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PARADIGM SHIFTS IN COGNITION

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Abstract. This essay studies the paradigm shifts in cognition occurring in human history due to the invention of three fundamental technologies of information and communication: writing, printing, and computation. What we question is not so much the operation of specific cognitive faculties (perception, memory, imagination, understanding or reason), as much as what after Yuk Hui we can call the "condition of philosophizing" (Hui 2019, p. 47). Hence, we will inquire into the paradigm shifts in the condition of thought due to the invention of different technologies of cognition. Or put it otherwise, borrowing a notion of Gilles Deleuze (1968, pp.169 – 217), we will look into three different "images of thought": the boundaries that define what can be thought and how it can be thought.

Keywords: cognition; grammatisation; logocentrism; mechano-centrism; computational technologies; cybernetics.

In *Thumbelina* Michel Serres (2015, p. 18) tells us a parable about St. Denis, the first bishop of Paris (circa 250 AD), persecuted for his Christian faith by the Roman Emperor Decius. Executed by decapitation, he performed a miracle by climbing the top of the hill of the nowadays Montmartre while carrying his severed head in his arms. Serres then makes an analogy with the contemporary condition of human cognition.

> Not long ago, we all became like St. Denis. Our intelligent head has been externalized outside our skeletal and neuronal head. In our hands, the computer-box contains and manages what we used to call our "[cognitive] faculties": a memory thousands of times more powerful than our own; an imagination stocked with millions of icons; and a faculty of reason as well, since software programs can solve hundreds of problems that we could never solve on our own. Our head has been projected before us in an objectified cognitive box (Serres 2015, p.19).

Due to the advances of digital technologies most of human cognitive faculties, taken for granted for millennia, seem to be transferred to an external medium. An urgent question follows this observation: "After the beheading, what is left on our shoulders?" (ibid.) And immediately comes a possible answer: what we are left with is "the incandescent joy of invention." (ibid.). The sudden emptiness in place of a head full of knowledge and information, creates a gap in our capacity for cognition, which can lead to a breakthrough in the habitual forms of knowledge production and might allow entirely novel cognitive capacities to emerge.

This essay is an attempt to elucidate Serres' question by studying the paradigm shifts in cognition occurring in human history due to the invention of three fundamental technologies of information and communication: writing, printing, and computation.

We could define cognition as the ability to build coherent models of the world. A coherent model is necessary for humans to be able to make sense of the multiplicity of phenomena they encounter. Such model is necessary not only for a deeper understanding how individual phenomena function, but also how they position themselves in relation to each other, to the cognitive agent herself, and to the cosmos as a whole. Such understanding allows the cognitive agents to predict the next chain of events and thus, to know how to react to them in order to survive or achieve their goals. Hence, cognition involves the ability to recognize phenomena in their interconnectedness, to know where to place unknown phenomena in the existing model of the world and if necessary, to update that model so that it can include new knowledge that does not fit the picture.

Hence, what we will question is not so much the operation of specific cognitive faculties (perception, memory, imagination, understanding or reason), as much as what after Yuk Hui we can call the "condition of philosophizing" (Hui 2019, p. 47). Hence, we will inquire into the paradigm shifts in the condition of thought due to the invention of different technologies of cognition. Or put it otherwise, borrowing a notion of Gilles Deleuze (1968, pp. 169 – 217), we will look into three different "images of thought": the boundaries that define what can be thought and how it can be thought.

What we call technologies of cognition are technologies of grammatisation, on which the production of knowledge and consequently the building of a coherent model of the world depends. "Grammatisation" is a term used by Bernard Stiegler to designate the process of inscription of mental processes and behavioural flows (such as memory or speech, for example) onto an external material (Stiegler 2010, p. 70). As a result of this operation, thoughts and gestures are transformed from temporal and continuous flows into spatial and discrete units, subjected to logico-mathematical analysis. Inscribed into fixated form such knowledge becomes reproducible in a precise way and changes the minds of everyone, who uses the cognitive device (the book or the digital media). Apart from communicating ideas to others, these technologies also allow an additional level of self-distance from one's own thoughts and consequently, a critical reflection onto the mode of thinking itself. Once inscribed onto the surface of a paper, ideas can be analysed and scrutinised, which leads to the emergence of what we could call: meta-cognition, namely, a reflective thought about thinking, which asks how we know what we know. Hence, the consequence of technologies of inscription (writing, printing and digital) is that they enable paradigmatically new mental and behavioural models to be created. "We were never born to read. Human beings invented reading only a few thousand years ago. And with this invention, we rearranged the very organization of our brain, which in turn expanded the way we were able to think, which altered the intellectual evolution of our species." (Wolf 2008, p. 14)

The process of grammatisation has gone through several stages of evolution: writing, printing, and digital media/computation. In the following pages we will outline the specific conditions of philosophising or "images of thought" characteristic of each stage.

