http://dx.doi.org/10.23925/2316-5278.2017v18i2p187-204

Peirce and cybernetics: retroduction, error and auto-poiesis in future thinking[1]

Peirce e cibernética: retrodução, erro e autopoiesis no pensamento futuro

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Abstract: The aim of this paper is to connect Peirce's logic of abduction to the cybernetics of living systems. Living beings cannot be understood through a causalistic epistemology, as they behave according to the effects and not according to the causes. Cybernetics has analyzed the way in which non-trivial machines (that is, machines being able to reproduce themselves by correcting themselves) move through retroaction, or feedback loop: at each step the system (effector) corrects the previous step depending on how far the previous step goes with respect to a possible equilibrium. The dynamics implies a possible inhibition of excessive energy followed by a possible enhancement of insufficient energy. Each of these conditions are errors that automatically correct themselves reaching a temporary state of homeostasis. Self-correction means that they must add to the output a "creative" additional impulse, that is unique and unpredictable (or a new algorithm). The logic that is capable to make sense of this dynamics is Peirce's abduction, also called retroduction, in that the inferential act retroacts on an incomprehensible fact, an epistemological "error", by inventing its cause. Thinking and the auto-poiesis of living systems proceed on the same path, replacing occasional strategies to atemporal universal causes. Abduction is the evidence that it is possible to reach a condition of "knowledge" without resorting to causality. The possibility that the "laws of nature", (science itself), may proceed in this way concludes the essay, by adding physicist Lee Smolin's notion of the "principle of precedence", as inspired by Peirce's idea of the evolution of the laws of nature and their temporal, that is, contingent, character.

Keywords: Abduction. Algorithm. Auto-poiesis. Chance. Connectionism. Cybernetics. Effector. Effete mind. Error. Feedback loop. Guess-work. Homeostasis. Kairòs. Laws of nature. Retroaction. Retroduction.

Resumo. *O objetivo deste artigo é associar a lógica de abdução de Peirce à cibernética de sistemas vivos. Sistemas vivos não podem ser entendidos através de uma epistemologia causalista, pois se comportam conforme os efeitos e não conforme as causas. A cibernética analisou o modo pelo qual máquinas não triviais (ou seja, máquinas capazes de se reproduzirem*

1 I would like to thank to Allison Grimaldi Donahue for translating this article into English.

por auto-correção) se movem através de retroação, ou circuito de retorno: a cada etapa, o sistema (efetor) corrige a etapa anterior, dependendo de até onde a etapa anterior pode ir em relação a um possível equilíbrio. A dinâmica implica uma possível inibição da energia excessiva seguida de um possível aumento da energia insuficiente. Cada uma dessas condições é um erro que se corrige automaticamente, atingindo um estado temporário de homeostase. A auto-correção significa que é preciso adicionar à saída um impulso adicional "criativo" que seja singular e imprevisível (ou um novo algoritmo). A lógica que é capaz de fazer sentido dessa dinâmica é a abdução de Peirce, também chamada retrodução, onde o ato inferencial retroage sobre um fato incompreensível, um "erro" epistemológico, inventando sua causa. O pensar e a auto-poiesis de sistemas vivos percorrem o mesmo caminho, substituindo estratégias ocasionais por causas universais atemporais. A abdução é a evidência de que é possível atingir uma condição de "conhecimento" sem apelar para causalidade. A possibilidade que as "leis da natureza", (a própria ciência) possa seguir este caminho conclui o ensaio ao adicionar a noção do físico Lee Smolin do "princípio de precedência", conforme foi inspirado pela ideia de Peirce da evolução das leis da natureza e seu caráter temporal, ou seja, contingente.

Palavras-chave: *Abdução. Algoritmo. Auto-poiesis. Acaso. Conexionismo. Cibernética. Efetor. Mente esgotada. Erro. Circuito de retorno. Conjectura. Homeostase. Kairòs. Leis da natureza. Retroação. Retrodução.*

1 Introduction

One of Peirce's main issues was: how to understand change in nature? The laws of nature are indubitable. We can't conceive of anything without a law or a rule, or a regulating force. But how can laws make sense in the *real*, that is, the actual and changing environment, if they are fixed and atemporal? There must be a faculty of the mind or a logical modality that is able to relate itself to (or even to be merged with) a dynamic context.

It is the purpose of my paper to show that Peirce recognizes that faculty of the mind in abduction—also called retroduction in some early essays—and how it may become an increasingly useful tool to understand change and self-regulation in both natural and technological phenomena.

The epistemological model of the cause/effect relationship cannot fully satisfy Peirce's exigency to give an account of what he considers, beside the method of science, to be part of the cognitive process, that is, habit and social (or environmental) pressure. These basic elements of cognition can be re-read within a frame of comprehension of phenomena that reproduce themselves, regulate and correct themselves, whether they are living beings or physical events, or machines, in one word within the paradigm of cybernetics.

