dynamic silently propels our evolution as a species. As he sees it, the evolution of man is characterized by a 'freeing of memory'—the exteriorization of human capacities and genetic traits (what he calls 'organs') into techniques, language and material cultural artefacts:

The whole of our evolution has been oriented toward placing outside ourselves what in the rest of the animal world is achieved inside by species adaptation. The most striking material fact is certainly the 'freeing' of tools, but the fundamental fact is really the freeing of the word and our unique ability to transfer our memory to a social organism outside ourselves. (Leroi-Gourhan, [1993](#), p. 236, first published 1964)

From the appearance of *Homo sapiens*, the constitution of this external social memory dominates all problems of human evolution (Leroi-Gourhan, [1993](#), p. 229). Technology has, in this sense, created the human as a species; humanity is nothing but a process of 'exteriorization', a process in which our access to time and culture is accomplished through external supports which transfer our memories. Tools are 'exuded' by humans in the course of their evolution; they spring, literally, from the nails and teeth of primates, and in turn give us a non-genetic advantage over other species, who are condemned to hunt without weapons, to feel the cold against their skin without clothes. As a species, we are characterized by our physical and mental non-adaptation. Our memory is transferred to books, our 'strength multiplied in the ox, our fist improved in the hammer' (Leroi-Gourhan, [1993](#), p. 246). For Leroi-Gourhan, we can trace all contemporary technologies back to this process of exteriorization. Tool and gesture are now embodied in the machine; operational memory (technique) in automatic devices; the capacity to correlate recollections in the punched-card index (Leroi-Gourhan, [1993](#), p. 264).

Consequently, Leroi-Gourhan understands technological evolution as a relation of the human to matter, where the human exteriorizes technical forms. Further to this, he contends that technics is itself in perpetual transformation; it evolves in its organization.

It is at once its own milieu, separate from that of human animals. This evolution is parallel to the evolution of the human, but it also organizes itself. There is a systematicity to the evolution of technics, a kind of techno-logic which is not entirely human. For Leroi-Gourhan, there is an inherent dynamism to technics, itself productive of new lineages and machines.

French philosopher Bernard Stiegler retains and radicalizes several concepts from Leroi-Gourhan's thesis (1998). As Stiegler sees it, technics (inclusive of language, material cultural artefacts and techniques) constitutes its own milieu, and it evolves in its organization. But not only this—it is technics, as the support of the inscription of memory, which invents the human as a species. As biological humans, we are born into this structure, and we take it on as our own; it exists outside our genetically endowed capabilities, and will continue after us. 'Humans die, but their histories remain. This is what distinguishes them from animals' (Stiegler, [2000](#)). As we shall see presently, Douglas Engelbart also believes that as human beings we are *born into* technics (which he terms the human 'augmentation system', inclusive of technical artefacts, language and social discourse), and there is no human activity unaffected by it.

Bernard Stiegler and Technical Evolution

For Bernard Stiegler, human beings have always felt compelled to archive their experience. We leave traces of ourselves and our experience in other people's memories, in the memories of our children; but also in the non-living—in writing, in objects and artefacts, on cave walls and on computer screens, in language and culture. We leave traces of our experience outside ourselves as individuals, traces that will not be lost when we die, but will remain. For Stiegler:

most of these traces have in fact not been produced with a view to transmitting memories: a piece of pottery or a tool were not made to transmit memories, but they do so nevertheless, spontaneously. Which is why archaeologists are looking for them. Other traces are specifically devoted to the transmission of memory: for example, writing [and] photography. (Stiegler, [2000](#))

Stiegler argues that these inscriptions comprise a structure of inheritance and transmission, a structure that accumulates with each successive generation. It is a structure which exists outside our own genetic limitations, outside the finite lifetime of the individual, but which nonetheless carries in it our collective wisdom: the ideas and experiences that we have had, the techniques that we have learned, the tools and artefacts that we have created. Culture is a series of memorials, inscribed in technics.

Importantly, this structure of inheritance and transmission, the material it contains, is not inherent to us. We are not born with it; it is not a genetic memory. It is inscribed and transmitted outside our genetic programs. In other words, we are born *into* it, we acquire it through experience. In is in this sense that Stiegler calls the structure epigenetic—it exists outside and in addition to the genetic, like a surrounding layer. This is a word in use by the scientific community as well, to designate 'those characteristics inherited

outside of genetic encoding and transmission' (Cohen, [2003](#), p. 14). In this article I will be using it in the same sense, to designate that which is not coded for in our genes, but which we acquire and develop in our own lifetimes.

