Technology and the Laws of Thought

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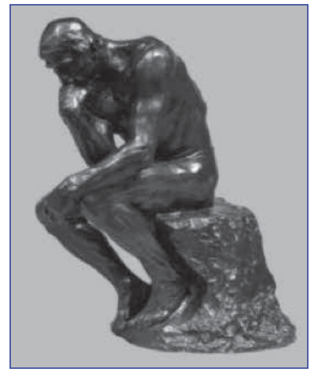
τέχνη (*techne*): art, craftsmanship, skill
λογική (*logike*): reason, rational thought

In the past couple of decades, the globe has been encircled by the web of technology. Devices have become obsolete so blindingly fast, that coming to grips with the pace of development has become tougher with time. It is not uncommon to feel as if one is on a roller coaster ride, hanging on to the seat by the tips of the fingers. From around the time Alvin Toffler's *Future Shock* became popular in the 1970s, several hundreds of books have been written, talks have been arranged, conferences organized under the theme of technology, especially about computing technology that has come to influence our lives so penetratingly. However, the glare of new technology has grown so strong that most descriptions restrict themselves to the past 50 years or so, as it is not worthwhile to describe and study an obsolete technology in full working detail. Even if the earlier history is mapped out,



the corresponding conceptual development, particularly the philosophical development, is not generally addressed.

Additionally, innovation has been a goal much stressed in recent years. In a rapidly changing environment, it is doubly difficult to identify what is really new, making it a tricky goal to work with. Hence what are most needed are an analysis of the way we came to be where we are today in terms of technology and a clear understanding of what the effect of technology is on the human mind. Only this context can show where we are headed.

These two aspects are addressed in this work: how the technology was created and how it is related to the thinking process. Not only is a historical overview provided, but the conceptual developments which came into being along the way are highlighted as well. This is seen to lead right back into the time of the Renaissance and the Age of Enlightenment, and by suitably arranging the different streams of thought so that their effect on each other can be seen, we can find a way into the much distant past—to the origin of the ideas guiding technology today. This path can get winding at times, but it is by no means random. The aim of the process is to see both if the way technology has developed was the only way possible and if any ideas can give a different orientation for it. At the same time, studying the effect of machines on the human mind can suggest ways to understand and to compensate for these effects. Such study should help not only to tackle technology in the right way, but also to enable new ideas to enter into this field that can prove fruitful for every free-thinking person.

> *The real question is not whether machines think but whether men do. The mystery which surrounds a thinking machine already surrounds a thinking man.* – B.F. Skinner

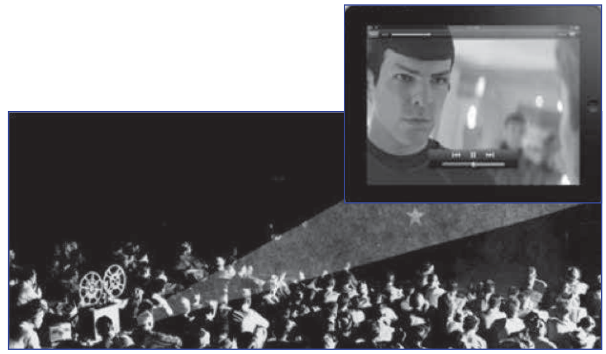
The Situation Today

One of the distinguishing features of the world today is the sheer number of distractions one is subjected to day in and day out. Every aisle in the supermarket has a thousand options, every street in the city has a thousand boards and advertisements, and every click of the button pours out myriad options for pursuit. The sights and sounds that blare forth from all directions, especially in the midst of a big city, have reached unprecedented levels, especially when all the earphones and small-screens are included. This development is noticed not only by the experts in psychology and the students of anthropology, but also by the general public. The sudden rise of electronic media and its consequences can hardly be missed by anyone. This transition into the world of distraction is being experienced by a larger section of the population today than ever before, and quicker than ever before.

As the things that demand our attention have proliferated, attention spans appear to have gone the other way. In just the last fifteen years, it can be observed that it is much harder to concentrate on only one topic at a time, in any field of life. In order to accommodate, and to somehow work with this limitation, the fields of knowledge have gradually splintered into innumerable tiny boxes. Observe the number of specialists that have arisen in the various fields of knowledge; e.g., "a doctor" is not to be found easily, but rather an "-ologist," whose specialty is one specific part of one specific organ of the body. It is difficult for a scientific investigator to even understand the vocabulary of another field of science, let alone communicate the thoughts accurately. It is actually easier to be "the expert" of a narrow topic than to have an in-depth grasp of a wide array of knowledge. This appears to be one of the side-effects of the Information Age: a fracturing of knowledge and attention. On one hand, the ability to access information has increased enormously, and on the other hand, the ability to remember, assimilate, and work with that information is more and more challenging.

(courtesy Manu Cornet)

Noticing this change is one thing; coming to terms with it is quite another. It is clear that with time, these effects of technology can only increase, which brings up several questions. How did this technology arise? Where did it originate, and where is it headed? How do we distinguish the harmful and useful effects of technology? Where is it possible to draw the line, if at all such a line exists?



It is possible to think about technology in simple terms, for example: the knife that is in the hands of a surgeon and the knife that is in the hands of a robber. If so, then it is not the knife that is the issue at hand, but the person and his motives, in which case all worrying about technology becomes irrelevant. However, things are not as simple as all that when comparing a knife with the effects of modern computing technology. The effects of a knife are clear and visible to all, while the effect of technology on the workings of the innermost aspects of the mind is not easily visible. The cooperation with the machine remains out of sight. Studying the *visible* effects of technology is easier than understanding the *invisible* effects on something as internal as thinking and focusing. Computing technology is, as the saying goes, a whole 'nother animal.

