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Technics as a Machine of Thought: How Simondon Thinks through Cybernetics

La técnica como máquina de pensamiento: ¿Cómo piensa Simondon a través de la cibernética?

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Abstract

Technics, the technical operation, is broadly regarded as a production or modification of objects and processes. I argue that Simondon's thinking paves the way to conceive technics not merely as a producing machine of things but also as a machine of thought, a production of schemas of intelligibility which can be eventually universal. As a way to understand this idea, the key passage from the energetic conception of thermodynamics to the informational conception of cybernetics is addressed, with special attention to the notion of noise. As a result, we will see that Simondon does not only construct one of the most original philosophies of technics of the 20th century but that his philosophy is, at its core, a technical philosophy.

Keywords: Simondon. Philosophy of technics. Cybernetics. Information theory.

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Resumen

La técnica, la operación técnica, es usualmente entendida como una producción o modificación de objetos y procesos. Aquí defendemos que Simondon abre la puerta a la consideración de la técnica no solamente como una máquina productora de cosas sino también como una máquina de pensamiento, como la producción de esquemas de inteligibilidad que eventualmente pueden ser universales. Para comprender esta idea, se aborda la transición clave desde la concepción energética de la termodinámica a la concepción informacional de la cibernética, prestando una atención especial a la noción de ruido. Como resultado, veremos que Simondon no sólo construye una de las filosofías de la técnica más originales del siglo XX sino que su filosofía es, en su centro, una filosofía técnica.

Palabras clave: *Simondon. Filosofía de la técnica. Cibernética. Teoría de la información.*

Introduction: how can we write about Simondon today

It is no longer possible to write about Simondon the same way as in the past. This idea, which can be obvious regarding any thinker whose philosophy has been discovered progressively, is especially apparent in the case of Simondon's philosophy. It must be clarified, first of all, in which temporal horizon are we situated when I say "today". We find an author whose only works published during his life are the two Theses (ILFI and MEOT) elaborated in order to obtain his Doctorate of State in 1958. Furthermore, ILFI was published by parts, partially mutilated and its original structuration was not respected until 2013's new French reedition of the whole work. These two works constitute, apart from some conferences and supplements, the only texts by the author that we knew until 2004. Although Simondon's philosophy was rediscovered in France and gradually abroad since 1989 (see Chatelet (ed.), 1994 as an example), the access to his thought, to his *operation of thinking*, has known a profound change twenty years ago, when Simondon's daughter, Nathalie Simondon, assumes the task of publication of Simondon's courses and conferences (Simondon, 2004; 2005b; 2006; 2008; 2010) and specially ten years ago, when all the preserved Simondon's writings began to be published (Simondon, 2014; 2015; 2016; 2018).

When we only had the two works of the Thesis available, the range of interpretations of his philosophy was wide but limited. There was a general impression according to which Simondon had built a new philosophy of nature that included the physical and biological domains and, breaking with certain divisions, a "psycho-collective" domain. This shared view agrees, quite unanimously, to point out that the radical novelty of Simondon's philosophy lies in a displacement. of the question of individuation from an ontological perspective – in which one starts from the individual as an already constituted reality – towards an ontogenetic one – in which one starts from the process of genesis through which the individual is constituted. Thus, Simondon builds a processual philosophy of nature that breaks not only with the substantialist perspectives dominant in much of the Western philosophical tradition, but also with certain assumptions present in the alternative process philosophies that reject this substantialist perspective, which can be summarized as the idea of the dissolution of the individual as a stable fiction in the supposed real process of becoming. In this sense, Simondon does not deny at all the reality of a stable structure of the individual, its internal ontological consistency. What he does is to place this structure in a process of genesis where it appears as the product of an operation and the structures thus produced – which are stable and real – remain likewise open to new transformations (even metamorphosis or dissolutions) through new operations.

The other side of the novelty of this philosophy of nature lies in his commitment to a strong form of relational ontology. If the individual, its structure, is the product of an operation, Simondon holds that this operation is basically a relation through which previously disconnected heterogeneous realities are put into communication; the activity or operation of relation gives meaning to the heterogeneity of these realities by creating a new dimension in which all their differences and nuances are not only integrated but used as a productive power of something new, namely the structure discovered and invented through this process. Therefore, there is no reality of the individual prior to or independent of the relation. Being an individual consists of operating a relation or, saying it otherwise, the individual is a problem-solving activity.