Writing => Logos

Preliterate societies interpret natural phenomena via mythological narrations about heroes, deities and supernatural forces and try to influence their behaviour by magical rituals. Imagination is a first step of distancing from the directness of experience, and its results are images and fables. With the invention of the technology of writing comes a fundamental shift in the conditions of thought, which leads to a different model of the world than the ancient world of magical imagination. The gesture of writing inscribes human experiences in a specifically structured way, which transforms them from images into abstract ideas. "The alphabet was invented to replace mythical speech with logical speech and so to be able, literally for the first time, to 'think'." (Flusser 2011, p. 32). Thus, script initiates the era of the *logos*. "Logos" according to its ancient Greek etymology means "ratio" (proportion) and "reason" but also "word", "discourse", and "speech". In philosophy, logos becomes a technical term indicating a principle of order, both in the realm of natural phenomena and in the realm of human knowledge. For Heraclitus, logos provides the link between rational discourse and the world's rational structure. Aristotle applies the term to refer to "reasoned discourse" or "argument from reason" and develops formal logic as a method of building arguments, which would lead to truthful statements, an *organon* for thinking. Rationality becomes the ability to form indubitable connections of ideas and to follow them to their infallible consequences.

While images work with particulars, concepts work by abstraction, ideation, and generalisation. For instance, the concept of the "human" comprises only the features which unify humans under common denominator (for instance *homo sapiens* or *animal rationale*) but excludes all features, specific to different individuals. Therefore, conceptual thinking emphasizes identities between individual objects and ignores their idiosyncrasies and uniqueness. Writing "tears our representations of the world apart to order the parts so torn into directional lines, into countable, accountable, criticisable concepts." (Flusser 2011, p. 7). Individuals subsumed under a category become analysable as discrete elements of a set.

According to Vilém Flusser, while images inscribe visual impressions into the two-dimensional code of the surface, alphabetic writing inscribes speech into the one-dimensional code of the line. Thus, the gesture of writing leads to the development of a diachronic, one-dimensional, one-directional process of linking and ordering ideas according to "linear thought sequences" (Flusser 2013, p. 10). "To write is a gesture in which the entire attention is absorbed by the effort to force thought into a series of shapes" (Flusser 2013, p. 17). This is to say, that before script have been invented, humans would be able link their ideas only in a rhizomatic and associative way. The invention of the written word, on the contrary, implies a disciplining ("violating") undirected streams of thoughts into well-ordered lines of thought. The linear code reduces the polyvalency of images toward the clarity of a one-dimensional logic. The gesture of writing, which violates thinking by imposing a linear structure upon it, creates a specific universe for thought, which would not exist without it, namely the universe of cause and effect (Flusser 2013, p.18). Contrary to the nonlinear magical model of the world based on a free play of associations between appearances, the method of causality leads to a model of the world based on scientific rationality. In the *Posterior Analytics*, Aristotle claims that each science consists of a set of first principles, which are necessarily true and can be demonstrated directly, and a set of truths, which are both logically derivable from and causally explained by the first principles. Aristotle is the first philosopher to develop a systematic theory of causality, on which truthful knowledge should be grounded. "We think we have knowledge of a thing only when we have grasped its cause" (APost. I 2, 71b 10, APost. II 11, 94a 20, quoted in Falcon 2023). Proper causal investigation demands a complete understanding of the range of possible causes which give rise to natural phenomena, as well as the systematic interrelations between these causes.

Writing gives rise not only to the emergence of causal thinking but also to the possibility of thinking the ideal objects of geometry and mathematics, a condition explicated in Husserl's *Origin of Geometry.* Unlike knowledge of descriptive sciences, which can only describe and classify the observed phenomena (Husserl 1989, p. 166), knowledge of ideal objects is apodictic (p. 179), universal (pp. 168 – 169, p. 179), objective (p.160), necessary, and eternal, "forever identically repeatable with self-evidence" (p. 166, p. 179). Ideal objects, such as a line, surface, triangle, sphere, and other geometric figures do not exist as such in nature. They are ideas of fundamental relations. For example, the Pythagorean theorem, which describes the relation between the three sides in a right-angle triangle in Euclidean geometry, is an ideal object and as such should be inferred by the formal method of deductive reasoning. Such method allows "construction of new [truthful] judgments on the basis of those already valid for us. This is the peculiar feature of logical thinking and of its purely logical self-evidences." (Husserl 1989, p. 168). Thus, by means of the formal logico-mathematical method a whole "systematic, endlessly growing stratified structure” (Husserl 1989, p. 166) of universal and coherent model of the world can be built.