To acquire something outside our genetic programs, then, this thing must exceed the biological. The epigenetic structure must pre-exist us; it must exist beyond our short lives to be subject to inheritance and transmission. We are born into it; it was here before us and it will continue after us. This is what Heidegger calls the already there, this 'past that I never lived but that is nevertheless my past, without which I would never have had a past of my own' (Stiegler, [1998](#), p. 140). For Stiegler as for Engelbart, language is the perfect example. It is not genetic; it is acquired, and yet it is a complicated structure that has its own history, its own past that exceeds the individual. According to Stiegler, in entering into language, it creates a past for us, and we acquire this past, which we continue as our own. We might call this acquisition an 'event'. It becomes the interface through which we enter into relation with the world. So when we are born, we acquire something that we have not individually created but which, nevertheless, shapes our experience of the world. And unlike the plant and animal kingdom, this acquisition, this epigenetic event, is not lost when we die. In the case at hand, observes Stiegler, life conserves and accumulates these events (Stiegler, [1998](#), p. 177). There is history, there is culture, and there are the artefacts and techniques which carry them beyond our death—technics.

Consequently, Stiegler demarcates a third structure, the structure which *stores and accumulates* our individual epigeneses, which exists beyond our own central nervous systems, beyond our individual genetic and epigenetic memories. This contains what we are for the moment calling culture (past epigenetic events, lessons of experience), but also what we are calling tools or artefacts. The structure is at once our own and also transcendental: it is larger than ourselves. It is a store, an accumulation, a sedimentation of successive epigeneses, a thing which evolves, which has its own historicity and dynamic (Stiegler, [1998](#), p. 140). Far from being lost when the individual human dies, it conserves and sediments itself. Stiegler calls this the epiphylogenetic structure, implying by that terminology a material genealogy proper to it.

So he distinguishes here between three types of memories out of which the human develops:

Genetic memory; memory of the central nervous system (epigenetic memory); and techno-logical memory [epiphylogenetic memory]. (Stiegler, [1998](#), p. 177)

Stiegler locates or amalgamates 'language', 'technics', 'technique' and 'technology' within this third type of memory, epiphylogenesis. Not because they are of an essence but because they are all forms of inscription, transmission and, ultimately, transcendence. They are larger than ourselves; they exceed our short lives as human individuals. Technics, however, is afforded a special place here; although in common parlance it designates tools and instruments, Stiegler also uses the term in the Greek sense (*tekhne*). In other words, it designates skill, art and craft; engineering discourse, for example, is a

suite of skills. Technical objects are the result of the transmission of these operational chains, which are transformed in time as artefacts. Language is also a skill, a mode of transmission—and thus it is a form of technics (Stiegler, [1998](#), p. 94).

Epiphylogenesis, then, designates a new relation between the human organism and its environment. It is technics, as the support of the inscription of memory, which is constitutive of transcendence. The biological human, with its limited genetic and epigenetic memory, dies. This is the paradox of Man: 'a living being characterized in its forms of life by the nonliving' (Stiegler, [1998](#), p. 50). But at the same time, this larger structure transforms the human as much as it is transformed by it; there is no originary term in the equation; this is a co-evolution. In Stiegler's terms, the 'what' (technics) invents the 'who' (humans) at the same time that it is invented.

I would now like to situate Engelbart's philosophy within this recent body of theory exploring technics as its own milieu, larger than that of human animals. Engineers are not commonly known for their contributions to philosophy, and Engelbart is no exception. I do believe, however, that we can learn something about the human-technology relations from engineers. Engelbart in particular believes that technics (which he terms the 'human augmentation system') develops atop our genetically endowed capabilities; as human beings, we are born *into* a larger structure, which we take on as our own. This philosophy guided his work as an engineer.

Unlike Stiegler and Leroi-Gourhan, however, Engelbart believes that so far it has been an *unbalanced* evolution in favour of technics, and that it is possible to direct the course of change, to regain control. This desire to put humans back in the driver's seat constitutes a retreat into a liberal humanism, and sits in contrast with the rest of Engelbart's philosophy. As an engineer, it has been Engelbart's project for over 50 years to harness this complex structure and 'boost' our capacity as human beings.