In this primitive interpretation of his thought, it was considered, *on the other hand*, that Simondon builds an original philosophy of technics which represents a true novelty with respect to the philosophical takes on the technical reality developed so far. His rejection of the prevailing separation between culture and technics, between knowing and doing, and his peculiar style of carrying out a philosophical reflection on technics *from within the technical reality itself*, results in the consideration of a "mode of existence" proper to technical objects. What is even more interesting, he offers an analysis, sometimes quite detailed, of the evolution of elements, objects and technical ensembles, that is, the idea that there is an intrinsic technicity whose evolution, even though may be affected by external conditions (social, economic, aesthetic), responds to strictly technical parameters. The existence of two aspects of Simondon's thought corresponding to his two Thesis – a processual philosophy of individuation and an ontology of technics – was somehow accepted. This view raised the question, already in his first systematic interpreters (Combes, 1999; Barthélémy, 2005a; 2005b), about the possible unity of his work.

One main objective here is to show that there is no such division in Simondon's philosophy, whether understood in a philosophical, methodological or programmatic sense. If we try to delve into the individuation of Simondon's thinking, it can be seen that there is not a processual conception of nature which would come first and a study of technical reality which would come after. Nature and technics are not addressed separately, and the reason for that is not only that they are not thought as separate realities, as he continuously emphasizes. Simondon really considers that technical objects, the functioning of their operations, provide intelligibility schemas which, in addition to being the materialization of knowledge and the reflection of doing of each historic age, somehow organize our way, as human beings, of understanding reality. Thus, his exploration of the technical operations, undertaken in the technological laboratories he created in the places where he taught, put his thinking into motion. There would not be, therefore, a Simondonian philosophy of technics as a separate domain of his thought; his philosophy is a technical philosophy, in the sense that all domains of reality are illuminated from schemas of intelligibility revealed by technology. What remains to be demonstrated is the meaning of this program and why the technical reality – a contingent result of the evolution of nature – can illuminate the mysteries of nature.

Two questions are opened here. Simondon's technical mentality leads to the differentiation of three phases in modern Western thought, each one corresponding to a theoretical-scientific construction, a technical and energetic development, and a psycho-social organization: the Newtonian mechanics of material points which is established as the paradigm of classical physics, the thermodynamic theory born in the 19th century parallel to the invention of steam engines and, finally, the creation of cybernetics that responds to the possibility of modulation of energy and self-regulating mechanisms. In technical terms, it is observed in this process the passage from the use of the mechanical transmission of physical forces towards the optimal availability of energy sources and, up to our epoch, in which energy is not only used but also informationally modulated in technical devices. The relationship between these three phases raises many interesting questions that require detailed treatment. The intention here is to study the transition from the energetic conception of thermodynamics towards the informational conception present in Shannon's communication theory and Wiener's cybernetics, in order to show why the concepts of information, self-regulatory mechanisms and causal recurrence provide a new intelligibility schema through which it is possible to observe the whole of nature.

The second question concerns the relationship between the various domains of reality whose process of genesis is sought to be understood. The anti-reductionist character of Simondon's philosophy, inherited among others from his master Canguilhem, does not need to be underlined. Simondon holds through and through the idea, which remains to be one of his greatest philosophical contributions, that placing primarily the philosophical reflection in the ongoing process of individuation opens the door to solve the problem of reductionism in a novel way. It is possible to respect the ontological plurality of physical, biological or technical beings and, at the same time, show the existence of analogical ontogenetic schemas in their formation; according to this ontogenetic perspective, there would be no division or separation between the various dimensions. What is more, this recognition of a common ontogenetic process, of a shared "deeper mode of existence", is precisely what makes it possible to discover the different modalities of individuation and to ward off, once and for all, the reduction of one product of genesis to another.