Printing => Technologos (Gestell)

The logocentric tendency reaches its apogee at the next stage of grammatisation brought by the invention of the printing press. The technology of printing mechanises the way information is reproduced and thus, enhances manyfold the impact of its transmission and communication. That leads to profound transformation in the forms of cognition as well, in the production of new knowledge and in the building of a novel coherent model of the world. While in Ancient Greece the highest form of knowledge production is a theoretical contemplation of the universal principles organising the cosmos (*logos*) and deducing them from initial self-evident premises via formal logical operations, in the era of scientific revolution (16th-18th centuries) theoretical knowledge merges with technological know-how and from *logos* becomes *technologos*.

In her thoroughly researched book “The Printing Press as an Agent of Change,” Elisabeth Eisenstein elucidates how the technology of printing plays a decisive role in bringing forth the scientific revolution. According to her study, one of the crucial consequences of the mechanisation of script by typography is *standardisation* of all accumulated textual materials, which in turn promotes greater accuracy in reproducing old and sharing newly collected scientific data. Printing makes possible to compare diverse literary sources, spot corrupted data and emendate it, synchronising as a result all scientific facts, measurements, calculations, and names of botanical, astronomical, geographical and other natural phenomena. Publishers can afford hiring professional artists to draw tables, charts, diagrams, maps, and other visual aids very precisely, which then are easily reproduced in multiple identical copies. Information on maps is synchronised throughout the world, mismatches and inconsistences revised.

Standardisation leads to almost obsessive desire for organising and classifying information (Eisenstein 1979, p. 102). Most published books incorporate tables of contains, page numbers, bibliographies, cross-references, and indexes. Reference guides, atlases, dictionaries and encyclopaedia proliferate. We could say, that if script externalises the faculty of human *memory*, print externalises the faculty of *judgement*: classifying particulars under categories. With printing, the need for a methodical systematisation of all knowledge reaches a peak. (Eisenstein 1979, p. 94).

There is another motivation behind the incessant drive of the literati of the era to invent better ways for the systematisation of knowledge. The technology of printing revolutionises the way *new* scientific data is collected, which leads to unprecedented accumulation of information. According to Eisenstein, early publishers encourage the public to “feed-back” all kinds of data to them which leads to a wide collaboration between enthusiasts around the world. “Sixteenth-century editors and publishers, who served the Commonwealth of Learning, did not merely store data passively in compendia. They created vast networks of correspondents, solicited criticism of each edition, sometimes publicly promising to mention the names of readers who sent in new information or who spotted the errors which would be weeded out." (Eisenstein 1979, p. 108) As a result, "[s]o much new knowledge was amassed that it tended to create confusion" (Sarton, quoted in Eisenstein 1979, p. 111).

This overwhelming accumulation of data promotes further levels of abstraction and systematisation. Logical rationality reaches its culmination in the age of "pure reason" (see Heidegger 1993, p. 305) by being grounded in mathematical apodicticity in a more decisive manner than ever before as we see in the work of Kepler, Galileo, Newton, Leibniz and Descartes. At the turn of the 17th century Galileo proclaims that the Book of Nature is written in mathematical language. Leibniz develops his idea of *characteristica universalis*, which would render all knowledge demonstrative and allow disputes to be resolved by precise calculation (Hui 2019, p. 115). Centred on the powers of human reason and the ideal of a unified system of knowledge founded on rational principles, Leibniz and Descartes advocate the project of a universal framework of exact categories and ideas, a *mathesis universalis* (Heidegger 1993, pp. 299 – 301).