Engelbart's Theory of Technical Evolution

What really connected for me was thinking about what an augmentation system really is, that humans learn how to live within and with social structures and discourses and facilities and tools, so all that is one giant augmentation system. (Engelbart, interview with the author, 1999)

As Engelbart sees it, the whole subset of learned behaviours and physiological capabilities which allow humans to modulate and interact with the environment is our 'augmentation system'. This includes tools and artefacts, from pens and toothbrushes to computers and hypertext systems. But it also includes the social structures we live within, the techniques and discourses we acquire, the 'training, knowledge and skills that have to be installed as well as language, an extremely important invention' (Engelbart, [1988](#), p. 216). This is a giant, complicated structure that has evolved over generations, and it 'gives us the benefit of what others before us have learned' (Engelbart, cited in Rheingold, [1985](#), p. 181).

Most importantly, the elements within this augmentation system are acquired; we are not born with them but born into them and take them on as our own (he uses a software metaphor for this process; they are 'installed' in the manner of a program: Engelbart, [1988](#), p. 216). For this reason, as we shall see below, he objects to the idea of building 'natural' or 'easy to use' technologies; for Engelbart, nothing is natural, everything is learned. According to Engelbart's daughter, humans acquire this structure 'atop their genetically endowed capabilities' (Engelbart, [2003](#)). This augmentation system is what makes us human; *we are what we can remember*. The strange thing is, we are not even conscious of all the ingredients in this structure:

Here's a human ... he's got all these capabilities within his skin we can make use of, a lot of mental capabilities we know of, and some of it he's even conscious of. Those are marvelous machines there—motor machinery to actuate the outside world, and sensor and perceptual machinery to get the idea of what's going on ... we've got a whole 'culture-full' of things we are indoctrinated and trained into, both conscious things and unconscious things. (Engelbart, [1988](#), p. 213)

Engelbart divides this augmentation system into two parts. One part has the material artefacts in it and the other has all the 'cognitive, sensory motor machinery' (interview). 'I called these the "tool system" and the "human system"' (Engelbart, [1988](#), p. 216). One lot of technologies is inside thought (and also the body—as motor memory), the other has been externalized as technical artefact in the manner of Leroi-Gourhan's exteriorized technical forms. But the line is blurred when it comes to human cognitive evolution: human cognitive machinery—examples being language or 'problem-solving' methodologies—is itself inherited, it has its own lineage, larger than the human that carries them.

Consequently, Engelbart divides this augmentation system further into four parts—tools or artefacts, which are outside thought, and then language, methodology and training (these last three are the 'human system'). The human system is what *equips* and *enables* us to use technical artefacts. It can in turn be 'boosted' by training to become more effective at using these tools:

Artefacts—physical objects designed to provide for human comfort, the manipulation of things or materials, and the manipulation of symbols.

Language—the way in which the individual classifies the picture of his world into the concepts that his mind uses to model that world, and the symbols that he attaches to those concepts and uses in consciously manipulating the concepts (i.e. 'thinking').

Methodology—the methods, procedures, and strategies with which an individual organizes his problem-solving activity.

Training—the conditioning needed by the individual to bring his skills in using augmentation means 1, 2 and 3 to the point where they are operationally effective. (Engelbart, [1962b](#), pp. 4-5)

For Engelbart, the most important of the last three technologies is language. As Thierry Bardini observes, he was heavily influenced early in his career by the work of language theorist Benjamin Lee Whorf, whose central thesis is that 'the world view of a culture is limited by the structure of the language which this culture uses' (Whorf, cited in Bardini, [2000](#), p. 36). For Engelbart, the basic means to augment human intellect lie in the simultaneous development of technical artefact and human user in a way that exploits the potential of language to shift these limits. Language is already a powerful machine. It is configured as a series of 'nonlinear relationships' that can be identified, mapped and changed (Bardini, [2000](#), p. 37). Engelbart would seek to 'harness' these nonlinear relationships with a computer system that externalized the networked structure of language. It would be the world's first hypertext system:

With the view that the symbols one works with ... represent a mapping of one's associated concepts, and further that one's concepts exist in a network of relationships as opposed to the essentially linear form of actual printed records, it was decided that the concept-manipulation aids derivable from real-time computer support could be appreciably enhanced by structuring conventions that would make explicit the various types of network relationships among concepts. (Engelbart & English, [1968](#), p. 398)

Language is our most powerful machinery—a tightly sprung network of relationships that mark the limit of what is possible. But underneath this acquired machinery is what Engelbart considers our more 'basic' human capabilities: perceptual and motor machinery. These are not pure or innate either; human beings must *learn* how to see, how to feel and how to think within a particular culture and language; even our basic sensori-motor skills are shaped by this larger augmentation system.