Notwithstanding, the fact that Simondon's approach in ILFI does not seem to correspond to this perspective has raised a serious problem of interpretation. He does not hesitate to hold that the basic paradigm present in his study of individuation is based on notions extracted from physics and, what is more, he takes as a paradigmatic example of individuation the process of crystallization, from which he extracts the concept of transductive amplification. That does not imply, if it were necessary to clarify it, a remnant of a reductionist aspiration; what Simondon extracts from physics are *operational schemas* which can eventually be transportable to other domains in order to have an epistemological access to other kinds of operations, without this implying, in any case, the reduction of the structure of one domain to the other. But the question remains: can we say that his commitment to a physical paradigm shows the basic mental schema that has set in motion his own characteristic way of thinking? It is difficult to answer this, and the truth is that we cannot obtain a conclusive answer.

The excellent investigation of Luis G. Mérida (2020) has shed new light on this matter. Using as a machine of thought the schema of the modulator, whose paradigmatic example is found in the triode and subsequent devices, Mérida holds firmly that a technical operational schema is at the base of Simondon's way of thinking. In addition, the modulator schema would be the key operation, the glass through which we can observe and evaluate the relevance that Simondon attaches to other paradigmatic examples, both physical and biological, since all of them would be different ways of modulating. Some preparatory writings of Simondon's thesis reinforce this idea of technics as a "paradigm of universal intelligibility". The analysis offered here of the conceptual transition from energy to information follows this clue of thinking.

From energy to information

The hallmarks of the Newtonian mechanics of material points and, by extension, of classical physics, are mechanism and reversibility. A physical system is understood as a set of material points whose positions and momenta can be known with precision and whose evolution obeys physical laws revealed by mechanics. Given the knowledge of the positions and momenta of the material points, and of their laws of evolution, it is possible to know the future (or past) states of the system, since these are fully determined by the evolution from the present state. Reversibility means that the equations of this mechanics are time-invariant, time-symmetric: whether the equations advance "forward" or "backward", the behaviour of the system as it is described by those equations is not disturbed.

The birth of thermodynamics in the 19th century meant, to a certain extent, a challenge to those pillars of classical physics. If anything characterises thermodynamic systems, it is precisely that they are not time-invariant, that is, show a temporal directionality. Starting from a far-from-equilibrium state, defined by the existence of a gradient (thermal, chemical, electrical, etc.), an isolated system will necessarily evolve spontaneously towards the elimination of the gradient, that is, towards equilibrium. However, it is worth emphasizing that thermodynamics, in its beginnings, was clearly guided by the ideal of reversibility. Its birth as a discipline responds to the attempt to give account, conceptually and mathematically, for a new technical object that also introduces a new operational schematism: the steam engine. Carnot (1824) shows that the maximum efficiency of thermal machines is obtained as far as the coefficient of reversibility of the conversion of energy into work approaches its higher limit. The impossibility of a full conversion, linked to the inevitable dissipation of heat and therefore to irreversibility, is understood as a loss of energy. So, the technical mental schema revealed or expressed in classical thermodynamics basically lies in the idea of *a disposition and use of energy*.

It is worth noting the relationship between the technical mentality that dominates an epoch and the conceptual development of a theoretical discipline that although initially arising out of this mentality acquires autonomy and is developed in its own terms. Thermodynamics did not take long to notice the serious contradiction between the irreversibility proper to thermodynamic processes, formalized as the inevitable directionality of these processes towards the state defined by the entropy state function (S) introduced by Clausius, and the reversibility proper to the equations of Newtonian mechanics. It seemed that nature send two contradictory messages and physics had to be placed between them, or in the face of them. For its part, the technical optimization of steam engines continued its course in a progressive and never-ending struggle against irreversibility.

In this context, it is Boltzmann who assumes the seemingly insoluble task of reconciling the irreversibility of thermodynamics and the reversibility of dynamics. In a first attempt, Boltzmann tries to endow an *objective dynamic meaning* to entropy. Taking the evolution of ideal gases as determined by the elastic collisions between its molecules and assuming the hypothesis of molecular chaos, Boltzmann mathematically defines a quantity H that acquires a minimum value in the state of equilibrium – corresponding, therefore, to the maximum value of entropy. The objections made to this H-theorem will cause Boltzmann's abandon of this first attempt, which will mean the definitive abandonment of his claim to define entropy in objective dynamic terms[1].

