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Instrumental Reason, Algorithmic Capitalism, and the Incomputable

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Algorithmic cognition is central to today's capitalism. From the rationalization of labor and social relations to the financial sector, algorithms are grounding a new mode of thought and control. Within the context of this *all-machine phase* transition of digital capitalism, it is no longer sufficient to side with the critical theory that accuses computation to be reducing human thought to mere mechanical operations. As information theorist Gregory Chaitin has demonstrated, incomputability and randomness are to be conceived as very condition of computation. If techno-capitalism is infected by computational randomness and chaos, the traditional critique of instrumental rationality therefore also has to be put into question: the incomputable cannot be simply understood as being opposed to reason.

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In the September 2013 issue of the journal *Nature*, a group of physicists from the University of Miami published the article “Abrupt rise of new machine ecology beyond human response time.” In the article, they identified a transition to “a new all-machine phase” (Johnson et al. 2013) of financial markets, which coincided with the introduction of high frequency stock trading after 2006. They argued that the sub-millisecond speed and massive quantity of algorithm-to-algorithm interactions exceeds the capacity of human interactions. Analyzing the millisecond-scale data at the core of financial markets in detail, they discovered a large number of sub-second extreme events caused by those algorithms, whose proliferation they correlated with the financial collapse of 2008.

In this new digital environment of trading, algorithmic agents make decisions faster than humans can comprehend. While it takes a human at least one full second to both recognize and react to potential danger, algorithms or bots can make a decision on the order of milliseconds. These algorithms form “a complex ecology of highly specialized, highly diverse, and strongly interacting agents” (Farmer and Skouras, 2011), operating at the limit of equilibrium, outside of human control and comprehension.

The argument I develop here takes this digital ecology of high-frequency trading algorithms as a point of departure. Thus, my text is not specifically concerned with the analysis of the complex financial ecology itself, but aims more directly to discuss a critique of automated cognition in the age of algorithmic capitalism. For if financial trading is an example of a digital automation that is increasingly autonomous from human understanding, this system has become *a second nature*. Therefore it seems to be urgent today to ask: What is the relation between critical thought vis-à-vis those digital ecologies?

My question is: Can the critique of instrumental rationality—as addressed by Critical Theory—still be based on the distinction between critical thinking and automation? Can one truly argue that algorithmic automation is always already a static reduction of critical thinking? By answering these questions, we cannot overlook an apparent dilemma: Both, philosophical thought and digitality, rely on principles of indetermination and uncertainty while featuring these principles in their core complexity theories. As such, both challenge and define the neoliberal order at the same time—a paradox.

To question this paradox, I will turn to the notion of incomputability as theorized by computer scientist Gregory Chaitin, who contributed to the field of algorithmic information theory in his discovery of the incomputable number Omega. This number has a specific quality: it is definable but not computable. In other words, Omega defines at once a discrete and an infinite state of computation occupying the space between zero and one. From a philosophical perspective, the discovery of Omega points to a process of determination of indeterminacy involving not an a priori structure of reasoning but more importantly a dynamic processing of infinities in which results are not contained in the logical premises of the system.

This centrality of the incomputable in information theory, I suggest, brings not only the philosophical critique of technical rationalization into question, but also the instrumentalization of reason. Thus, in the following text I argue that it is no longer sufficient to side with the critical view of technoscience on the basis that computation reduces human thought to mere mechanical operations. Instead, the paradox between realist philosophy and the realism of technocapital can be read as a symptom of an irreversible transformation in the history of critical thought in which the incomputable function of reason has entered the automated infrastructure of cognition.

The Algorithms of Cognitive and Affective Capital

Capital has been said to have entered all aspects of personal and social life. Before explaining the question of the incomputable in algorithmic automation, it is important to point out that with the so-called technocapitalist phase of real subsumption, digital automation has come to correspond to cognitive and affective capital. With this, the logic of digital automation has entered the spheres of affects and feelings, linguistic competences, modes of cooperation, forms of knowledge, as well as manifestations of desire. Even more, human thought itself is said to have become a function of capital. Our contemporary understanding of this new condition in terms of "social capital," "cultural capital," and "human capital" explains that knowledge, human intelligence, beliefs, and desires have only instrumental value and are indeed a source of surplus value. In this automated regime of affection and cognition, capacities are measured and quantified through a general field defined by either money or information. By gathering data and quantifying behaviors, attitudes, and beliefs, the neoliberal world of financial derivatives and big data also provides a calculus for judging human actions, and a mechanism for inciting and directing those actions.