I will start by using examples from cybernetic research and then will consider abductive logic as a way to think of cybernetic phenomena.

2 An example of cybernetic dynamics: Elsie

In the 1940s in Bristol, the neurophysiologist William Grey Walter, seeking to understand the human brain, constructs an automatic robot which for the first time doesn't have the mere form of an automaton, like the Jacques de Vaucanson's 18th century duck or the 19th century flautist Innocenzo Manzetti, but it reproduces the internal structure of movement, that is the dynamics of retroaction, which renders the automaton a true automaton, a self-propelled entity. For the first time, cognitive science seeks to reproduce the autonomy of movement, that doesn't depend on a predetermined mechanism (algorithm), but on the very same mechanism that reacts with just the right amount of energy needed to continue movement. These automatons aim to understand the dynamics of uncertainty and decisions, rather than that of predetermined rational processing, that is not outside but inside the "body" of action. Elsie (Electro-mechanical robot Light-Sensitive with Internal and External stability) looks like a turtle and comes to be called *machine speculatrix*. Following her comes Elmer and Cora, which, perfected, respond also to sounds and are reconstructed on the foundations of Elsie.[2]

Elsie is phototropic, she responds to light, has photoelectric cells that "explore" the environment, detects the light that attracts her until she is filled. The light actually moves her (increasing heat) until the heat, once absorbed, no longer moves her. She stops and cools and therefore has space to contain the light, which she seeks by moving, and so forth. When the accumulator (the "stomach") is full, her behavior changes: she no longer seeks out light and she stops. In addition, when she meets an obstacle, she doesn't stop but begins to vibrate, as though she were looking for a way around it. Sooner or later she is able to circumvent it, because slowing down and ricocheting, she causes a positive feedback that increases momentum, or a negative feedback that moderates it. Each direction she takes, each modulation of energy (diminished or increased) is provoked by prior input (DE LATIL, 1957, p. 235).

It seems like a magnetic attraction moves her towards the light, but in effect it is only a homeostatic dynamic: Elsie moves due to the transmission of energy and she stops because of the overabundance of energy. Each of her actions is not determined by a predetermined algorithm, but rather by the same movement that is an effect of the previous movement: if it is too strong the movement diminishes, if it is too weak the movement increases: each succeeding movement is therefore adjusted by the previous movement and so on. This effect that produces each sequential movement, the next action and resembles a decision (diminishes or increases energy) is called the effector in cybernetics. It is the electronic version of the water mill: the water that lowers the mill blade causes an upward thrust: a rotary movement which is auto-determined. The process in Elsie occurs through the transmission of energy and its regulation, without the intervention of an outside energy.

Elsie is like a brain with two neurons (she has two motors, that is two regulation valves). But already, Pierre De Latil—the scientific disseminator who in 1953 wrote *Introduction à la cybernétique: La Pensée artificielle*—was aware that it wasn't about simulating the human brain (as were the intentions of the neurophysiologist Grey

2 Grey Walter and his tortoises at University of Bristol website. See the link in the bibliographical references.

Walter), but only to test a response which was automatic and "living" at the same time, namely the capability for error and therefore for decision making (which is the overcoming of uncertainty). The electronic turtle doesn't share a common structure with the human brain, it isn't the hardware but rather, the software, and the fact that they are both non-programmed machines that operate on internal feedback. It is therefore its instability which procures for it a momentary equilibrium, and therefore what makes it homeostatic.

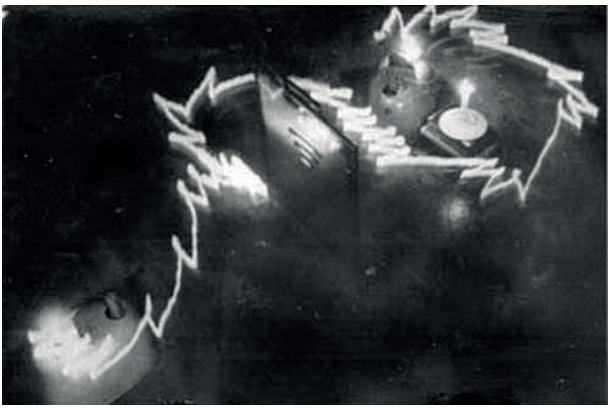

Figure 1

Elsie's movement as highlighted by the photograph demonstrates a zigzag, explorative and uncertain pattern of movement.[3]

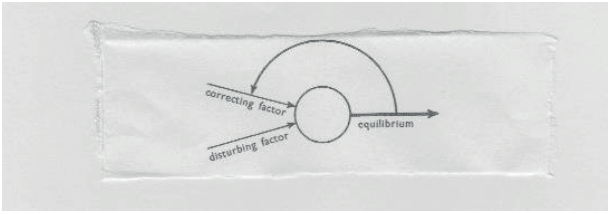

Figure 2

Pierre De Latil's effector diagram. According to the effect, the disturbing element is adjusted by the correcting element.