In a second attempt, Boltzmann starts from the relationship between the macrostates of a gas, corresponding to macroscopic magnitudes such as pressure or temperature, and the microstates or complexions of it, corresponding to the position and momenta of all its molecules. Assuming the equiprobability of the microstates, Boltzmann gives a *probabilistic meaning* to the evolution from far-from-equilibrium states towards the final state of equilibrium, that is, towards the maximum value of entropy. A far-from-equilibrium state (for instance, cold molecules on one side and hot molecules on the other) is compatible with a smaller number of complexions of a gas compared to the state of thermal equilibrium, compatible with a much greater number of complexions. So, there is a much larger number of possible states or complexions of the gas corresponding to the equilibrium state, and the tendency of the system is toward that most probable state. Now, and this is the point here, the irreversible tendency towards the increase of entropy is understood as the tendency towards more probable states, but there is nothing that objectively forbids – only a high improbability – a decrease of entropy. Boltzmann's formula ($S = k \log W$) seals the subjectivist interpretation of entropy assumed to this day by physics and the aforementioned abandonment of any claim to define it objectively in dynamic terms. Cleverly, if incompletely, Maxwell pointed out what was at stake here through his demon's thought experiment: if we could know the position and momenta of all the particles in a gas, it would be possible to manipulate the molecules in such a way as to decrease entropy. What is revealed here is that, according to the probabilistic conception of entropy, there is a connection between the physical

[1] This issue means a fundamental turn in the history of physics, if little noted. Maxwell, on whose mean distribution of gas velocities Boltzmann had relied to state his theorem, directly laughed at the attempts of "German physicists" to give entropy an objective meaning. The fundamental objection that will cause Boltzmann to abandon his theorem comes from his colleague Loschmidt, who casts doubt on his hypothesis of molecular chaos. The objections will become even more serious in Zermelo's arguments, supported by Poincaré's recurrence theorem. For a rich conceptual exposition of these issues, see Stengers (2003[1997]).

evolution of a system – supposedly objective, independent of the observer or of what the observer may know about the system – and the knowledge or uncertainty about the state of each of its molecules. It shows that physics, to the extent that Boltzmann's equation is accepted, potentially transfers the undeniable reality of the increase of entropy to the field of the more or less precise knowledge that we may have of the effective behaviour of the material particles that make up a system. Putting it simply, if entropy increases it is because it usually does, but it might not. Our present state of knowledge shows that this is false. But the fact that a theoretical solution that stabilizes an empirical problem is incomplete, transitory or even wrong does not prevent this solution from giving rise to new perspectives and theories with fruitful development, even more so if the solution is successfully used and unanimously accepted.

And this is what actually happened in this case. This question of the uncertainty about the possible states of a system is what connects Boltzmann's work with Shannon's theory of communication. Before addressing this question, it is necessary to point out the change in mentality that has been taking place in the meantime, in which the mutual feeding between technical invention and the development of physics is once again observed. If the invention of the steam engine placed the problem of the use of thermal energy at the centre, in the 20th century we witnessed, with the birth of electronics in the technical field and of information theory and cybernetics in the theoretical field, a new problematic. The invention of the diode and, especially, of the triode and subsequent ones, marks the entry into a new technical, theoretical and psycho-social era. Until then, it was already clear that any energy gradient – be it thermal, chemical or electrical – can be used and converted into another type of energy; there was awareness of the convertibility of energies, and energy was understood in an abstract way as a kind of reserve that can be converted and also exhausted. The great change in mentality that electronics entails resides in the idea that energy is not only a reserve with *capacity for movement* but also a structured flow that enables the *transmission of information*. Previous electrical inventions such as the telegraph or the telephone had already shown the possibility of sending messages through a chain of energy conversions, but the possibility of modulating and amplifying energy is what opens up the great field of technical invention typical of our time.