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Therefore it is important to identify what the relationship is between thinking capacities and our current technology-filled life, and what can be done about it. This is a vast field, and it would involve delving into an obstacle course of sorts to trace the origin of the relevant ideas. Since these developments are not easily visible to the eye, it requires some patience to identify the path to trace. Hence, a good approach would be to consider the changes themselves in greater detail and try to get a clear image to work with. The right questions can reveal themselves along the way, instead of trying to force-fit the situation into specific questions. Since the topic is about the recent changes in thinking capacities, we will begin with the present day and work backwards.

Since the path of approach is not easily visualized in the case of internal thought processes, the first thing to do is to study the current scenario in a bit more detail. The ideal place to start the inquiries is with what is right "in our face," i.e., the "screen" on which you are reading this. It could be either a paper or (more likely) the computer screen. If you are reading hard copy, most likely it was printed from a computer after selecting it on the screen, which leads us back to the computer screen, a good starting point.

In general, what would the response be if a person is asked today: "How does this screen work?" The chances are that "how computer screens work" would be typed into a search on Google, Wikipedia, or perhaps howstuffworks.com. Within a few minutes, everything related to the computer screen will be available, right from the pigments on the sheets that make up the screen to the way the screen is refreshed. A YouTube video might even provide a look into the cross-section of the screen. Everything appears very straightforward. However, imagine the situation after a week. When the same question is asked, what would be the likely result? Of course, a person might remember "googling" it, but remember the details only vaguely, and would probably do a quick re-search to provide the answers. Similarly, after a month… It is likely that the person would be halfway through an article on screens, and then realize: "Hey, I have read this before! Some time recently…" Hence, there is a definite observable variation in both memory and understanding.

Now, let it be further assumed that a project report is required on the same topic, "How Display Screens Work." What would be the obvious approach? Most likely it would involve clicking on a lot more links and perhaps a visit to the library. Discussion with others would occur through email, online forums, and social media. The report would be typed up on a computer, reorganized, edited, proofread, and submitted via email. We can imagine a student completing the entire project on a laptop without even leaving the bed. In other words, it might not even be necessary to move away from the computer screen, in order to understand how a computer screen works! At the end of it all, if there are 200 people completing such a project today, how many would have involved actually taking apart an old computer screen? And how many would involve links picked from the first page of results in Google? It is worth pondering that for a moment.

Time and effort involved in any mental activity are seen to increase for every decade traveled into the past.

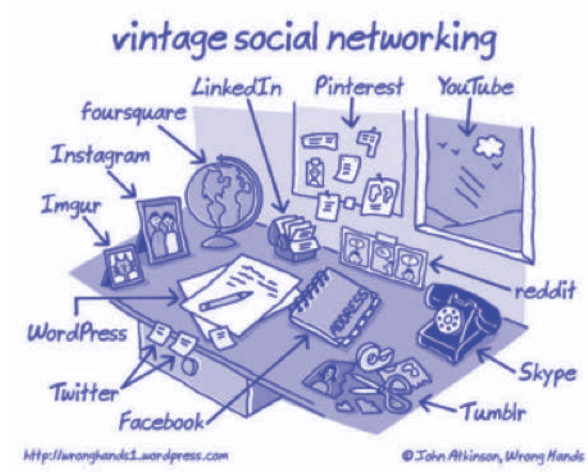
Now, consider taking a few steps back, about 30 years into the past, in order to compare it with the situation today. Imagine the results of the previous project as written by 200 young students in the 1980s, who embark on such a project. To stay true to the different time periods, assume that the students of the 80s have a project to submit on the *television* screen. Imagine the movements of the students in the library; it is easy to see several different starting points from different books, involving a lot of physical movement to and from bookshelves, to study desks and perhaps coffee shops. Probably a good number of the students would be in the junkyard, pulling out spare parts of a discarded television set. A typical student would have at least travelled from the house to the library to look up references. In the writing process, from one sentence to the other, there would have been a lot of time involved. Every sentence would have had to be first thought out, discussed, and then written or typed out with care, with little correcting (save for typos). The sentences spent a lot more time in the mind before getting transferred to paper. In addition, a considerable amount of activity, both mental and physical (muscular) activity, was involved in the process. There is quite a big difference between planning a bus ride to the library among several other chores and the push of a button. Hence, these two aspects can be seen to clearly distinguish between the two eras: the element of *time* and the element of *effort*.

The next step is to confirm this observation by considering an even earlier time period. By moving back 50 more years into the past, somewhere in the 1930s, we can visualize a different scenario. Consider a slightly different project for the student of 1930: to identify how the cinema worked, for example (keeping the theme of screens alive). At this point, there were virtually no technical aids to the thinking process itself, except one's own capacities, books, and slow-paced communication with other people. There were only a few machines that the average student could use to help him, perhaps the local press and the radio. The practical side would have likely involved actual protracted work with cinematic equipment and projectors, which were not owned by many people at the time. It would have been necessary to learn to operate the instruments related to projecting an image on the screen in the cinema hall itself, the effort and scope of the project magnified and the time taken for it likewise lengthened.

Thus, time and effort involved in any mental activity are seen to increase for every decade traveled into the past. It is a common experience for those who communicate with their grandparents to marvel at the amount of effort even simple tasks took in their time. Of course, this is no great revelation, because, after all, a machine is an object that saves human time and effort. The important point here is to have a clear visual of the inner *mental* situation with regard to this requisite time and effort, as this is the part that is not readily visible.

At the same time, when we observe devices other than computing devices, we see a comparatively slower evolutionary process. For example, the shape of the knife has not really changed in several centuries. Even automobiles, airplanes, bicycles, and ships have all sustained their basic structure for nearly a century. It is mainly with computing technology that the pace of change is accelerated so tremendously. Since all technology before the computers helped to assist physical work, the possible reason for this accelerated speed has to be related to its connection to the human thinking process. That is the conclusion one is led to when comparing rates of change of technology: The speed of evolution of technology that is related to mental activity far outstrips the evolution of other forms of technology.