Therefore, if a machine is also capable of uncertainty and decision making, the human brain can also operate without resorting to "consciousness," "metaphysics," "rationality." We learn from Charles Sanders Peirce how intelligence is sought in the immediate, pragmatic, explorative relationship with the environment and therefore manifests according to challenges presented by the environment itself. The cognitive act *contains* the environment, as it contains an ability for thought which is in the body (ANTOMARINI, 2012, p. 51).

3 HOLLAND, 2003, p. 2104.

The automatic dynamic analyzed by the first cybernetic, then expanded by the next generation, to that of living systems, is that intelligence is common to machines and to living beings: each is auto-determined in the continuous correction of its own reactions, through the effectors which counterbalance, change a linear direction (with oscillating or circular movements, that is, they change direction or correct possible errors), they refuse a stimulus if it is destabilizing, they reinforce that which is stabilizing, an intelligence that expresses itself when it detects an alteration, an "error" to correct. Without that alarm, there is no intelligence. Elsie is like smoke for an alarm that lets out foam when it is under pressure: no need for instructions, a priori algorithms, or central processors. Human mental processes are not reproduced by Elsie, Elsie is, however, their material manifestation (DE LATIL, 1957, p. 42), emancipating epistemological research from the old idea of rationality.

Human intelligence manifests itself when we drive a car and the hand, little by little, follows the information of the steering wheel, which follows information from the wheels, which follows the information from the flow of petrol which varies according to the curves of the road. We are a *kybernetès* (the pilot inside the boat) a man-machine complex. It isn't the driver who moves the car from outside, it is the car that suggests the action, which is the effect of one of the causes (excess or defect) (DE LATIL, 1957, p. 48).

The same dynamic, evolved as an always more complex retroactive machine, becomes analyzable on the epistemological level, as abductive thinking.

3 Abductive logic

> "How am I able to obey a rule?"—if this is not a question about causes, then it is about the justification for my following the rule in the way I do.
>
> If I have exhausted the justifications I have reached bedrock, and my spade is turned. Then I am inclined to say: "This is simply what I do."
>
> (WITTGENSTEIN, § 217, 85c).

If "nature" keeps itself in balance—though unstable and modifiable—evidently what is necessary is not a fixed law, but algorithms which are constantly modifiable, internal and self-produced and self-sufficient in procuring a provisional homeostatic state; therefore, the causal epistemological structure is not a sufficient explanation, if it is able to only produce "initial" causes (but in order to be "initial" they must be in turn produced, imagined, therefore abstracted from the continuum that does not have initial conditions).

Nor does the concept of "effect," which derives mechanically from the cause, explain the effector which is something completely other than passive and pre-determined, but rather it is that which in the real world substitutes the cause. The real world, in fact, is a dynamic reality, made of events, processes, passages, trans-categorical crossings, necessary through the constant retroaction that never results from the same causes and which modifies the conditions of possibility of the effects. We need to formalize another kind of thought. A precursor to this new model is

Charles Sanders Peirce who in various passages in a range of articles and diverse forms defines a type of reasoning he calls *retroduction* or *abduction* (this second term comes from the Latin translation of the Aristotelian term *apagoghè*, even if it is not the same thing, but only one of the possibilities of abductive expression, as we will see).

Let us revisit one of these passages in order to reread retroduction as a cybernetic instrument. In the essay *Abduction and Induction*, Peirce begins to define the specifics of abductive inference:

> The surprising fact, C, is observed;
>
> But if A were true, C would be a matter of course,
>
> Hence, there is reason to suspect that A is true.
>
> Thus, A cannot be abductively inferred, or if you prefer the expression, cannot be abductively conjectured until its entire content is already present in the premise, "If A were true, C would be a matter of course"
>
> (PEIRCE, 1955, p. 151-152).

I seem to find the explanation of C (a fact that lacks explanation, or any pre-determined algorithm, an effect without a cause) in a hypothesis that has itself to be confirmed, and that might be confirmed by turning C into a matter of fact: I see smoke in the room. I can't find the cause. If I imagine that someone cooked a steak in it, *and I take it for true*, the smoke would be a matter of fact. The truth does not concern C so much, as it does the scenario that can transform my anxiety into confidence. My inferential activity retroacts on the missing cause, turning the puzzle into fact. What we call 'fact' is neither theory-free nor theory-laden. It is "posed," relying exclusively on an effect and on my thoughts. I might have different scenarios, different conclusions/retroactions: I open the window, call the firefighters, I eat the steak, go to the Turkish bath […] Each of these actions is an effector which is consequence of the effect/surprising fact/effector.

In the *Cambridge Lectures on Reasoning and the Logic of Things*, Peirce uses a variant in the definition:

> Anything of the nature of M would have the character P, taken haphazard;
>
> S has the character of P
>
> .·. Provisionally, we may suppose S to be of the nature of M. (RLT 140).