Paradoxically, in the time when "immaterial labor" is privileged over material production (Hardt and Negri 2000), and when marketing is increasingly concerned with affective commodities such as moods, lifestyles, and "atmospheres" (Biehl-Missal 2012), capitalist realism seems to be fully expressed (Fisher 2009), guided by the findings of cognitive psychology and philosophy of mind. Central to these findings is the plasticity of the neural structure as well as the extension of cognitive functions—from perception to the capacity to choose and to judge—through algorithm-based machines. It is not difficult to see that nowadays the social brain is nothing else than a machine ecology of algorithmic agents.

A different aspect is discussed by Stiegler's view of technocapital. He sees thinking and feeling as the new motors of profit, which are repressed or captured by capital and transformed into mere cognitive and sensory functions (2014). In other words, technocapital is what denies desire and knowledge, reason and sensation. Instead, it reduces these potentialities to mere probabilities determined by the binary language of yes and no, zero and one. Exploring this further, Lazzarato (2012) has argued that a critique of technocapital can focus neither on the capitalization of cognition nor its automation. In *The Making of the Indebted Man*, Lazzarato (2012) maintains that knowledge exercises no hegemony over the cycle of value, because knowledge (and thus thought) is primarily subject to the command of financial capital. Here, the neoliberal form of capital in its current phase of real subsumption corresponds to the production of a new condition: the general indebtedness. This form of neoliberalism governance has entered all classes, even those that do not own anything. Hence, the most universal power relationship today is that of debtor and creditor. Debt is a technology of government sustained by the automated apparatus of measuring and evaluation (credit reports, assessments, databases, etc.). Lazzarato understands this axiomatic regime in terms of a semiotic logic, whose core scientific paradigm and technological applications are always already functioning to capture (by quantifying in values) primary aesthetic potentials.

From this perspective, automation is the semiotic logic par excellence, which does not simply invest labor and its cognitive and affective capacities, but more specifically becomes a form of governmentality, which operates algorithmically to reduce all existence to a general form of indebtedness. This algorithmic form of governability is also what has given way to a diffused financialization of potentialities through which aesthetic life is constantly quantified and turned into predictable scenarios.

Not only Lazzarato, also Massumi (2007) has noted the diffused ecological qualities of this new form of algorithmic governmentality, which he describes in terms of *pre-emption*, a mode of calculation of potential tendencies instead of existing possibilities. The calculation of potentialities that describe this dynamism is no longer based on existing or past data. Instead it aims at calculating the unknown as a relational space by measuring the interval between one existing data and another. This form of pre-emptive calculus indeed transforms the limit point of this calculation—infinities—into a source of capitalization.

From this standpoint, one can suggest the following: Contrary to the logic of *formal subsumption,* which corresponds to the application of unchanging sets of rules, whose linearity aimed to format the social according to pre-ordained ideas, *the logic of real subsumption* coincides with the interactive computational paradigm. This paradigm is based on the responsive capacities of learning, openness, and adaptation defining human-machine interaction as well as distributed interactive systems. With the extension of quantification to the indetermination of the environments—and thus to contingency—an intrinsic transformation of the logic of calculation has happened. In fact, the development of this interactive approach has been crucial to the now dominant form of real subsumption.

Historically, interactive algorithms were invented to circumvent the algorithmic constraints of the Turing Machine. The concept of this machine was insufficient or unable to cope with the complexity of the empirical world—a complexity that one could say, philosophically speaking, has its own nonrepresentational logic. Here, the advance of real subsumption cannot be isolated from the emergence of a dynamic form of automation, which constitutes a historical development in computer science from Turing's algorithmic modeling. Back then, Turing's conceptualization of a mechanism, which is based on a priori instructions, strongly resonated with a mechanism as defined by first order cybernetics (a closed system of feedback). Today, the combination of environmental inputs and a posteriori instructions proposed by the interactive paradigm embrace second order cybernetics and its open feedback mechanisms. The goal of this new dynamic interaction is to include variation and novelty in automation to enlarge the horizon of calculation, and to include qualitative factors as external variables within its computational mechanism.