In addition to changing much faster than conventional "visible" technologies, computing technology has also absorbed the activity of older devices into itself. For example, a good comparison between the situation before and after the turn of the century can be seen in this picture:



Observe that the working office or study desk has become "virtualized" and sucked into the computer and the Internet. This is the major difference between the tools used in the middle of the 20th century and the tools used today: Most of the tools have been replaced by the computer. For most projects involving mainly analytical thinking, in place of the library, the office desk, the telephone (and perhaps even the television), there is one instrument: the computer. Thus, the focus would have to be on computing technology, with other forms of technology remaining in the background.

It is important to visualize this entire process clearly: how a project is approached, started, and finished in today's world. The patterns of thought used in implementing this technology lead to the central issue: How exactly does a computing machine affect the human thinking process? And how is this effect different from the effect of other machines?

Internal and External Effort

For it is unworthy of excellent men to lose hours like slaves in the labor of calculation which could safely be relegated to anyone else if the machine were used. – G.W. Leibniz

Before the age of machines, it was the work animals that provided the motive force for all of mankind's activities. Once the machines took

over, the burden of generating power fell on inanimate processes. What would once have taken many people months of back-breaking, repetitive work could be accomplished with the help of moving a few levers and buttons. In addition, up to about a century ago, what the machines took over was almost always related to some skeletal or muscular movement of the human body. The six simple machines, as most of us were taught in grade school, all replace movements of one kind or another carried out by the muscles and bones of the human being.

- Wedge (fingers)
- Pulley (joint movement)
- Inclined plane (tilting)
- Lever (arm, knee)
- Screw (wrist)
- Wheel and axle (rotating joint)

Movements of the hands and legs are "outsourced" to the machines, and multiplied. This is the origin of technology in its conventional form, as it existed until the 19th century.

So, it can be said that movements of the hands and legs are "outsourced" to the machines and multiplied. This is the origin of technology in its conventional form, as it existed until the 19th century.

However, manual effort is not the only kind of effort that exists in this world, as anyone who has struggled for hours on end with a mathematics problem will gladly attest. This was also seen in the comparison of the TV-screen project report from decade to decade. In this case, effort belongs to the thought process alone, which does not pass over to the limbs. It is here that the apparent difference between a thought process and a mechanical movement of the skeleton and muscles can be observed: one is *internal*, the other *external*. For the time being, the words "internal" and "external" will be used to indicate only their general nature as a matter of experience, and whether or not the two are strictly distinct will be examined in a later chapter [Part 2 will be included in *Research Bulletin* XXII-1, Spring/Summer 2017.] In terms of experience, most analytical, scientific, or meditative effort is directed at the cultivation of internal effort for producing results, while athletic and gymnastic efforts are directed at the cultivation of external effort.

Humanity spent large periods of time when bodily effort determined daily life to a great extent. However, skills were developed over a period of time which prepared the way for the formulation of the laws of mechanics and the rise of technology. This indicates that just as the laws of mechanics were formulated after several generations of men and women had steeped themselves in the work of building various structures, what is external work at one point of time evolves into a capacity for internal effort at a later point of time. It is quite possible that Galileo had never had his hand crushed by a boulder or spent years building a tower, but that did not prevent him from observing the laws of falling bodies. This indicates the important transformation that occurs from age to age: External bodily effort of one era transforms into the capacity for inner effort of a later era. (It is important to note at this point: External effort develops only the *capacity* for inner effort, not the effort itself! It is up to the individuals to develop that, a fact which will be examined in the later sections while expanding on the vague term "inner effort.")

As the external work got outsourced to the machines as technology, mathematics and natural science bloomed parallel to it. This period continued from the 16th century until the end of the 19th century, when a new idea entered mankind: Is it possible to outsource the inner effort of *thought* to the machines as well? Side by side, another idea was also taken up seriously: What if my so-called inner effort or willpower is nothing but a mechanical effort of my own mind? In other words, what if my mind is a machine?

While pursuing these questions, we must analyze the process of outsourcing thinking. An overview of this process reveals that first such machines were used purely as calculating machines or calculators, to supplant the rote calculation that was done before then. What followed was the creation of calculating machines whose rules of calculation could also be included within their operation, i.e., programmable machines or computers. Further, the programmable machine has served as the "nervous system" of all other machines, helping to interface several of them at once. It has thus been possible to merge the functionalities of several devices into one device, as shown in the earlier illustration about social media. Ever since then a great controversy has been raging as to whether the mental capacities of a machine are comparable to human mental capacities, or not. Currently, the computer leads technological revolutions, as every process in the world is reproduced within the computer, and the computer also generates new data never generated before.

This phenomenal success of computing has also given rise to the notion of computers "becoming conscious/self-aware" or even coming to life. In other words, life processes are seen as a combination of extremely complex mechanical interactions, and since computers perform these calculations in a fraction of a second, would it not be feasible to call a computer *alive*? These and many other related questions have cropped up in the past few decades with increasing intensity.

Essentially, the key question is regarding the thinking process itself. How *does* a human being think? Once the process is understood, it is only then that a comparison with the computer can be correctly made.