Here, more clearly, the solution to the puzzle is at the same time M (inexplicable fact) and S, which is not a cause, because M is not inductively produced by S, "unless" we associate them analogically, or unduly, or hypothetically, or "haphazard", apply the properties of S to M. There is not S as hypothetical truth but M as new fact: the new fact consists in a new entity that has both known and unknown characteristics.

Peirce calls this scheme the second figure of reasoning, preceded by deduction and followed by induction. It is an analogical reasoning, which lacks

every probability, not only in the conclusion, but also in the way of thinking (RLT 141-142).

Everything we can say about what is happening is what we need to do, in order to make a decision or choice. Before an unexpected and incomprehensible event, we cannot reason ad infinitum, we cannot wait to accumulate a sufficient quantity of data to stabilize the probability to some degree, nor can we seek help in universal categories.[4]

Here is a bare particular without a universal. Guided by the "economy of research" we can test a hypothesis "at any given stage," and we hold it as long as the facts allow. In the absence of probability we put faith in the suggestions our mind finds anywhere, in other *similar* facts. The hypothetical therefore can diminish through the addition of clues, or remain as such, but in any case, it is not necessarily a phase that tends towards induction or deduction (as it may seem in Luciana Parisi's reading, 2016, p. 478). It can be sufficient to itself, if the effects do not require further clarification. Or it may simply be nullified, once they are redundant at the conclusion (based on further clues). Or, as in the case of the elaboration of a dream or in a work of art, it may remain as a signifier that can activate a number of other signifiers (to paraphrase Kant on the aesthetic analogical thought).

Now, if there is no starting point, from where can we begin researching S? Why do we take one suggestion over another? Given that things occur in a dynamic environment, this thought also needs to be dynamic, it is as mental as physiological-unconscious, and it is certainly a perceptual judgment, that responds to the environment while it accepts it and corrects it: if the solicitation is directed towards an excess (smoke is more similar to a fire) abductive inference will have to anticipate a negative feedback; if it is directed towards a defect (the smoke is the steam in a Turkish bath) it will anticipate a positive feedback.

Peirce calls this activity *guess-work* (a conclusion without a premise, a firstness, pure quality and possibility), a disposition of producing not a truth but an invention, a scenario that describes that which is happening independently from its truth. Instead of looking for confirmation, I go forward, I proceed as an effector, until my hypothesis is sufficient to the effects, until another suggestion corrects the possible error that it shows itself to be, which in turn can be corrected by another suggestion and so on.

That is, there is no truth that is not a correction of an error.

The properties that cause me to associate the unknown fact with another known fact are haphazard and applied by chance to M. Therefore, I can arrive also at inventing a solution to the enigma myself in ways that can rely on few clues or even no clues. The intermediary premise, that should connect the missing premise (the inexplicable fact) to the conclusion, is introduced by the "unless," a diminution of doubt. For this Peirce traces the term abduction from the literal translation of Aristotelian *apagoghè* (RLT 140) which is only one of the possibilities of abduction, or the *modus tollens*, an elimination that can open up fantastical premises: if P therefore Q, but not P and therefore not Q, that is they eliminate the cause and therefore open the possibility of abductions in the Peircean sense.

To recapitulate, the dynamic of the retroaction, which explains the beginning of things, in their spontaneous movement, and the dynamic of retroduction, which

4 See: HP 2:898-899.

explains the spontaneous movement of thought, are in reciprocal systemic relation and use these same instruments:

- Error as a push towards comprehension (towards correction, towards movement).
- A procedural modality which modifies itself step by step, at each phase.
- The solution strategies, that are not found in the available data, that is, they do not emerge from data but require going further, making use of a solution that did not exist before.
- The provisional nature of the conclusion, expressed by the implication: "and so on…"
- The automatism (it is a fast, unconscious reasoning, a guessing power) simultaneous with its creativity (in the retroaction, the effector finds correction strategies not in the causes, but in its own process).
- The anticipation, that is the guess-work of a stratagem of perspectival action.
- The effector, which takes it upon itself to resolve and to maintain (homeostatically, that is, sufficiently) the solution.
- The "active" way, meaning acting continually on the cause (anticipating and correcting errors).
- The fact that the cause depends on the effect. The reasoning occurs based on what the effect (effector) is able to excogitate.
- The fact that the effect/effector *precedes* the cause. The sense of "retro" in both cases indicates a change in the perturbing element with a corrective element, manipulating and therefore identifying the cause due to manipulation.

This is what we call a cybernetic model of the conscience: the cause is substituted by an invented scenario (a possible theater that describes the event), automatic (in the sense that it depends on nothing rational), that in turn (as effector) causes the behavior and the action (and this is of course the basis of pragmatism). The auto-correction does not guarantee movement towards a certainty, but only allows acceptable effects (plausible or advantageous, or pleasant, or sufficient, etc.). And even if one receives confirmation of the validity of the hypothesis, the correction remains as an ongoing possibility, a suspension of every pretense of certainty.