Entropy, information and noise

The connection between Boltzmann's and Shannon's works marks the transition, through the notion of entropy, from the energetic phase of modern thought to the informational one. In his search for a quantitative definition of information, Shannon (1948) picks up Boltzmann's probabilistic equation of entropy and defines an amount H of information ($H = - \Sigma$ p1 log p1) which he coins as "information entropy"[2]. This information entropy has been usually understood as the noise that threatens the correct sending and selection of a message (probability p1 of occurrence of a possible state of the system) among all the possible states of the system. In the founding work of cybernetics, Wiener (1961[1948]) agrees with Shannon's mathematical definition and conceptually understands information as the capacity of a system to sustain an organization that opposes the increase of entropy, continuing with the line of thought opened by Schrödinger (2008[1944]) where information is defined as negentropy.

[2] Actually, Shannon uses here Gibbs' generalized formula for entropy ($S = - k\ \Sigma$ p1 log p1). Furthermore, since what Shannon is looking for is a definition of information, he eliminates Boltzmann's constant k, thus stripping the equation of all physical significance. The only thing that counts here is understanding information in probabilistic terms, and this is why Shannon uses Boltzmann's mathematical apparatus. These technical details show that Shannon is defining a new kind of entropy, that is, information entropy.

In this sense, there seems to be an opposition between the understanding, on the one hand, of physical entropy as the evolution towards more probable and more uncertain or unpredictable states of a system (that is, a greater number of complexions or microstates corresponding to a macrostate: the more numerous the complexions, the more difficult it is to know the effective complexion) and, on the other hand, of information as the ability to select between equiprobable states of the system: information enables to discern which is the effective state of the system, that is, the possible state that is the case. This opposition between entropy and information, between disorder and organization, between uncertainty and predictability or, in other words, between noise and information, has been brilliantly analysed and questioned by Malaspina (2018).

Malaspina argues that it is absurd to identify information with certainty. Shannon's conceptual "audacity" would be to understand that entropy, taken as the maximum indiscernibility between microstates, is the maximum state of "freedom of choice". The greater the impossibility of discerning a message (uncertainty), the greater the freedom of choice between possible states and, therefore, the more informative is that macrostate of the system. Consequently, "information entropy" should not be understood as the entropy that *threatens* information but as the information that entropy *carries with it*.

However, it seems that we fall here into another contradiction. Information cannot be the confirmation of what we already know, that is, pure certainty but cannot be pure disparity, randomness, or uncertainty neither. Shannon underlines that, for a message to be informative, it must bring with it something new, an uncertainty: it is in this sense that more "freedom of choice" (more noise or entropy) implies more information, understood as the possibility of selection between possible states. Thus, noise, as Malaspina emphasizes, should not be understood as a mere obstacle to communication or information; rather, it is the structured and not undifferentiated background which makes possible the emergence of a selection. The key to understand information would lie in differentiating between productive noise (openness to freedom which results in a meaningful choice) and background noise, diffusion, which threatens all significance. Weaver (1964) tried to conceptualize them as "desirable uncertainty" and "spurious uncertainty". Malaspina holds that this distinction is historical and contingent: noise is an already structured background on which we operate our distinctions between what is relevant and what is irrelevant, what is significant and what is *uninformative*.

Therefore, there would be no need to oppose information and noise. Placing information between pure predictability (certainty) and pure randomness (uncertainty) prevents from understanding its nature. If we assimilate information with certainty, we fall into pure redundancy; if we assimilate it with pure novelty, we fall into randomness. The paradox of information is that, to be informative, it must provide something new, but not *excessively* new. It is in this dichotomy between redundancy and contingency where Simondon's intervention is situated.

Cybernetics as "universal technology"

Is Simondon looking for a new philosophical theory that would find its explanation or its expression in the technical domain, or are his reflections on technics which lead him to a new philosophical theory? We are probably dealing with a case of circular causality, in such a way that the concepts highlighted by his philosophy are performatively executed in his own thinking operation: his philosophy acts his philosophy. Here we can find the reason why he welcomes Wiener's *Cybernetics* none other than as "a new *Discourse de la méthode*" (SIMONDON, 2016, p. 38), thus granting the technological conception of a mathematician the same status as the work considered foundational of modern philosophical thought.