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Hence it is necessary to trace the idea of computers, or "thinking machines" as they were called earlier, until a clear view is obtained of the thought process itself. The route can be taken backwards in time as follows: Starting with social media (2000s), which involves interfacing several profiles over the Internet, one can work back to the idea of the Internet, which was first developed (from the late 1960s to the early 1990s) by several computer engineers to connect the data among universities. Since this interconnection duplicated the single computer, it is necessary to trace the development back to the inspiration for the computer. Prior to the 1960s, the milestones in this development can be outlined in the following chart:

Year	Concept	Pioneers
1945	Computer architecture Programming	John von Neumann, Grace Hopper
1937	Switching theory	Claude Shannon
1936	Computability of numbers	Alan Turing
1931	Incompletelness theorems	Kurt Gödel
1879	Symbolic Logic	Gottlob Frege, Charles Peirce
1847	Digital logic	George Boole
1670	Mathematical logic, binary numbers	Gottfried Leibniz
1642	Calculating machine	Blaise Pascal
1641	Mechanics, coordinates	René Descartes
1601	Binary codes	Francis Bacon (Lord of Verulam)

There is a gap of about 200 years leading up to the Age of Enlightenment (mid-1600s), when mechanical calculators were first developed. In the same period, philosophy played a strong role in generating these ideas, involving, for example, the beginning of mathematical logic. So the Enlightenment era, during which the first seeds for today's technology were laid, is a good place to start the analysis. Starting from this time period, one can progress forward to the present, paying attention to the developments and the pioneers who developed them. The course of the path, as well as the contribution of each pioneer, will now be analyzed, keeping in mind the relationship with the thinking process throughout the analysis.

Ideas behind "Thinking" Machines

> *For by this Art a way is opened, whereby a man may expresse and signifie the intentions of his minde, at any distance of place, by objects which may be presented to the eye and accommodated to the eare: provided those objects be capable of a twofold difference onely; as by Bells, by Trumpets, by Lights and Torches, by the report of Muskets, and any instruments of like nature. But to pursue our enterprise, when you addresse your selfe to write, resolve your inward-infolded Letter into this Bi-literarie Alphabet.* – Francis Bacon, 1623

Language is the mode used to communicate human thoughts. Hence it is essential, while studying the development of thinking processes,

Example 3. Of a Bi-literary Alphabet.

Aaaaa,	aaaab,	aaaba,	aaabb,	aabaa,	aabab,
A,	B,	C,	D,	E,	F,
aabba,	aabbb,	abaaa,	abaab,	ababa,	ababb,
G,	H,	I,	K,	L,	M,
abbaa,	abbab,	abbba,	abbbb,	baaaa,	baaab,
N,	O,	P,	Q,	R,	S,
baaba,	baabb,	babaa,	babab,	babba,	babbb.
T,	V,	W,	X,	Y,	Z.

to study the mode of their communication in every time period.

The foundation for the modern day communication device—the computer—is the binary code system, which originated in the methods for passing secrets and codes, i.e., in cryptography of the 17th century. Binary numbers as a mathematical system were explored in ancient cultures and even tribal societies while using different "bases" for a number system, such as 2, 10, 12, 16, and 60. However, it was the idea of Lord Bacon of Verulam to associate an alphabetical character to a binary code, thus bringing mathematical application into language. Base 2 was the most natural base to use, as most physical objects can be affected in that fashion, e.g., "by trumpets, by lights and torches."

Bacon's researches into cryptography brought into culmination something that had begun in several old cultures such as China, Meso-America, and Sumeria: the art of writing. During this ancient period, what was formerly transferred only via the human voice from generation to generation (before 3rd millennium BC according to historians, which marks the start of Sumeria) was engraved in tablets. This occurred in several stages. For centuries following the early stylus marks and hieroglyphs, mankind used *writing* for keeping record. In its earliest stage there was still an imprint of the writer in the particular record: the *handwriting*. It is possible to illustrate a considerable amount of variation within the way something was written down, not in content, but in form, giving rise to various styles of writing, each with its own nuance. Beauty and art played a major role in much of the earlier writing styles, as is evident when calligraphy or even hieroglyphics are studied. This can be called Stage I: the transfer from voice to script. In this stage, as one writer copied what was written down by his predecessor, individual variations in the style of writing (which was predominantly cursive) were naturally present for any particular written content.

This prevailed until the 14th century AD. The next massive variation in communication occurred at the beginning of the 15th century with the invention of the printing press. Now, the "style" of handwriting was "frozen" into the machine, and letters were split up into blocks, which could then be used to produce and infinitely reproduce a particular page. Thus, in this Stage II, individual handwriting no longer mattered. However, there was still considerable variation book to book, language to language, ink to ink, and paper to paper. In spite of the mass production, these aspects made it through.

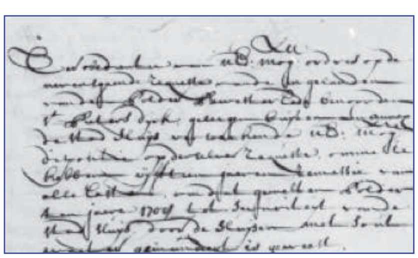
It is well known that the printing press revolutionized culture, as knowledge penetrated to the masses in a way never possible before, and "literacy" as a social concept came into being. About two centuries after the invention of the press, all personality is driven away from the expression of writing with the advent of Bacon's cipher, as each character is reduced to "on" and "off," so to speak. There can be no individual variation possible in the transfer of this code, even if a wide variety of physical objects is used for the transmission. One can light fires, shine mirrors, or bang on drums, and the net effect is the transfer of the same character from one place to another. The "paper" could vary, but there was no leeway for variation in binary code. This is Stage III, which developed later into other forms, such as Morse Code and even Braille. The transformation can be represented as shown in the diagram below.

Hence, mathematics and language became intertwined, with a mathematical construct *replacing* a letter of the language. The full effect of the individual was diluted in stages: from the unique human voice, to the varied handwriting, to the standardized letter, to the universal code.