Schematically, here below, we reproduce the diverse relation between the terms that come from the three diverging forms of reason: deduction relies on a universal—and therefore defines a way of thinking that is turned towards the past; induction relies on the discovery of a universal—and therefore pretends to have one, until its eventual falsification; in retroduction the universal (cause, law, a priori) is completely redundant. Linguistically, deduction defines a common meaning to every particular event; induction finds a probable meaning; retroduction may even rely on improbable meaning, which, not having data upon which to apply itself, is

a purely logical intentionality, a signifier which auto-legitimates through the chain of signifiers it opens, or the effects it produces. According to Luciana Parisi the type of meaning implicated in a non-a-priori and explorative algorithmic research, is a type of index continuous with the meaning to which it refers; an index that "points, here and now" at a signifier which is not other than the signified, but supports it and transfers it in other signifiers (PARISI, 2012, p. 14).

DEDUCTION	INDUCTION	ABDUCTION
A particular confirmed by a universal (cause, law…)	A particular which is the result of a universal (probable)	A particular which has no universal but rather, clues
cause/effect	effect/cause	effector/effector/ effector/effector
S/s	s/S	s/s/s/s/s…

Abduction suggests—rather than a meaning—an ability to anticipate a reaction and correct it or embrace it, independently of inductive data, an auto-poietic *interpretant*, which is also a natural physiological tendency to prepare future interpretants (BRIER, 2008a, p. 54, and ANTOMARINI, 2012, p. 89). This triadic logic is composed of a truth-table of three-valued connectives: T, F, L: true, false, limit, where the limit is precisely the passage to the other than given (See: MS 339, also NEGARESTANI, 2012, p. 289).

The concept of limit can be read as a signifier that can be neither true nor false, and implies the secondary character of true/false, not because it eliminates the distinction but because it is fluid, valid in its doing and undoing.

From this premise Luciana Parisi reformulates the abduction as an "experimental" or "interactive" algorithm (PARISI 2012, p. 15, and passim) which learns as it forms and uses errors and contingencies as potential sources of new solutions. The action/anticipation is regulated -it does follow an algorithmic rule—but in the sense that it is auto-regulated, auto-poietic, free from a priori premises. This dynamic—inspired by Peirce and applied by Parisi—comes to be acknowledged by Katherine Hayles and further reformulated: non-conscious cognition is conceived as thinking and solving problems in a way that is *intuitive* in the sense that it uses associations rather than connections, namely:

> Data environments are the milieus out of which cognitive assemblages are formed and through which they are able to create new concepts via experimental axiomatics, which in turn change the rules governing how data are processed, which feed back into the cognitive assemblages to transform how they operate (HAYLES, 2017, p. 192).

Retroduction lacks, or rather doesn't need, recourse to the cause or to the law of deduction, because "to know" is unnecessary (in the sense of understanding

a "hidden" meaning). What is necessary is rather the need to attenuate (negative feedback) the error of certainty and of ignorance, to avoid namely an excess of mental energy (certainty) which provokes the error of the fixity of things (which are in reality always in process and never static objects), or a defect of mental energy (which provokes the absence of exploration and namely the absence of novelty). This epistemological structure presupposes that things exist as an infinitely divisible continuum and therefore can only be understood in their particularity-reticularity in respect to other particular things. Consciousness is the construction of scenes projected in a future where hypothesis, event and behaviors coincide.

Peirce uses the example of Mars, a planet that does not seem to fit any of the Keplerian orbits, unless Kepler does not suppose that it behaves a bit like the objects that move in ellipses:

> Kepler did not conclude from this that the orbit really was an ellipse; but it did incline him to that idea so much as for him to decide to undertake to ascertain whether virtual predictions about the latitudes and parallaxes based on this hypothesis would be verified or not. This probational adoption of the hypothesis was an Abduction. An Abduction is Originary in respect to being the only kind of argument which starts a new idea. (CP 2.96).

Other examples can be found in science, such as Maxwell's discovery of electromagnetic waves, guided by the analogy of these "waves" to those in water. The electromagnetic power didn't have a theory, *unless* it resembled waves that move in water. Therefore, hypothesizing an "imaginary fluid" that moves air wave, might the phenomenon make sense:

> By referring everything to a purely geometrical idea of the motion of an imaginary fluid, I hope to attain generality and precision, and to avoid the danger arising from a premature theory to explain the cause of the phenomena. (MAXWELL, 1890, p. 159).

The imaginary fluid, air waves like water waves, was a retroaction that acted on the unknown cause, correcting its possible fallacies, itself being a fallacy, but without which Maxwell wouldn't have made any discovery.

The same trend can be observed in the discovery of the Higgs particle, first hypothesized as an abductive scenario and then discovered experimentally. In the same conditions of abductive hypothesis one finds concepts such as dark matter, the barion Xi, gravitational waves (currently undergoing experimentation) and others.