Opposite to the famous Heideggerian statement according to which science (and, by extension, technics) “does not think”, technics appears in Simondon as a true thinking machine and, more specifically, cybernetics would allow philosophy to grasp a new operational thinking. His 1950’s writings in preparation for the two Theses show that his meditations on the philosophical meaning of cybernetics lead him to the study of two closely connected fundamental questions: causality and individuation. In a more generic way, they also show what is, according to Simondon, the task of philosophy. The opposition between being and becoming inherited from the philosophical tradition is a hindrance that prevents understanding the individual. Instead of assuming the dichotomy between stable structures that would constitute the essence of the individual and operations that would dissolve the individual in a dynamic process that deprives him of a stable identity, he affirms that “the individual is the being that is capable, inside of a given structure, to carry out operations that allow it to change the structure” (Simondon, 2016, p. 65).

While the various sciences achieve a positive knowledge of the structures proper to each domain (physical, biological, etc.), the inter-scientific relationship is technical: it is not a relationship with the proper object of each domain, but the search for an “operative compatibility” between the sciences (Simondon, 2016, p. 41). Thus, the relevance that Simondon grants to cybernetics lies in the fact that it constitutes, for the first time, the theoretical search for a functional equivalence between the various domains studied by the sciences. If we start from the structures, and from the relationships between them, we inevitably fall into a substantialist ontological perspective and a reductionist epistemological view. If we start from the operations, we can find an ontogenetic equivalence between the formation processes of the structures belonging to the various domains. With great insight, Simondon surprisingly recovers the Cartesian theory of the living being as an automaton to vindicate it as an attempt to rationalize becoming. Descartes would not simply be carrying out a reduction of the biological becoming to a static mechanism but also, symmetrically, he discovers an operative becoming in the mechanical functioning. While in Aristotle there is a separation between structure and operation, which implies a tendency (*telos*) “which is an operational tension towards the achievement of the structure in the form of an entelechy”, in Descartes’ automaton they are united, since “the operation it is no longer an actualization but the development of a series that has its reason in a structure” (Simondon, 2016, p. 403). Thus, against the usual criticism according to which Descartes reduces living beings to the pure mechanism of matter, Simondon claims that, in this attempt, he discovers an operational equivalence between the biological and the technical domains, even though his philosophical inquiry is directed by the aspiration to subject becoming to the rational schematism of a structure that advances step by step. Descartes should be taken, in this sense, as a precursor of technical paradigmatism, of which information theory and cybernetics constitute their heirs.

Next step of this philosophical discovery is found in the transition from the automatism of direct causality, in which a (structural) cause organizes an (operational) effect, to the automatism of recurrent causality, where the effects of the cause intervene in the organization and modulation of the cause itself (feedback) and the self-regulation of the cause dynamically modifies its effects (feedforward). Maxwell's governors already introduced the idea of a recurrent causality between an energy source (steam) and the command of that supply based on the information obtained from the acceleration or braking of the machine. In cybernetics we find a generalization of this schema. The technical invention of the modulator introduces the possibility that an energetically weak form (the signal) conditions informationally, or modulates, the force provided by the energy. It is here where we clearly appreciate the transition from the energetic conception to the informational one: the form does not only modulates the energy but also “the way in which the form conditions the force in the modulator constitutes the structure of the latter” (Simondon, 2016, p. 49). Going into details, Simondon shows that in the modulator there is not only a causal effect of the form on the energy; there is a diversity of causes (signal-form, energy and, lastly, the structure of the modulator resulting from the interaction between them) that enter into a complex game. As an example, a signal-form can modulate an energy that has already been previously modulated if the amplitude of its cyclic duration is greater than the cycle of this energy; these temporal relationships can also be thought spatially, since an energy with a certain frequency can only give spatial details larger than its wavelength (see Simondon, 2016: 52-53). This new operational schematism revealed in the technical domain shows the need to broaden the concept of a linear causality with the idea of a circular or recurrent causality in order to account for a large number of technical and non-technical phenomena.