In addition to the systematic advancement of logico-mathematical reasoning, a new experimental questioning of nature is advocated by Francis Bacon, Robert Boyle, and others. Thus, classical *logos* merges with modern technology, which provides the apparatus in scientific experiments and research. As a result, modern science hypotheses are no longer about eternal laws of nature but about the results of the interaction between the experimental devices and natural systems. The instrumental reason behind this *technologos* establishes the expectation "that nature reports itself in some way or other that is identifiable through calculation and that it remains orderable as a system of information" (Heidegger 1993, p. 328). To know means to design the best scientific protocols and apparatuses to produce the expected reactions from natural phenomena. "Modern science's way of representing pursues and entraps nature as a calculable coherence of forces. Modern physics is not experimental physics because it applies apparatus to the questioning of nature. The reverse is true. Because physics, indeed already as pure theory, sets nature up to exhibit itself as a coherence of forces calculable in advance, it orders its experiments precisely for the purpose of asking whether and how nature reports itself when set up in this way." (Heidegger 1993, p. 326).

That leads to the "triumph" (Heidegger 1993, p. 435) of the scientific method and to the establishment of a new, deterministic, mechanistic, and consequently "disenchanted" (Weber) model of the world, in which not only every being could be analysed in a generalised way, but also manipulated as a decomposable resource. In "The Question Concerning Technology" Heidegger defines the *technologos* of modern science as *Gestell* (Enframing). *Gestell* signifies the condition according to which all natural beings can be gathered and ordered in a standing-reserve, as resources to be exploited. As a standing-reserve "[e]verywhere everything is ordered to stand by, to be immediately on hand, indeed to stand there just so that it may be on call for a further ordering. Whatever is ordered about in this way has its own standing. We call it the standing-reserve [*Bestand*]" (Heidegger 1993, p. 322). As a consequence, beings are correctly and objectively known only when they can be efficiently embroiled as productive resources. "[T]he energy concealed in nature is unlocked, what is unlocked is transformed, what is transformed is stored up, what is stored up is in turn distributed, and what is distributed is switched about ever anew" (ibid.). Physical systems are considered as patterns of information that can be used to produce further information and measured towards the efficacy of a goal. The danger, says Heidegger, comes not from instrumental reason as such, but from absolutizing its scientific logic and its technical modes of revealing, or in other words, from making it the ground of all thinking.

Digital technologies of computation => Cybernetic logos

So far, we have recognised two paradigms of thought: logocentrism and mechanocentrism. In the first section we discussed how script *externalised the recording* of information and facilitated the invention of the deductive method of cognition with geometry as its ground. In the second section we discussed how printing *mechanised the reproduction and transmission* of information and allowed for optimised methods of its organisation (in the forms of encyclopaedias, dictionaries, indexes and other forms of systematisation of information). The collection and analysis of information was coordinated between researchers around the globe, which stimulated the development of more advanced methods of measurement, control and manipulation of natural phenomena, founded on scientific experimentation and *mathesis universalis*.

The paradigm change we are going through in the current historical epoch started around the mid-twentieth century with the invention of digital technologies of computation. Computation optimises the *processing* of information in such a way that most of the production of knowledge becomes automatically performed by algorithmic devices outside of the human brain. While we can consider the script technology as a simple (albeit powerful) writing *tool* (pen and paper) and the printing press as a deterministic *mechanism*, computational *systemic assemblages* introduce a fundamentally new category to the evolution of the technologies of cognition. For the first time in history, we can speak of technology as cognitive, namely, capable of autonomously perform cognitive operations such as collecting data directly from the environment, analysing it via algorithms, interpreting it as patterns, communicating it to other cognitive agents, and making decisions on the basis of its own interpretations. This transforms technologies of cognition into cognitive technologies (see Hayles 2017, p. 131).

In the following paragraphs we will shed some light on the logical principle of operation which makes possible cognitive technologies, namely the *cybernetic logos*.

At the foundation of computational technologies lies cybernetic thinking (see Hui 2019). The principle of cybernetics can be summed up as follows: self-regulation driven by information and feedback. The self-regulated system could be biological, technical, cognitive, economic, cultural, social, or other. The cybernetic approach advances the organic condition of philosophising developed by Kant (Hui 2019, p.47). It aims at overcoming the mechanistic paradigm of thinking, grounded on Newtonian laws of physics and predominant in the printing era. The main difference between the organic and the mechanistic is that the organism is self-determined and emerges as a result of the relation of its parts to each other and to the whole, while, in contrast, the form and the function of the mechanism as well as of each of its parts are designed "in accordance with an idea of a whole" (Kant 2002, p. 246) by something outside of the system. Hence, the mechanism is determined externally and in advance of its construction, while the organism is self-generating and its form is emerging in the process. The mechanism works according to a linear causality with predetermined finality (A→B→C→D), while the organism works according to a nonlinear movement of recursive causality with auto-finality (A→B→C→A) (Hui 2019, p. 14). Auto-finality is a circular movement, in which the organism constantly returns back to itself in order to redefine its *telos* and itself as a whole. The new information encountered by the organism is incorporated in this process of self-projection and self-organisation (Hui 2019, p.143).