To know is an action of error correction, it is not the opposite of error but the dynamic use of it. It is error that lays out the background upon which the exploration happens and never ends. There is no knowing subject and knowable object, but only the continuing processes of auto-poiesis and self-correction, which are revealed through other processes, in continuous, reciprocal coincidence and discrepancy.

On the other hand, if the interaction between systems is not chaotic or left to chance, it is because there is this anti-chance factor that is the effector, and which procures a telos for each concluded action (provisionally). This projection, anticipation of the future is the telos "which is much more probable than if it had been left to chance" (DE LATIL, 1957, p. 132). Between general design (mental) and chance (blind reaction to external stimuli) there is a third possibility: the internal (embodied, enactive) constitution of the effector.

4 What corrects an error can be only an error

The constructive power of error ("It is the existence of feedback in living organism that gives error its constructive power", DE LATIL, 1957, p. 112) not only an aesthetic value (as in Sklovsky's Tolstojian declaration: the energy of the error) but an empirically testable hypothesis, which in turn modifies the very definition of error.

As opposed to the Newtonian and modern physics model of a universe in which "everything happened precisely according to law, a compact, tightly organized universe in which the whole future depends strictly upon the whole past" (WIENER, 1989, p. 7), according to this paradigm a state is in continuous modification and the uniformity determined by a measurable initial condition is only the selection of a moment which is a break with the past, therefore not compact nor measurable except as a statistical distribution (WIENER, 1989, p. 8).

There is an active intervention by the observer (DE LATIL, 1957, p. 237) who *chooses* an object as if it were an isolated entity but he or she understands it as such because it is part of his or her auto-poietic system. In the dynamic of retroaction, every object is "organic" to its environment and each organism is integrated with that which it perceives. Elsie is the evidence of it.

The slowness of human retroaction—in respect to that of retroactive machines, or non-trivial machines as von Foerster called them, from the steam engine to the computer—is balanced by the simultaneous use of diverse neuronal areas that amplify the possibilities of anticipation and therefore the correction of past errors or the prevention of future errors. For example: in going down stairs, the body moves forwards and backwards in order to maintain its perpendicular position on the ground thanks to touch (to feel the ground at your feet, with the vibrations from the shoes), at the sight (fore-seeing): diverse systems in reciprocal exchange of information that adapt the body to circumstances and anticipate, retroduct to possible errors. The robots are learning it now, but with great difficulty.

To anticipate, to explore (imagine and experiment before actually having to react) is one of Elsie's characteristics which has developed tremendously in human animals, which have a greater intelligence in absence of (or before) an object (DE LATIL, 1957, p. 271).

That we use errors as a possibility to be provisionally discarded and kept "on hold" is also the premise of Connectionism, or Parallel Distributed Processing (PDP), introduced by Rumelhart and McLelland et al. in the 1970s and 1980s. The simulation does not concern the neuronal structure but its dynamic "software." Neural Networks hypothesize how neuronal connections work.

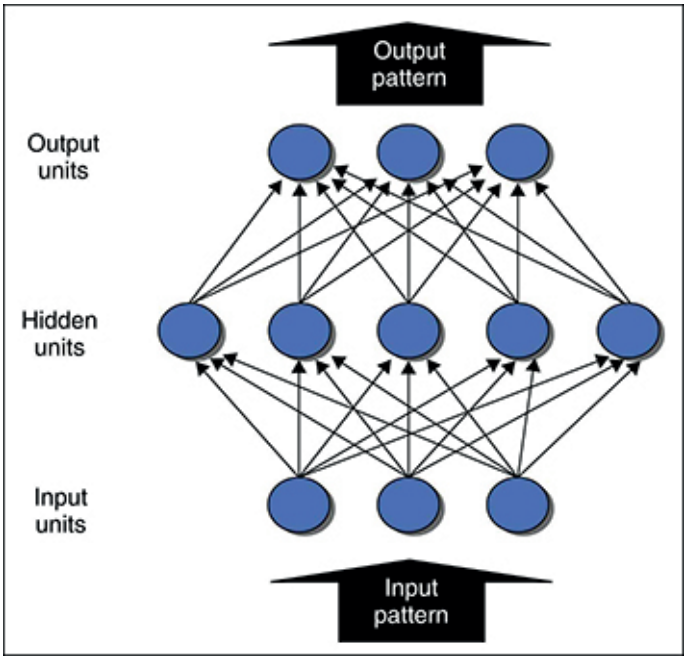

Figure 3

The old model: *input* > *process* > *output* is substituted in Artificial Life with that of cybernetics (although the disciplinary connection between these fields of research still seems problematic (Froese)):