Simondon’s concept of information and cybernetics

It is time to return to all of the above from Simondon's perspective. Why, in his main Thesis, is the question of individuation observed “in light of notions of form and information”? Simondon rejects that the hylomorphic conception of the genesis of the individual as the imposition of an active form on passive matter is an adequate schema to think individuation. An energetic point of view is also necessary to reveal how the energies carried by matter are used for the extension, propagation or imposition of a form. In this sense, the form does not disappear, far from it, as a transcendental condition of individuation. But form does not cease to be a static concept that limits the understanding of individuation as an open process of genesis. In addition, it is needed a structural point of view in which the inherent forms of matter are taken into account, revealing why *such* matter can take *such* form. The result is an advance, in the study of individuation, from the schema of an imposition of form to matter towards the conception of individuation as in-formation, that is, a structuring activity made possible by certain conditions which are material, energetic and of structural compatibility.

Simondon thus opts for a concept of information as an activity, as a process, and not as data. This is the main reason for his rejection of the concept of information present in the mathematical theory of communication, in which information is understood as the signal sent from a sender to a recipient. Firstly, Simondon explains Wiener's negentropic concept of information. If entropy is understood as a measure of the disorder of a system, “information is, in the transmission of a message, that which opposes the general flattening of the energy modulated by the signal” (Simondon, 2005a, p. 221), that is, it is what allows to distinguish between the possible states of a system. Information must contain, with respect to the modulated energy or its support, a certain degree of unpredictability, but it cannot be absolute unpredictability, since then we would not have information but noise (pure randomness).

Simondon denounces that, in this schema, there is a fundamental oversight, since information has not only to be sent but also received and effectively integrated into the recipient's functioning. And if we look at the conditions of reception, the concept of information is antagonistic to the negentropic concept, since “it implies regularity and periodic return, predictability” (Simondon, 2005a, p. 222). To take reception into account, information theory should introduce a new element, the confrontation between the signal and the recipient's structure, so that we find a polarity between two extremes in which there would be no information. If there is a total coincidence between the signals and the structure, we would be facing a total predictability which is not information but “external iteration of an internal reality” (Simondon, 2005a, p. 223). If, on the contrary, there is a total divergence, we would be facing a total unpredictability in such a way that the signal cannot receive a meaning and be integrated into the current structure of the recipient. In between these two extremes there may be information, which demands the signals to be *significative* for the recipient or, in other words, they should be integrated so the structure of the latter is modified. A concept of information that is not reduced to the amount of information contained in a signal is required, but it cannot be understood neither as pure quality, as a property of the signal; what is needed is a relational concept: “in order to be received, signals must find *prior forms* in relation to which they are *significative*; signification is relational” (Simondon, 2005a, p. 223; original emphasis).

Simondon detects a relevant breakthrough in cybernetics, since it does not limit the concept of information to the technical issue of sending signals[3]. According to the negentropic conception, information corresponds to the emergence of organized structures that oppose the degradation of energy, which allows to understand the nature of both biological and technical beings. What is more, the great value of cybernetics would lie in the fact that it puts into work an operational concept of information, so that it is not linked to the formation of structures in a particular domain (physical, biological or technical) but rather highlights, as we have seen, an operational analogical equivalence between the structures. Although this mental schema constitutes a great advance towards Simondon's fundamental objective, that is, to be able to think ontogenesis, and allows to get out of the opposition between reductionism and holism, Simondon still demands one step further: to establish an authentic science of the general convertibility of structures and operations, an *allagmatics*, so that structures can be understood as a “series of more or less durable instantaneous functionings” (Simondon, 2016, p. 53) and operations as genesis, modifications or dissolutions of structures. This perspective would substantiate the operational equivalence of the structures of different domains, what was missed in cybernetics. Thus, it is the general convertibility of structures and operations that grounds the operational analogies, and not the other way around.

Conclusion: the structural effect of noise

In all this theoretical landscape, we detect two unthought oppositions that are clearly connected: between information and entropy, and between information and noise. The development of thermodynamics raised the serious problem, since Schrödinger's seminal work, of the distinction between physical entities subjected to the increase of entropy and the maintenance of organization in living beings. This led to the negentropic conception of living beings according to which they somehow “evade” the increase of entropy, reinforcing the opposition between order/organization/information and entropy, between living and inert beings. The subsequent development of non-equilibrium thermodynamics made it possible, to a large extent, to get out of this opposition: it is precisely the tendency towards the elimination of gradients, towards the increase of entropy, which cause the emergence of organized structures, whether physical, chemical or biological, in far-from-equilibrium states.