To illustrate this, Howard Rheingold gives the example of a 'transplanted native'; if you drop a lifelong New Yorker into the New Guinea Highlands, don't expect him or her to know how to sense a looming tropical storm or build a grass shelter. The New Yorker would *perceive* the physical signs for an approaching storm (e.g. birds going quiet, a sudden drop in temperature), but wouldn't have the skills to interpret them. There would, however, be a way of *acquiring* these skills—'transmitted human software'—which the New Yorker might move through step by step as an organized program with the aid of a native, thus shaping his skills (Rheingold, [1985](#), pp. 182-183). This 'software' is not genetic, it is acquired—yet it shapes our way of thinking, of seeing and of moving about in the world.

For Engelbart, there is no human capability or tendency unaffected by our augmentation system. Humans invent themselves within this structure, and 'what we consider to be natural is just what we have grown to accept' (Engelbart, [1988](#), p. 217) from within a historically specific period. Consequently, when it comes to the tool system, there is no

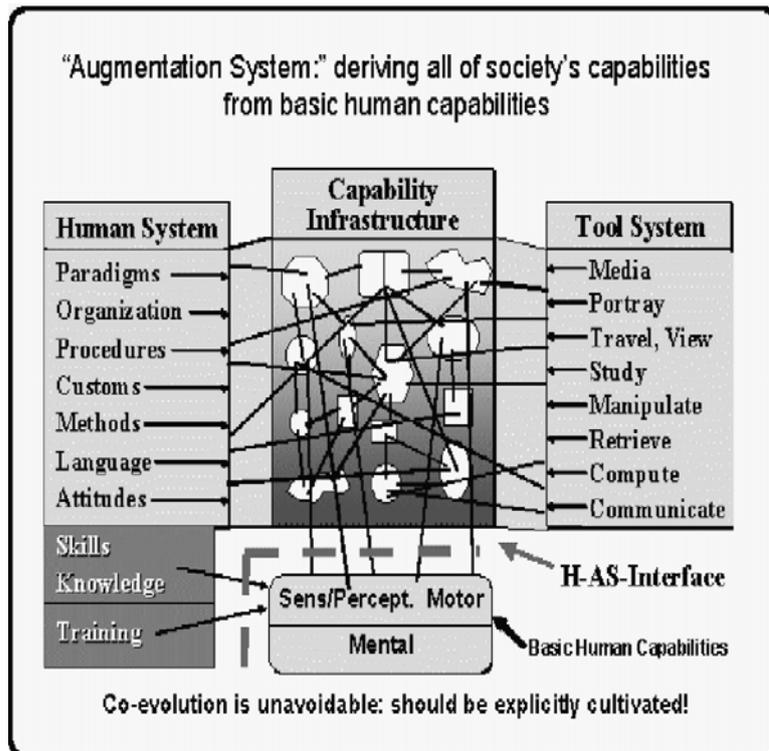
truly 'natural' technology or way of doing things for human beings. 'Whenever you hear somebody say it has to be “easy to learn and natural to use”, put up a little flag and go question it. What's “natural”? Is there a natural way to guide a vehicle, as with reins? Well that didn't last long' (Engelbart, [1988](#), p. 217). Invention is entirely located within a particular time and culture—or as Stiegler puts it, within a particular technical system.[2](#)

Importantly, the elements within the human system were developed as techniques and as skills in order that we might better utilize the material artefacts of culture, and in particular, technical objects. The human system *invents itself to better utilize the tool system*; this is the reverse of the liberal human perspective, where an originary human culture exists prior to and separate from technology. For liberal humanism, the tool is envisioned 'as an object that is apart from the body, an object that can be picked up and put down at will' (Hayles, [1999](#), p. 34), an object that exists outside of the originary human being, who is entirely separate from technology. What Engelbart is suggesting is that man's unique nature is defined by tool use; all human action is, after a fashion, *techné*. Kate Hayles (1999, p. 2) calls this perspective posthumanism; Engelbart calls it an 'integrated man-machine relationship' (1962a, p. 237):