Contemporary computational systems are new species, which transcend the traditional opposition between mechanism and organism. Despite being externally designed and constructed, these cybernetic machines are unfettered by a fully predetermined mechanistic behaviour. Instead, their movement is becoming increasingly organic and they are often recognised under descriptions such as "thinking" or "living" automata. The reason for this transformation is the cybernetic logic of their behaviour, which abides by the recursive dynamics of information and feedback (see also Wiener 1948). "*Feedback* here means *reflection*, a circularity between a being and its environment, a nonlinear movement of self-adjustment toward a purpose or *telos* that defines the whole" (Hui 2019, p.123; emphasis in the original). According to Yuk Hui cybernetic thinking "constitutes a new epistemology" (ibid.), which facilitates not only the invention of new scientific methods and approaches to knowledge, but a new model of the world.

There are two species of computational systems: the classical Turing machine and machine learning algorithmic systems. The former are general-purpose devices programmed to carry out a set of logical operations automatically, according to well-defined rules. Most computer programs subsume under this category. Even if they work according to a recursive movement (the function repeats itself as many times as necessary), their steps are designed in advance and they are programmed to halt once they reach a desired outcome. This is what Hui (2019, p. 14) calls cybernetic machines with predetermined finality.

Machine learning algorithms, however, are intriguing species. They are increasingly capturing the popular imagination under the name of ‘artificial intelligence’ (AI). These are complex algorithmic systems operating on the principle of machine learning. Machine learning is a nonlinear recursive movement, which is only partly pre-programmed in advance. Using various statistical methods such algorithmic systems are capable of autonomously process a given dataset and abstract the general patterns, which describe the behaviour or the correlation between the individual data units. Moreover, when they process new information, machine learning algorithms not only provide an outcome (abstract generalisation in the form of a pattern or regularity), but are capable of modifying their own *modus operandi*. Simply said, while processing external data such computational systems constantly rewrite their own program. That makes them adaptive systems, effectively working toward self-organisation. Therefore, unlike classical programming which automates formal logical operations, “[m]achine learning automates automation itself” (Domingos 2015, pp. 9 – 10).

Having gained some basic understanding of the foundational principle behind computational technologies, let us discuss now how they transform our idea of cognition and the very process of producing new knowledge.

One of the epistemological consequences brought by digital technologies is the way they have expanded the range of scientific methods. Algorithms are mobilised in all branches of science, medicine, legal and economic systems for processing the enormous amount of data accumulated via measuring devices integrated in our interior and exterior environments (molecular, biological, cosmic, and virtual). By applying various statistical strategies, they find regularities in the data which are inaccessible to the traditional cognitive approaches. Computer simulation, on the other hand, is a new scientific tool, which allows scientists to represent, understand and predict the behaviour of dynamic systems and processes, such as climate change, biological systems or other unimaginable in their scale and complexity phenomena, indicated by Timothy Morton (2013) as “hyperobjects”.

Moreover, various algorithmic systems are ubiquitously distributed throughout the whole planet. Connected via satellites they become *ecological*, that is to say, they become cognitive *environments* in which all beings are turned into digital data to be calculated and interpreted by algorithms. These “smart” environments stack over each other creating multiple layers of feedback loops between human and machine cognition. Thus, automatic cognition becomes the milieu in which human cognition operates and which outlines the “image of thought” of our epoch – namely, the artificial boundaries, which limit what could and could not be thought.

Conclusive remarks

I would like to conclude this essay by quoting a Facebook post, written by Ivette Granata, media artist and university professor of media art at the University of Michigan. The post is triggered by the increasing hype around ChatGPT, a publicly accessible AI software for generating texts.

> "I am not interested in developing methods to police students in order to prevent them from using AI generators. I am concerned about them handing over their voice to the artificial boundaries of a machine. I am concerned that instead of learning how to exercise their voice, they will learn how to silence it. That they will curl up into the warm test-tube of AI, training themselves to go to sleep among the political nightmares of the present and future. I worry that they will learn to comply with the restrictions of language generators, slowly building boundaries upon their own thought. Until it is too late. I'm not against AI in general – so long as books are not being banned, journalists are not being killed, and the kids still learn that their voice is a weapon to sharpen." (Ivette Granata, Facebook post from 15th of December 2022)

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