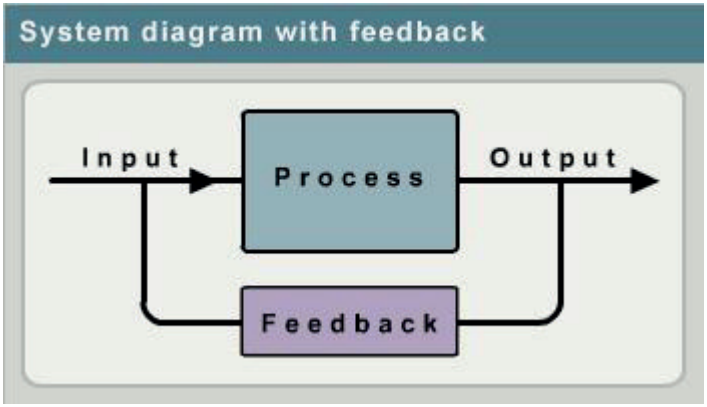

Figure 4

In the two models (cybernetic and neurological) the processor is not a center from which a rule-algorithm is produced as a decision but a field of continuous elaboration modified by the output/effectors that retroact upon the input: if I move

forward onto a suddenly deserted terrain, I begin to make a scenario in which, effectively, I am in a desert, but I leave this scenario in my head depending on how the next steps that I take either reinforce or inhibit my output. My thoughts do not react blindly, but they anticipate —thanks to changeable scenarios with slight modifications in the weight of the synaptic connections—a possible action of auto-protection or adjustment of the pull (strengthened or inhibited *over time*). The modifiability, flexibility and therefore slowness of the system implies that uncertainty, exploration, fallibility, invention of explanatory and provisional scenes, which are part of the power of "human" thought but which, ultimately, are automatic. They are the evolutionary heirs of retroaction, of the effector, of the feedback loop at work in all of the non-trivial machines and natural phenomenon of auto-poiesis.

5 Knowledge *in* time

A consequence of this epistemological structure is the necessity of thinking of laws as temporal, that is, able to avoid explanations that exclude the temporality intrinsic in both the cognitive agent and the effector. If the effector is to extend the possibility of other effectors (effectors in their own turn), we lack a meta-theory. One of the few scholars to test this idea of evolving laws of nature is the theoretical physicist Lee Smolin, who, in the 2014 book *Time Reborn. From the Crisis of Physics to the Future of the Universe*, takes quantum mechanics as a model of reference for its hypothesis: its area of research demonstrates that having a both successful and incomplete theory is possible (SMOLIN, 2014, p. 140-141) and depends on the working procedures which search different algorithms for diverse experimental results. It is as if every experiment had a different law, which is then generalized in a statistical quantification.

This depends on the fact that we can imagine what is happening in time but we cannot imagine the "moment by moment" phenomenon and we proceed without a principle of individuation or sufficient reason. Every experiment may suggest an arbitrary, that is a "free" result. But a set of experiments (collected in a system) shows that in the long run there is a regularization of the arbitrariness. As general systems theory has shown, a complex system has laws which are irreducible to those that govern its members and each complex system cannot in any case attribute those specific laws to a totally predictable atemporality that is applicable in each single case. A result is always a "choice" that acts as an effector, that is as an occasion for other effects. It is as if there were a (not a priori) "cause" distributed ad infinitum in each of the "things" that change it in time, according to (contingent) motives of (positive or negative) feedback. And provided that there may be foreseeable cases, they may be so only on condition that their experimental repetition is "sufficient". Without this test—empirical, finite and contingent—there could be no prediction. This is what Smolin calls the "principle of precedence (SMOLIN, 2014, p. 146, and ff.). To explain the regularity of certain phenomena, we have invented something like a 'universal law', but actually there is no need for it. "But to explain these cases, we actually need much less than a timeless law. We could get by with something much weaker…" (SMOLIN, 2014, p. 146), namely a principle derived from the repetition of tests that have yielded similar results.

It is not a coincidence that Smolin cites Peirce, like a rare case of considering the law as non-atemporal: "All things have a tendency to take habits" (EP 1:277 apud

SMOLIN, 2014, p. 147). Every "real object" is an aggregate which has constructed itself thanks to the tendency to form aggregates, "acting as on a former occasion than otherwise" (ib). The tendency, or habit, of forming aggregates (in symbiotic or physical forms) results in new systems formed according to the previous (contingent) results, and it implies that the law itself (since the complex aggregate-system cannot be reduced to its simple elements) is a habit that changes according to the evolution of things (Cf. BRIER, 2008a, p. 39, and passim). This attitude which was lost in modernity, was, however, present in the tradition of mechanical craftsmen or "practical mechanics."

For example, in the 17th century the chemist Robert Boyle, who was defined as a mechanical philosopher, maintained that "natural law" did not mean that matter responds to the law in the same sense that a citizen responds to a civil law. A natural law is a "custom of nature," contingent in any case (SHAPIN, 1994, p. 331), because there are too many variations in reality and therefore a scientific conclusion needs to be just "good enough" (SHAPIN, 1994, p. 311), because there are practical decisions based on a *certain* level of precision, namely that level of exactness that *we expect* is sufficient to decide.