The expression that Engelbart used to describe his crusade to improve human capability to cope with 'the complexity/urgency factor' was the augmentation of human intellect, a term that ... located his project firmly in the emerging field of cybernetics. (Bardini, [2000](#), p. 11)

Engelbart modelled the human psyche as a technical system, and proposed a fundamentally technical solution to the problem of human knowledge. His tool and human systems 'communicate' via a process of 'feedback' (Bardini, [2000](#), p. 34), a fundamentally systemic process. Humans and technical machines are also articulated together as different kinds of systems—one of the hallmarks of cybernetics (Hayles, [1999](#), p. 4). This is not surprising; cybernetics influenced most engineers working in the 1950s (Bardini, [2000](#), p. 11). Like Norbert Wiener, Engelbart also has a systemic explanation for social structures and their relationship with technologies, the co-evolution of the human system and the tool system.

Figure [1](#) shows the dynamic of this co-evolution. The field where the tool and human systems communicate is called the 'capability infrastructure' (this is the box in the middle). This field or plane is where we live our lives as individuals, but it also represents what we are capable of as a culture or organization, how well we can use our tools. This is the field where invention takes place, and also the limit of what is possible. The human system and the tool system are in constant communication, and they evolve over time.



[\[Enlarge Image\]](#)

Figure 1. The Augmentation System (Engelbart, [1962a](#), 1992)

But for Engelbart this is an *unbalanced* evolution; so far the tool system has been 'inappropriately' driving the human system and the pace is accelerating. This aspect of his theory could be seen as a form of technological determinism.³ For Engelbart, the tool system currently moves faster than the human system, and it takes generations before we can develop the appropriate human infrastructure to deal with changes. He believes that technology moves in large, rapid steps, and that this can cause distress amongst human beings as old paradigms and techniques are outdated.⁴ Further, he believes that the world is far more complex now than it was 100 years ago; unless we address it, the problem could become acute. Unlike Leroi-Gourhan and Stiegler however, he thinks we might be able to create a more 'balanced' co-evolution:

It takes a long time (generations) to discover and implement all of the changes in the human system made possible by a given, radical improvement in technology. Where, as is the situation now, technology moves in large, rapid steps ... the human system will become critically stressed in trying to adapt rapidly in ways that formerly took hundreds of years ... [t]he technology side, the tool system, has inappropriately been driving the whole. What has to be established is a balanced co-evolution between both parts. How do we establish an environment that yields this co-evolution? (Engelbart, [1988](#), p. 217)

Engelbart's conception of human-technical evolution fundamentally influenced his approach to invention in the 1960s and 1970s. Not only did he explicitly seek out 'basic

cognitive machinery' at this time via empirical experiments to 'augment' them with tools, but he refused to take the dominant mantra of the engineering community on board. 'Easy to learn, natural to use' implies that humans should not have to learn from technology (Engelbart, [1988](#), p. 201). Engelbart believed, and designed technical systems, otherwise. Humans learn from technology; they acquire new techniques and new skills from material artefacts, and this process is not only desirable, it is unavoidable. So the only way we can direct this evolutionary dynamic is to become conscious of the process itself; we have to become 'conscious of the candidates for change—in both the tool system and the human system' (Engelbart, [1988](#), p. 217). Technical evolution does not have to be unbalanced.

Some technologies, Engelbart believes, can cause paradigm shifts. To create technologies that cause paradigm shifts, one must focus on the human system—what our current social structures and techniques are for doing things, and how these might be 'boosted' using elements from the tool system. Engineers should reflect on our own basic cognitive machinery, reflect on where the limits of these reside. Language is the most important technology—if we can effectively map this 'pattern system' and externalize it as artefact, we can begin to change the limits of what is possible, to 'expand the house of consciousness' (Bardini, [2000](#), p. 37).

This reflexive technique is what he calls 'bootstrapping', and it was the methodological basis of the lab he set up at the Stanford Research Institute (SRI) in the early 1960s. The philosophy is also a return to liberal humanism, and sits in contrast to the rest of Engelbart's thinking on technical evolution; he believes that humans can and should learn to *direct the tool system*, to control the direction technology takes. It is possible, he believes, to change the relationship in favour of human beings.