Mérida (2020) has done a great job trying to demonstrate that this approach is not enough, since non-equilibrium thermodynamics would still remain in an energetic point of view. It would be necessary, Mérida tells us, to address the question of information from a purely structural, morphogenetic point of view. In this sense, he rejects the adoption by cybernetics of the probabilistic concept of information inherited from Boltzmann and Shannon: to identify entropy with the amount

[3] Communication theory actually acknowledges that it limits the question of information to the optimal sending of signals (what it calls the "technical problem"), but it also mentions two other "relevant” levels: the “semantic problem” (how symbols convey the desired meaning) and the “effectiveness problem” (how the received meaning affects the recipient's conduct). In fact, it alerts from the beginning that its concept of "amount of information" is not the usual one, since it leaves aside the significance of information. Two similar amounts of information can have very different significance. See Weaver, 1964, p. 4-6.

of information we do not possess (uncertainty) introduces “a nebulous subjective idealism, an acosmism of incognito” (Mérida, 2020, p. 37-38). On the other hand, the technical schema of the modulator is what would allow Simondon to penetrate the “black box” of ontogenesis and establish the differences between the various modalities of individuation. While in physical individuation modulation is produced at the limit, in the living being a “double resonance” is produced, both at its limit and throughout its interior: “what is previous for the physical individual is contemporary for the biological one” (Mérida, 2020, p. 169). For its part, the technical operation of the modulator “marries” both modalities of individuation since “successive modulations” take place in it, just as it occurs at the limit of the crystal and in the organism, which is all of it a modulator and a “cascade” of modulators. Crucially, in the modulator there is a distinction between the energy feed, the incident signal and the structure of the modulator, allowing for an “informational feedback” of the latter on the first one. This last condition is the one that would not be met in far-from-equilibrium dissipative structures, which are “informationally impermeable”: there the environment does not only energetically feeds the process, but it is what enables self-organization. In conclusion, Mérida considers it necessary to preserve a distinction between a mere “emergent complexity”, typical of dissipative structures, and the “organized complexity of biological systems” (Mérida, 2020, p. 177). Only the latter would be a true self-organization in which there is recursion of the emergent structure onto itself, so that a loop of causal and informative recurrence is produced between the structure and the energy feed.

This perspective represents a great advance in the unveiling of the technical mental schema that sets Simondon's thought into motion. Now, to what extent is still there an unthought opposition between information and noise? Is it possible to reveal, as Malaspina defends, a positive contribution of noise in the emergence and creation of new structures? If the structure is understood as the informational cause with the power of recursion and noise as pure randomness between possible states of the system (thermal dissipation linked to entropy; inability to decide between possible messages in communication), it is clear that the opposition between information and noise remains. As a way of conclusion, we will try to show that this opposition needs to be nuanced.

In energetic terms, a system at equilibrium is in its most random state, in which macroscopic magnitudes can be realised by a greater number of complexions. But non-equilibrium thermodynamics has shown that as an open system get away from equilibrium, fluctuations between possible states can start to play a structural role. Although empirical studies show that most fluctuations are “amortized” by the system, at critical points, called bifurcations, a microscopic fluctuation can “invade” the system and cause the emergence of a new macroscopic structure of functioning. And this structure, despite not modulating the energy feed as occurs in the modulator, does condition the subsequent structural development of the system: the specific path followed in the bifurcation determines, as it continues to get away from equilibrium, which new macroscopic structures can emerge in the following bifurcations.

This is the origin of Prigogine's concept of “order by fluctuations”. In informational terms, we can translate it, based on Shannon's work, as “information from noise”. What other sense can the definition of an “information entropy” have? With this last concept, the opposition between information, on the one hand, and entropy and noise, on the other, is clearly called into question. The opening of the system to greater randomness, to a greater number of possible states, potentially contains more information, that is, a greater “freedom of choice” in the exploration, emergence, and sustaining of new structures. In other words, it is the openness to noise which allows a system to get out of pure redundancy, of the repetition of what is already known.

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