Contrary to Lazzarato's critique, it seems important not to generalize automation as being always already a technocapitalist reduction of existential qualities. The task is rather to address the intrinsic transformation of the automated form of neoliberal governability and to engage closely with the question of the technical. However, rather than arguing that the technical is always already a static formal frame, delimited by its binary logic, I suggest that there is a dynamic internal to the system of calculation. If so, it is necessary to engage with the real possibility of a speculative question that according to Isabelle Stengers (2010 and 2011) is central to the scientific method: What if automation already shows that there is a dynamic relation intrinsic to computational processing between input data and algorithmic instructions, involving a non-linear elaboration of data? What if this dynamic is not simply explainable in terms of its a posteriori use, i.e., once it is either socially used or mentally processed?

The interactive paradigm concerns the capacity of algorithms to respond and to adapt to its external inputs. As Deleuze (1992) already foresaw, an interactive system of learning and continuous adaptation is at the core of the logic of governance driven by the variable mesh of continuous variability. Here, the centrality of capitalism in society forces axiomatics to open up to external outputs, constituting an environment of agents through which capital's logic of governance increasingly corresponds to the minute investment in the socius and ultimately life variations. The question of the undecidable proposition is important, because it defines an immanent and not transcendent view of capital, as Deleuze and Guattari (1987) remind us. This is the case in so far as the extension of capital to life requires its apparatus of capture to be open to contingencies, variations and unpredictable change.

It is here that the organizational power of computation needs to be more closely investigated to clarify the transformation that automation itself has undergone with the re-organization of capital from formal to real subsumption. Interactive automation of cognition and affection should be examined anew. Whether we are faced with the critical conception of cognitive capital, or with the critical view of an automated governance based on a general indebtedness, we risk overlooking what can be considered the most radical process of artificialization of intelligence that human history has ever seen; this involves the conversion of organic ends into technical means, whose consequences are yet to become unpacked.

Although my thoughts are still in an early phase, I want to consider the possibility of theorizing that algorithmic automation heralds the realization of a second nature, in which a purposeless and impersonal mode of thought tends to supplant the teleological finality of reason, echoed by Kant's conception of reason in terms of motive—i.e., the reason behind the action—that substantiates the difference between understanding and reason. This is also a proposition, which more importantly works to challenge the theory that there is a mutual relation or undecidable proposition between philosophy and technology as well as between thought and capital. Instead of the idea that the refuge of thought and of philosophy from an increasingly dynamic technocapitalism lies in the ultimate appeal to intellectual intuition and affective thought as the safe enclaves of pure uncertainty and singularity, I want to pursue the possibility that algorithmic automation—as rule-based thought—may rather be indifferent to these all too human qualities, whilst actively encompassing them all without representing philosophical and or critical thought. This is a proposition for the emergence of an algorithmic mode of thought that cannot be contained by a teleological finality of reason, which characterizes both capitalism and the critique of technocapitalism.

The Turing Experiment and the Omega Number

As we know, algorithmic automation involves the breaking down of continuous processes into discrete components, whose functions can be constantly reiterated without error. In short, automation means that initial conditions can be reproduced ad infinitum. The form of automation that concerns us here was born with the Turing Machine: an absolute mechanism of iteration based on step-by-step procedures. Nothing is more opposed to pure thought—or "the being of the sensible" as Deleuze (1994: 68) called it—than this discrete-based machine of universal calculation. The Turing architecture of pre-arranged units that could be interchangeably exchanged along a sequence is effectively the opposite of an ontogenetic thought moving through a differential continuum, through intensive encounters and affect.

Nevertheless, since the 1960s the nature of automation has undergone dramatic changes as a result of the development of computational capacities of storing and processing data. Previous automated machines were limited by the amount of feedback data. Now algorithmic automation is designed to analyze and compare options, to run possible scenarios or outcomes, and to perform basic reasoning through problem-solving steps that were not contained within the machine's programmed memory. For instance, expert systems draw conclusions through search techniques, pattern matching, and web data extraction, and those complex automated systems have come to dominate our everyday culture, from global networks of mobile telephony to smart banking and air traffic control.