Hayles ([1999](#)) locates a similar contradiction and anxiety in Norbert Wiener's work. Like Engelbart, Wiener is concerned that humans 'must not let machines become their masters' (Hayles, [1999](#), p. 85), yet he explicitly promotes computers as 'thinking machines capable of taking over many human decision-making processes' (Hayles, [1999](#), p. 85). He retreats from the consequences of his own philosophy. The line blurs the boundary between thought and technics—a boundary Engelbart is also concerned with.

In particular, Engelbart maintains we need to create tool systems that help us deal with knowledge work in a more effective way. This objective is something he claims he inherited from Bush's 1945 paper, *As We May Think* (Engelbart, [1962a](#), p. 235), and it formed the basis of the 'Conceptual Framework for Augmenting Man's Intellect' he would later erect to explain and support the development of the oN-Line System (NLS), a prototype hypertext system:

We need to think about how to boost our collective IQ, and how important it would be to society because all of the technologies are just going to make our world accelerate faster and faster and get more and more complex and we're not equipped to cope with that complexity. (Engelbart, [1999](#))

This sense of urgency, this feeling that the world is getting more complex and moving faster, that we need a way to 'harness' the inherited mess, and that this would be *the most important project mankind could undertake*, has obvious parallels to Vannevar Bush's project:

The summation of human experience is being expanded at a prodigious rate, and the means we use for threading through the consequent maze is the same as was used in the days of square-rigged ships. (Bush, [1945a](#), p. 89)

[Memex] is a much larger project than merely the extraction of data for the purposes of scientific research; it involves the entire process by which man profits by his inheritance of acquired knowledge. (Bush, [1945a](#), p. 99)

Boosting our capacity to deal with this inherited knowledge and its 'extreme complexity' (Engelbart, cited in Bardini, [2000](#), p. 212) is the challenge. Engelbart shared this basic urgency and also this basic understanding of the problem with Bush. We are what we can remember—so 'improv[ing] the human capability to cope with that' is our most basic goal (Engelbart, cited in Bardini, [2000](#), p. 10).

For both Engelbart and Bush there is also a structure to this acquired knowledge; a *networked structure* we should seek to preserve. All our ideas have basic systemic interconnections, and this structure is what enables the creation of new concepts as well as recall. Bush explicitly theorized this structure in terms of association, and considered association the best technique and model for organizing information. Engelbart theorizes it in terms of 'basic mental structures' and in particular 'basic concept structures' (Engelbart, [1962b](#), p. 35).

Unlike Bush, however, Engelbart considers this basic structure as derivative of *language*—this is where his philosophy differs from Bush (Bardini, [2000](#), p. 39). For Engelbart, language is a vast system of interconnections that defines the limits of what we know or can know, of what is possible. As a technology, language engenders our basic mental structure and enables or enframes our basic concept structures. Human beings are born into language; it is the interface through which we relate to the world, and its pre-existent structures shape both our own consciousness (our 'basic mental structure') and our way of understanding that world (our 'general-purpose concept structuring'):

A natural language provides its user with a ready-made structure of concepts that establishes a basic mental structure, and that allows a flexible, general-purpose concept structuring. (Engelbart, [1962b](#), p. 35)

Because he believed that human beings are born *into* technologies like language, and that these are already engineered, Engelbart was not opposed to manipulating them and seeking finer levels of control. Human beings should learn how to manipulate tools to their advantage; they should seek to extend their augmentation system. Consequently, the NLS system involved a whole new set of techniques and had many levels of control and

manipulation. It was difficult to learn and difficult to use; this was a common criticism of the system at the time. NLS was an exteriorization of human 'cognitive and associative processing' in a group environment, a refinement of an already complicated technical process:

... to externalize your thoughts in the concept structures that are meaningful outside; moving around flexibly, manipulating them and viewing them. It's a new way to operate on a new kind of externalized medium. (Engelbart, [1998](#))

For Engelbart, it is the greatest challenge an engineer can undertake to augment or extend human thought, to 'boost our capacity' as a species. Engineers are in a privileged position to be able to do this, with access to specialized techniques and technical discourses (Engelbart, [1988](#), p. 189). Unlike many engineers at the time, however,⁵ Engelbart was not elitist about this; he believed that other disciplines had something to contribute to engineering—in particular, psychology, as this discipline has deep knowledge of the human system. He employed a psychologist at the SRI labs.