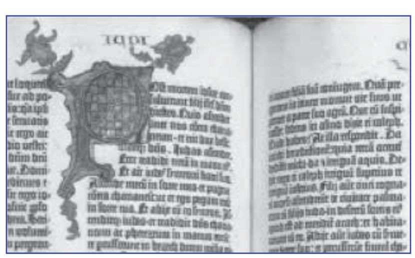
What rose up as the art of printing in the 15th century in Europe happened to be a reflection of an art developed in China in as early as the 3rd century AD. Chinese printing had advanced considerably, but was restricted in its use of movable type because of the immense complexity of its language, which was entirely unsuited for developing a large-scale process. It was in Greek, Latin, and Anglo-Saxon languages that the phonetic script allowed the best possible application of printing. Another idea of Ancient China was, however, much more amenable to an adaptation, which was carried out by the German philosopher, Gottfried Wilhelm Leibniz (1646–1716).

Leibniz, along with his contemporary Newton, is famous today mainly for developing Calculus and for developing the binary representation of digits, which he was studying for application in computing. He had a deep interest in Ancient China. He studied Chinese writings extensively and is said to have remarked to a friend in a letter, "I shall have to post a notice on my door: Bureau of Information for Chinese Knowledge." This fascination with China increased when he encountered the Hexagram arrangement of Fu Xi, which closely mirrored the binary system. Thus, he was deeply influenced by Chinese philosophy

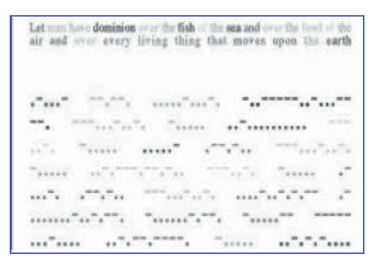
Bagua of Fu Xi



Stage I – Cursive handwriting



Stage II – Printed letter



Stage III – Binary code

in the very work that laid the foundation for modern binary computing.

Of course, Leibniz was also interested in fully functional calculating machines and had even constructed one, much like Blaise Pascal, who had designed one such machine in 1642. These machines employed the well-known system of interlocking gears to add, subtract, multiply, and divide. While Pascal's machine utilized the decimal system, Leibniz also outlined a method for a binary calculating machine:

> This type of calculation could also be carried out using a machine. The following method would certainly be very easy and without effort: a container should be provided with holes in such a way that they can be opened and closed. They are to be open at those positions that correspond to a 1 and closed at those positions that correspond to a 0. The open gates permit small cubes or marbles to fall through into a channel; the closed gates permit nothing to fall through. They are moved and displaced from column to column as called for by the multiplication. The channels should represent the columns, and no ball should be able to get from one channel to another except when the machine is put into motion. (Leibniz, *De Progressione Dyadica*, 1679)

In the case of the calculations necessary to generate extensive mathematical tables, … a mechanism certainly helps the thought process. Does this however mean that a thought process is *identical* to a mechanism?

While calculation with machines was mainly seen at the time to be an aid to repetitive mathematical work, what is more interesting is the relation to thinking that was happening at the same time. Leibniz was very interested in showing that all statements that express human thought can be represented using a symbolic method, hence forming an "alphabet of thought." He stated his ideal as follows:

> … if one could find the characters or symbols to express all our thoughts as cleanly and exactly as arithmetics expresses numbers, or as analytic geometry expresses lines, one could do the same as one can do with arithmetics and geometry, as much as they are subject to reasoning. This is because all investigations that depend on reasoning would take place through the transposition of these characters and by a kind of calculus. This would make the invention of very nice things very easy...
>
> And the characters which express all our thoughts would constitute a new language which might be written or pronounced. This language will be very difficult to make, but very easy to learn. This language would be the most powerful instrument of reason. I daresay that this would be the last effort of the human spirit, and when the project will be executed, humans will only care about being happy because they will have an instrument which will serve as much to amplify reason, as much as the telescope serves to improve the vision. (Leibniz, *Characterica Universalis*, 1677)

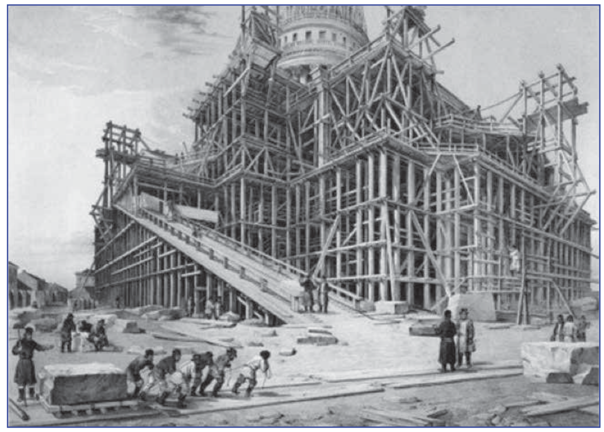
> The only way to rectify our reasonings is to make them as tangible as those of the Mathematicians, so that we can find our error at a glance, and when there are disputes among persons, we can simply say: Let us calculate [*calculemus*], without further ado, to see who is right. (Leibniz, *The Art of Discovery* Wiener 51, 1685)

Leibniz articulated the origin of a second stream of thought, one which strives to convert the reasoning or logical process into a mathematical process. These ideas indicate both the interest in representing thoughts as mathematical expressions and the ideal of a machine that enhances reasoning "as much as the telescope serves to improve the vision." Here, *thinking* and *mechanism* are closely interlinked as an ideal.

Meanwhile, French philosopher René Descartes was convinced that the world was a mechanism and everything in it followed the same laws as those found in a machine. This view saw the material Universe as a gigantic clockwork mechanism, set in motion by the Creator and continuing forever in that fashion. The laws constituted the rules of coordinate geometry and mechanics. However, Descartes believed the mind to be distinct and separate from matter, superior to the mathematical mechanism of the world, while Leibniz considered the process of the mind itself (reasoning) as a mathematical process. Here the two views of relationship of thinking to mathematics are revealed: one which views the thinking as distinct from mathematics and one which views them as being identical for all practical purposes.