Despite this development, much debate about algorithmic automation is still based on Turing's discrete computational machine. It suggests that algorithmic automation is yet another example of the Laplacian view of the universe, defined by determinist causality (see Longo 2000 and 2007). But in computational theory, the calculation of randomness or infinities has now turned what was defined as incomputables into a new form of probabilities, which are at once discrete and infinite. In other words, whereas algorithmic automation has been understood as being fundamentally Turing's discrete universal machine, the increasing volume of incomputable data (or randomness) within online, distributive, and interactive computation is now revealing that infinite, patternless data are rather central to computational processing. In order to appreciate the new role of incomputable algorithms in computation, it is necessary to make a reference to the logician Kurt Gödel, who challenged the axiomatic method of pure reason by proving the existence of undecidable propositions within logic.

In 1931, Gödel took issue with Hilbert's meta-mathematical program. He demonstrated that there could not be a complete axiomatic method, not a pure mathematical formula, according to which the reality of things could be proven to be true or false (see Feferman 1995). Gödel's incompleteness theorems explain that propositions are true, even though they cannot be verified by a complete axiomatic method. Propositions are therefore deemed to be ultimately undecidable: They cannot be proven by the axiomatic method upon which they were hypothesized. In Gödel's view, the problem of incompleteness, born from the attempt to demonstrate the absolute validity of pure reason and its deductive method, instead affirms the following: No a priori decision, and thus no finite sets of rule, can be used to determine the state of things before things can run their course.

Turing encountered Gödel's incompleteness problem while attempting to formalize the concepts of algorithm and computation through his famous thought experiment, now known as the Turing Machine. In particular, the Turing Machine demonstrates that problems are computable, if they can be decided according to the axiomatic method.[1] Conversely, those propositions, which cannot be decided through the axiomatic method, will remain *incomputable*.

By proving that some particular functions cannot be computed by such a hypothetical machine, Turing demonstrated that there is not an ultimate decision method of the guise that Hilbert had wished for. The strength of Turing's proposition is that his Turing Machine offered a viable formalization of a mechanical procedure. Instead of just crunching numbers, Turing's computing machines—and indeed contemporary digital machines that have developed from them—can solve problems, make decisions, and fulfill tasks; the only provision is that these problems, decisions, and tasks are formalized through symbols and a set of discrete and finite sequential steps. In this respect, Turing's effort can be seen as a crucial step in the long series of attempts in the history of thought geared towards the mechanization of reason.

However, what is more important is how the limit of computation and thus of the teleological finality of reason—automated in the Turing machine—have been transformed in computer science and information theory. Here, the work of mathematician Gregory Chaitin (2004, 2006, and 2007) is particularly symptomatic of this transformation as it explains what is at stake with the limits of computation and the development of a dynamic form of automation. Distinguishing this transformation from the centrality of the interactive paradigm in technocapitalism is crucial. This paradigm, born from the necessity to include environmental contingencies in computation, mainly works to anticipate or pre-empt response (as Massumi 2007 has clearly illustrated). Instead, and more importantly for me and my proposition of algorithmic automation as a mode of thought, it is a serious engagement with the function that incomputable data play within computation. To make this point clearer, I will have to explain Chaitin's theory in greater detail.

Chaitin's algorithmic information theory combines Turing's question of the limit of computability with Shannon's information theory demonstrating the productive capacity of noise and randomness in communication systems, to discuss computation in terms of maximally unknowable probabilities. In every computational process, he explains, the output is always greater than

1 See Turing 1936. For further discussion of the intersections of the works between Hilbert, Gödel and Turing, see Davis 2000.

the input. For Chaitin, something happens in the computational processing of data, something that challenges the equivalence between input and output, and thus the very idea that processing always leads to an already pre-programmed result. This something is, according to Chaitin, *algorithmic randomness*. The notion of algorithmic randomness implies that information cannot be compressed into a smaller program, insofar as between input and output an entropic transformation of data occurs, which results in a tendency of these data to increase in size. From this standpoint, the output of the processing does not correspond to the inputted instructions, and its volume tends in fact to become bigger than it was at the start of the computation. The discovery of algorithmic randomness in computational processing has been explained by Chaitin in terms of *the incomputable*: increasing yet unknown quantities of data that characterize rule-based processing.