Fifty years later, Engelbart soldiers on. With his daughters he now runs the Bootstrap Institute in Fremont, California, an organization he founded to continue evolving the relationship between humans and their tools. He is 81 years old.

We're trying to tell the world that an improvement infrastructure is something every organism has, every society has. So people need to start thinking about this on a national scale. Every nation needs to ... augment it as much as possible, and then, since countries have to do things together, we need to have a global sense of that. That's the challenge, it always has been, boosting our collective IQ. (Engelbart, [1999](#))

Notes

[1] Now known as Windows-Icons-Menu-Pointing device.

[2] Stiegler takes this concept from the work of Bertrand Gille.

[3] In contemporary philosophy, the charge of technological determinism has a stigma attached to it, and is often used to end an argument. I certainly do not mean it in the dismissive sense here. As I see it, the opposite perspective, the 'social shaping of technology', is similarly problematic.

[4] This concept also has parallels with Gille's work on technical paradigm shifts.

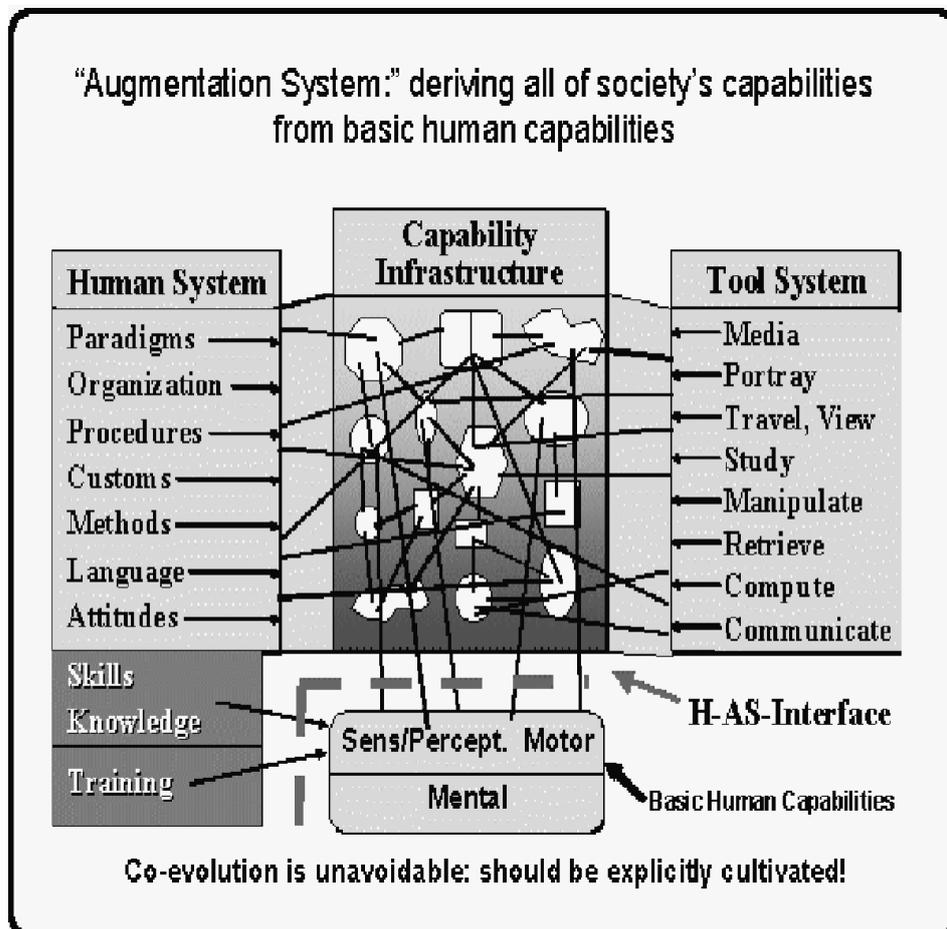
[5] For example, Vannevar Bush (1945b), who believed that the general public had little understanding of science, and urged the government to fund engineers, who are the source of all technological progress.

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Figure 1. The Augmentation System (Engelbart, [1962a](#), 1992)