This intersection of mechanism, thought, language, and its representation is the determining factor with regard to all computations of the later years. Just as Bacon's ideas were instrumental in making all writing universal and mathematical, Leibniz and Descartes concerned themselves with universal logic and universal mechanism respectively. This theme of Universality, or removal of the expression of human thoughts from the personal sphere to one governed by mathematical laws, guided the development of ideas for technology until the end of the 17th century.

In terms of philosophy, there is a substantial passage of time from these preliminary investigations of Bacon, Leibniz, and Descartes to the developments of Boolean algebra and mathematical logic of the 19th century. While this might give the *appearance* of a gap, it points once more to the aspect of *internal* development hinted at previously, where thinking itself undergoes a gradual change. To trace this internal development accurately, the thought process has to be understood in all its aspects; i.e., thought construction has to be studied next.



Thought Construction

> *Un tas de pierres cesse d'être un tas de pierres, des qu'un seul homme le contemple avec, en lui, l'image d'une cathédrale. [A rock pile ceases to be a rock pile the moment a single man contemplates it, bearing within him the image of a cathedral.]*
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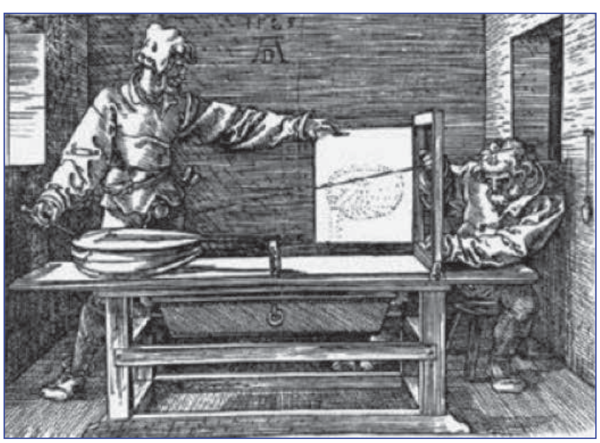
> – Antoine de Saint-Exupéry

In the previous section I described the transitions that occurred at the end of the 17th century, which served to intertwine logic and mechanisms into a system. The question naturally arises: Is thought a form of mechanism? In the case of the calculations necessary to generate extensive mathematical tables, it is clear that a mechanism certainly can support the thought process. Does this mean, however, that a thought process is *identical* to a mechanism? This is the central core of the problem, and hence has to be addressed carefully.

When considering any topic, particularly the issue of thought, it is important to realize how quickly a worldview transforms. A fact taken for granted today might not have been conceivable two centuries ago, and this is even more true today when a *concept* or idea is taken for granted. Most historical overviews find it difficult to make this transition: not only to describe events of a bygone era, but also to really *think* as the people thought at that point in time. This aspect has to be cleared up before an understanding of the thinking process itself can be undertaken.

Let us begin with some illustrations. Consider the solution of a straightforward problem: How must a drawing be created on a sheet in order to represent a 3-dimensional image? It is clear to anyone today with the slightest artistic training that it is simply a matter of drawing the farther objects proportionately smaller. It is called the use of perspective in drawing, where parallel lines appear to be meeting at a point on the horizon called the *vanishing point*. Anybody who has drawn a row of houses in their childhood knows that it is perhaps the most straightforward rule to identify and follow with respect to drawing.

However, studying the history of art reveals something astonishing: It was not until the 15th century that artists even discovered this rule, which until then had applied rough approximations of sizes in order to achieve the 3-dimensional effect. For millennia, *the mathematical laws of perspective were unknown*. In fact, once discovered, a machine with strings and weights was utilized for implementing this technique as shown in the image below.



Albrecht Dürer, *Instruction How to Measure with Compass and Straight Edge* (1525)

Numerous descriptions of perspective in art and Renaissance art include these technical descriptions, but an important question is missed. How is this enormous discrepancy possible, in something as “normal” as watching train tracks or road lines meeting at a vanishing point? Even though geometry of lines had been known and well-studied for millennia, why did one have to wait until the 15th century for artists to catch on to something that even a young child, with his eyes open, can identify? This is one question to keep in mind, as it prevents a projection of today’s ideas backwards indiscriminately, and shows that entirely different points of view (literally) existed in different time periods.

Just as worldviews change, the thinking process also changes along with it, and so it is necessary to know how thought evolved—or how it was constructed over a period of time. This change in thought process over time can be tackled by observing how the change occurs in an everyday situation. For example, consider a scenario in which a logical mathematical proof is being taught to students: The solution to quadratic equations gives two roots. Even with adult students, it is clear from the learning process that there is a big difference in solving equations before and after proving this rule. Seeing something solved is different from solving it oneself. Something that appears insurmountable previously appears easy, straightforward and logical after learning it. Similarly, mathematical rules taught in high schools today required, in the past, the best minds in mathematics to design and identify them; they had to be formulated, or constructed, for the *first* time.