Chaitin calls this algorithmic randomness Omega (the last letter of the Greek alphabet refers to the probability that this number is infinite). Chaitin's investigation of the incomputable reveals in fact that the linear order of sequential procedures (namely, what constitutes the computational processing of zeros and ones) shows an entropic tendency to add more data to the existing aggregation of instructions established at the input. Since this processing inevitably includes not only a transformation of existing data into new inputs, but also the addition of new data on top of what already was pre-established in the computational procedure, it is possible to speak of an internal dynamic to computation.

From this point of view, computational processing does not mainly guarantee the return to initial conditions, nor does it simply include change derived from an interactive paradigm based on responsive outputs. This is because Chaitin's conception of incomputability no longer perfectly matches the notion of the limit in computation (i.e., limit for what is calculable). Instead, this limit as the incomputable is transformed: It becomes the addition of new and maximally unknowable algorithmic parts to the present course of computational processing; these parts are algorithmic sequences that tend to become bigger in volume than programmed instruction and to take over, hereby irreversibly transforming the pre-set finality of rules. Chaitin's re-articulation of the incomputable is at once striking and speculatively productive. What was conceived to be the external limit of computation (i.e., the incomputable) in Turing, has now become internalized in the sequential arrangement of algorithms (randomness works within algorithmic procedures).

At Chaitin's own admission, it is necessary to see algorithmic randomness as a continuation of Turing's attempt to account for indeterminacy in computation. Whereas for Turing there are cases in which finality cannot be achieved, and thus computation—*qua* automation of the finality of reason—stops when the incomputable begins, for Chaitin computation itself has an internal margin of incomputability insofar as rules are always accompanied and infected by randomness. Hence, incomputability is not simply a break from reason, but rather reason has been expanded beyond its limits to involve the processing of maximally unknown parts that have no teleological finality. To put it in other terms, automation is now demarcated by the incomputable, the unconditional of computation. Importantly, however, this challenges the view that computational processing corresponds to calculations leading to pre-programmed and already known outputs. Instead, the limits of automation—that is the incomputable—have become the starting point of a dynamism internal to computation, which exceeds the plan for technocapital's instrumentalization of reason. From this standpoint, relating Chaitin's findings to the positioning of critical thought and technocapitalism reveals a new aspect: the incomputable cannot be simply understood as being opposed to reason. In other words, it is not an expression of the end of reason and cannot be explained according to the critical view that argues for the primacy of affective thought.

According to Chaitin, the incomputable demonstrates the shortcomings of the mechanical view of computation, according to which chaos or randomness is an error within the formal logic of calculation. But incomputables do not describe the failure of intelligibility versus the triumph of the incalculable—on the contrary. These limits more subtly suggest the possibility of a dynamic realm of intelligibility, defined by the capacities of incomputable infinities or randomness, to infect any computable or discrete set. In other words, randomness (or the infinite varieties of infinities) is not simply outside the realm of computation, but has more radically become its absolute condition. And when becoming partially intelligible in the algorithmic cipher that Chaitin calls Omega, randomness also enters computational order and provokes an *irreversible revision of algorithmic rules* and of their teleological finality. It is precisely this new possibility for an indeterminate revision of rules, driven by the inclusion of randomness within computation, that reveals dynamics within automated system and automated thought. This means the following: While Chaitin's discovery of Omega demonstrates that randomness has become intelligible within computation, incomputables cannot, however, be synthesized by an a priori program or set of procedures that are in size smaller than them. According to Chaitin, Omega corresponds to discrete states that are themselves composed of infinite real numbers that cannot be contained by finite axioms.

What is interesting here is that Chaitin's Omega is at once intelligible yet non-synthesizable by universals, or by a subject. I take it to suggest that computation—*qua* mechanization of thought—is intrinsically populated by incomputable data, or that discrete rules are open to a form of contingency internal to algorithmic processing. This is not simply to be understood as an error within the system, or a glitch within the coding structure, but rather as a part of computation. Far from dismissing computation as the evil incarnation of technocapitalist instrumentalization of reason, one realizes that incomputable algorithms emerge to defy the superiority of the teleological finality of reason, but also of sensible and affective thought.

Speculative Computation

It would be wrong to view this proposition that incomputables define the dynamic form of automation with naïve enthusiasm. Instead, it is important to address algorithmic automation without overlooking the fact that the computation of infinity is nonetheless central to the capitalization of intelligible capacities—even in their automated form. My insistence that incomputables are not exclusively those non-representable infinities, which belong to the being of the sensible, is indeed a concern, with the ontological and epistemological transformation of thought in view of the algorithmic function of reason. Incomputables are expressed by the affective capacities to produce new thought, but more importantly reveal the dynamic nature of the intelligible. Here, my concern is not an appeal to an ultimate computational being determining the truth of thought. On the contrary, I have turned to Chaitin's discovery of Omega, because it radically undoes the axiomatic ground of truth by revealing that computation is an incomplete affair, open to the revision of its initial conditions, and thus to the transformation of truths and finality. Since Omega is at once a discrete and infinite probability, it testifies to the fact that the initial condition of a simulation—based on discrete steps—is and can be infinite. In short, the incomputable algorithms discovered by Chaitin suggest that the complexity of real numbers defies the grounding of reason in finite axiomatics and teleological finality.

From this standpoint, several thoughts unfold. I agree that the interactive paradigm of technocapitalism already points to a semi-dynamic form of automation, which has enslaved the cognitive and affective capacities and established a financial governmentality based on debt. But beyond this, there still remain further questions regarding the significance of algorithms.

If we risk confusing the clear-cut opposition between digitality and philosophy (Galloway 2013), what and how are algorithms? For now, I want to point out that algorithms, this dynamic form of reason, rule-based and yet open to be revised, are not defined by teleological finality, as impersonal functions transform such finality each time. This is not to be conceived as a mere replacement or extension of human cognitive functions. Instead, my point is that we are witnessing the configuration of an incomputable mode of thought that cannot be synthesized into a totalizing theory or program. Nonetheless, this thought exposes the fallacy of a philosophy and critical thought, which reduces computation to an inferior mechanization of reason, destined to mere iteration and unable to change its final directions.

Here, my argument was mainly concerned with the critique of computation as the incarnation of the technocapitalist instrumentalization of reason. It was an attempt at suggesting the possibility that algorithmic automation coincides with a mode of thought, in which incomputable or randomness have become intelligible, calculable but not necessarily totalizable by technocapitalism. Despite all instrumentalization of reason on behalf of capitalism, and despite the repression of knowledge and desire into quantities, such as tasks, functions, aims, there certainly remains an inconsistency within computation. This is the case insofar as the more it calculates, the more randomness (patternless information) it creates, which exposes the transformative capacities of rule-based functions. In the algorithm-to-algorithm phase transition that most famously characterizes the financial trading mentioned at the beginning of this essay, it is hard to dismiss the possibility that the automation of thought has exceeded representation and has instead revealed that computation itself has become dynamic.

To conclude I want to add this: dynamic automation cannot be mainly explained in terms of a necessary pharmacological relation between philosophy and technology, knowledge, and capital, or the conditional poison allowing for a mutual reversibility defined by a common ground as Stiegler (2014) does. Similarly, one has to admit that the dynamic tendencies at the core of algorithmic automation are not simply reducible to the technocapitalist logic of semiotic organization declared by Lazzarato (2012) or to the exploitation/repression of the cognitive-creative functions of thought.

The challenge that automated cognition poses to the post-human vision—that thought and technology have become one, because of technocapitalism—points to the emergence of *a new alien mode of thought*, able to change its initial conditions and to express ends that do not match the finality of organic thought. This also means that the algorithm-to-algorithm phase transition does not simply remain another example of the technocapitalist instrumentalization of reason, but more subtly reveals a realization of a second nature in the form of a purposeless and automated intelligence. If algorithmic automation no longer corresponds to the execution of instructions, but to the constitution of a machine ecology infected with randomness, then one can suggest that neither technocapitalism nor the critique of technocapitalism can contain the tendency of the automated processing of randomness to overcome axiomatic truths.

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