In these examples there is a lot more to the thinking process than mere logic, the same concept that was earlier hinted as “inner effort.” This defines the difference between something that has been discovered already and something that has to be discovered anew. It also shows that discovery is by no means a simple process of logical extension, or many of these discoveries would have been as straightforward as drawing two straight lines to identify where they intersect. Observing numerous instances of the thinking and learning processes in people can confirm that there is a significant difference before and after a thought structure has been built up. *Before the construction of a logical sequence, effort of will is paramount, while after its construction, one can simply observe the process and find it to be logical.*

We will identify this process of inner effort as "willing," which is something joined to the activity of "thinking." It must be emphasized that these concepts are not arrived at in a theoretical fashion, but directly from the observation of the thinking process itself, something that every thinking person can verify from experience. An objection can be raised that this element of internal effort might not be real, but just a figment of imagination caused by the situation. However, the criteria being used to determine its validity is the same as that used by logic: an internal observation of truth and its external verification. As long as it can be verified that there is a difference between memorizing a concept and understanding a concept, this fact of internal effort stands on solid ground. Just as the builders of a mansion must spend an enormous amount of physical effort in constructing all the staircases and interconnected rooms, which the occupiers can then simply walk over, in the same fashion the structures of thought built by the great thinkers of one era are simply "walked over" by their descendants. If thinking were a matter of logical/intellectual connections alone, then it would be as simple to *make* a road as to *walk* on it. Reality shows otherwise; there is a large difference between the two. The factor that comes into play beyond logic is *effort*, or *will*.

What this means is that just as worldviews change, thinking process also changes along with it, and it is hence necessary to know how thought evolved, or how it was constructed over a period of time.

However, application of effort and knowledge of logic are necessary but not really sufficient in order to lay down the pathway from one idea to another. Continuing the analogy of construction, consider a railroad builder who cannot see past a mountain. In other words, he knows the laws of mechanics enough to dig a tunnel and he has the necessary manpower to get the job done; however, whether the job can really be accomplished or not cannot be determined with only these conditions. Something else more mysterious comes into play: *skill* or *feeling*. Whether gained from long experience or due to innate talent and genius, this realm of feeling is that from which the mysterious nature of *skill* manifests itself and actually completes the entire process.

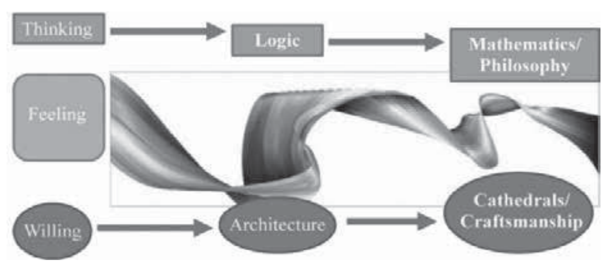
In the example above, a skilled builder would have developed a *feel* for the terrain (please note that the word is used here in a different sense from that denoting emotions alone) that would indicate whether or not the task can be done in a satisfactory way. This same skill is observed by mathematicians and engineers as well, who speak of the beauty of certain theorems and the artful way in which proofs or even machines are constructed. Thus, while the thinking process might superficially appear to be a straightforward matter of connecting one concept to another logically, the actual process is similar to the building of a cathedral. Laying one brick on another does not a cathedral make. A complete idea of the entire building (the layout), the effort necessary to build it (the manpower), and the artistic flourish that gives each cathedral its individual stamp (skill of the workers) are all necessary for the structure to stand and function.

These are hence the distinctions within the process of thinking: thinking itself, thinking

colored by willing (inner effort), and thinking colored by feeling (individual skill). Just as the strength of a building lies in its framework, and the strength of a limb is determined by the skeletal bones, the strength of a thought process lies in how well it stands up to scrutiny and verification, i.e., how it leads to a better understanding of the world. When there are inconsistencies within a structure, it has the same effect as that of a broken pillar, which cannot support the building any more. This is why it was necessary for the most vigorous efforts to be applied by many individuals in order to create a theory or a philosophy, as the thought framework had to be built. An individual who works on developing this internally consistent thought structure can be called the *Philosopher*.

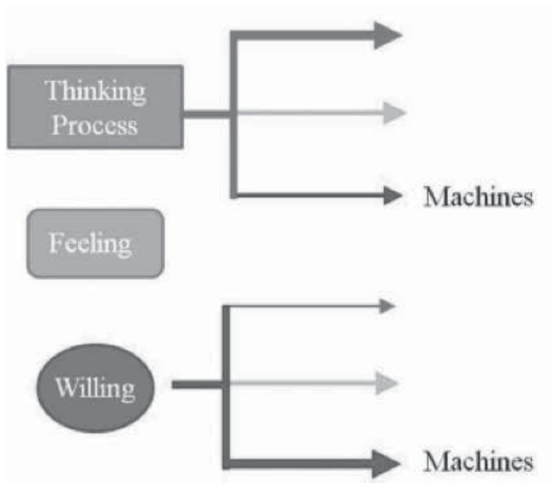
This differentiation of the thinking process also sheds light on a different approach in the development of civilization. Just as it was observed that thinking involved a feeling or nuance and also inner effort or willing, the same can be observed in the actual physical toil: the domain of willing. Someone who spends the entire day working at a construction while obeying the orders of an architect can be described as living in the action or willing alone. However, when the construction worker not only piles stone upon stone, but also has a say in the design underlying the construction, the element of thinking enters into the physical actions, which ultimately leads to the development of skill. Instead of starting with the concept or idea, this person transforms things by starting with actual building experience. This individual can be called the *Craftsman*.

The Philosopher and the Craftsman are thus the essential actors on the world stage, with the Artisan or Artist serving as a mediator between them. A Philosopher begins with thinking and merges the other aspects into it. The Craftsman begins with something tangible, with the actual building process, and merges the other aspects into this activity. They both utilize skill: an artistic Philosopher sculpts one thought to another with the same skill that an artistic Craftsman brings to the buildings. The Artisan is hence active in both the approaches. Thus, thinking, feeling, and willing are observed to be concepts which intermingle with one another, and whichever is dominant generates the mode of activity. These two parallel streams, one which took the route of philosophy and the development of thought structures (Philosopher), and the other which dealt with the building of devices, cathedrals, and temples (Craftsman), ran parallel for several centuries, with some mediation from art. One culminated in the knowledge of mathematics, while the other in practical expertise of architecture and technology. The threefold nature can be represented thus:



After the Renaissance, the two streams of Philosopher and Craftsman started merging, from which “offspring” resulted: Natural Science, Physics, Technology. Thinking and willing merged together gradually, creating new machines.

The three divisions illustrated above are not airtight boxes, but they indicate the biases within the activity of man. There is hence an overlap of each quality with the other two, i.e., thinking has aspects of feeling and willing, willing has aspects of thinking and feeling, and so forth. Since it is the element of physical toil, i.e., the *external* *effort* or physical will that gets outsourced to the machines, a similar process is to be expected for the thinking process too: the *internal effort* of thought (the will-element of thought) is likely to be outsourced to the calculating machines. This distribution can be indicated like this:



The aspect of feeling contributes to both extremes, and for the purpose of understanding the extremes better, it is kept aside for the time being. Both thought and physical action have the potential of getting outsourced. Just as various tools and devices help by multiplying the physical effort of man, there is an element of inner effort that machines, when suitably designed, may multiply as well. This was the situation at the end of the 17th century Enlightenment era when the first "aids to thought" were being constructed.

While the differentiations of thought into the willing and feeling element were perhaps not addressed clearly, thought was still not restricted to a mechanical process in this time period. Other aspects of thought life were still seen, and in fact, the ethical motivation for will power was still very clearly emphasized. For example:

> I found it appropriate to insist a bit on these considerations of final causes, incorporeal natures and an intelligent cause with respect to bodies, in order to show their use even in physics and mathematics: on the one hand, to purge the mechanical philosophy of the impiety with which it is charged and, on the other hand, to elevate the minds of our philosophers from material considerations alone to nobler meditations. (Leibniz, *Discourse on Metaphysics*, 1686)

The lives of many philosophers and mathematicians of this era were also steeped in both arts and devotional religious works (feeling and willing), which are generally discounted as irrelevant or mistaken by modern scientific researchers. For example, Newton considered his theological works to be of more importance than his scientific ones. Leonhard Euler, one of the most prolific mathematicians of all time, wrote the *Defense of the Divine Revelation against the Objections of the Freethinkers*. Blaise Pascal, discoverer of projective geometry and child prodigy in mathematics, underwent a religious conversion when he was 31 and produced works on theology. Leonardo Da Vinci is the epitome of the Artist-Craftsman, whose feats are perhaps unparalleled by any individual today.

Modern research has great difficulty in accepting that there is more to the thinking process than is commonly believed today and is especially confused with the firing of inner effort by religion. The following passage shows this clearly:

> This combination of fanatical devotion and original scientific thinking was not uncommon during the period. And such obsessive faith was no self-protective affectations of genius either. Van Helmont, Pascal, Spinoza, and Newton all considered that their religious thought was their major contribution. A curious aberration… (P. Strathern, *Mendeleyev's Dream,* 2000, p. 171)

It is neither a curious aberration nor a weird obsession, but a necessary component of the complete thinking process. It is straightforward evidence of the fact that the inspiration for inner effort—the will element—has a major role to play in the production of mathematical and philosophical works. The feeling element as well as the inner effort enhance external construction by multiplying the physical effort of man. There is an element of inner effort that machines, when suitably designed, may help complete the thought process. A study of the lives of scientists reveals this working together of the Philosopher and the Craftsman to various degrees. It also reveals mistakes in thought processes clearly through their life experiences. For example, Francis Bacon has had an enormous influence on the experimental method followed in the past two centuries, and his method of coming to generalities by way of individual instances has become famous as the Inductive Method in science. His writings on *The New Atlantis* and his descriptions of Solomon House inspired the foundation of the Royal Society. Yet, in spite of all the descriptions of experimental methods to be followed, the only experiment that Bacon ever carried out himself had ironic, unexpected results: Wondering if flesh can be preserved by refrigeration, he got out of his carriage in the snow, borrowed a chicken, and stuffed it with snow—a feat that led to an infection of pneumonia and death barely two weeks later. Once more, it shows the fallacy in the philosophy that neglects the thinking capacity of the human being and emphasizes exclusively the repetitive experimentation. The willing element of thinking, especially that relates only to repetition, dominates everything else and, hence, leads to a dead end.

The Philosopher and the Craftsman are thus the essential actors on the world stage, with the Artisan or Artist serving as a mediator between them.

However, with the introduction of the first calculators, this inner effort of repetitive thinking was outsourced to a mechanical device. Just as huge engines multiplied the efforts of men in industry, the possibility of multiplying calculating capacities also arose. Hence, the thinking process does contain an element that involves effort, and all repetitive effort can be outsourced to a machine.

This does not exhaust all that thinking can accomplish in the world. This is how the question posed at the beginning of this article can be answered: Thinking is not identical to a mechanism, but does contain elements which can be mechanized. That is the crucial idea.

As the streams of the Philosopher and the Craftsman intersected one another, several philosophical issues arose regarding the free will of man, his thoughts, and his relationship to machines. The first time the streams intersected, it gave rise to the works of Leibniz and Pascal in the area of “thinking machines” and the work of Newton in the area of natural science. After this era of Enlightenment, the streams diverged slightly for another two hundred years, when both the Philosopher and the Craftsman worked more in their own domains. The 200-year gap was filled with the discovery of numerous technological devices, and philosophy took the center stage in most of Europe of the time. When the two streams intermixed again in the second half of the 19th century, they gave rise to the field of mathematical logic for the Philosopher and that of numerous calculating machines for the Craftsman. These subjects need to be studied further, to illuminate the transformation of the thought process over the next two centuries.

[to be continued in the next issue of the *Research Bulletin*]

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