Along this path of experimental cognition, the "things" are auto-poietic (cybernetic, automatic, but not chaotic) systems endowed with a free *intelligence*: free not only from the constructions of rationality, but also free to produce algorithms a posteriori, simultaneous with the aggregate/system that is being formed. Smolin takes from Peirce the idea that this is the only way to understand dynamic nature, whose future is, as a matter of fact, open in a way that the future may not resemble the past and is therefore 'free' from it (SMOLIN, 2014, p.147).

What Newton introduced as a universal law is only an algorithm created by a collection of past outcomes (without repetitions or experiments, no law. Perhaps this explains how it often happens that they find first the theoretical object and then they confirm its existence through experimentation? Maybe the theorist makes thought-experiments that catch the temporal self-making of the object of research?), an algorithm that catches the behavior of the real object stochastically, giving it a beginning and an end. In this sense, just as Elsie is "free" to move and decide, each thing has an arbitrariness to create its own rules. Here "free" means: without reason, contingent, occasional. The concept of law is reduced to occasion: the Greek *aitìa* (cause) becomes *kairòs* (the right moment, or a chance).

Peirce in regard to this:

> As for retroduction, it is itself an experiment. A retroductive research is an experimental research; and when we look upon Induction and Deduction from the point of view of Experiment and Observation, we are merely tracing in those types of reasoning their affinity to Retroduction. […] The hypothesis, as the Frenchman says, *c'est plus fort que moi*. It is irresistible; it is imperative. (RLT 170; CP 5.581).

Therefore "there's more to how any small system unfolds than could be captured, than in any deterministic or algorithmic framework" (SMOLIN, 2014, p. 149). And: "As new states arise in nature, new laws evolve to guide them" (SMOLIN, 2014, p. 153).

Now the problem is: is a qualitative algorithm conceivable, which forms and disperses along with the evolution of its elements, without fixing itself in a numerical value that determines it according to truth-values?

Let's once again take up the abductive structure of thought: something happens that has no apparent cause (and if we look for it, we find an occasional reason, not a universal law), but in any case, it provokes an effect (that is an effector) on the mind that improvises (anticipates) a scenario, independently of the truth-values. The mind shows to be capable of thinking in absence of cause. The scenario replaces the cause becoming the effector of action and behavior. It retroacts on the event giving it meaning, and the meaning evolves together with the event and the action that it has provoked (as effector).

Instead of thinking through the past (the cause) we think through the future (the effector). And "true" means testable, and testable is common to the mind and to nature, as both tend to pick up habits: Peirce said that though in certain cases phenomena arrived at their full evolution (the habit is completed), like for instance the law of gravity, in other cases: "we find plasticity and evolution still at work. The most plastic of all things is the human mind, and next after that comes the organic world, the world of protoplasm" (PEIRCE, 1992, p. 241; CP 7.515).

The uniformity that is, in fact, required of a law of nature will be never precise. By way of example let's think of the pattern of cellular evolution, and how now we add to it the singularity of technological evolution, that is, the effector that accelerates (or compromises) biological evolution itself.

In this case a law is put into place "… not to be obeyed precisely. It makes an element of indeterminacy, spontaneity, or absolute chance in nature" (PEIRCE, 1955, p. 318).

And as the lack of precision can be due to errors of observation, so we must assume that there may be also a "swerving of the facts from any definite formula" (idem), or else for example cataclysms that change the laws of nature, or viruses that modify DNA.

The habits of things are what become physical laws, as if things had an "effete mind" (PEIRCE, 1955, p. 322). Laws are expanded habits, gentle forces, living realities (PEIRCE, 1955, p. 248).

This "effete mind" is in all things, to the extent that they belong to an auto-poiesis system; therefore any cognitive action—including the experiments and hypotheses of science—results from this omni-pervasive mind that doesn't reproduce things in simulated forms, doesn't mimic the phenomena of the "real" world (the experiments of Galileo were analogue models, taken as fractals of real phenomena) but inserts itself into the real, with theoretical models that do not have empirical equivalents, but serve to understand pure relations, like computer experiments and artificial data: "They are everywhere and nowhere" (KELLER, 2002, p. 200-209).

They can be sub-atomic particles isolated and emptied of "noise," as they could not exist in the real world. They can be cellular automata, that have nothing in common with organic cells (since they are discrete entities) but serve to understand how a cell modifies and adapts to other cells to constitute itself in a symbiotic system. This is not a question of representing but of expanding the possibilities of reality: "An alternate reality" (KELLER, 2002, p. 202), built upon a succession of experiments that things make themselves with themselves. The data are real entities,

but not imitations of other entities: they are not "given" at all if not in the moment of their being conceived and made.

Now the possibility to work with enormous amounts of data, or even with the total amount of data, can reduce the necessity of a theory, but it also changes the definition of "experiment" and "simulation": they do not replicate but they are creative scenarios that work in a double direction: either they are hypotheses of how real phenomena work "ideally" (they reproduce their effects, through the 'discovery' of their causes, though these remain hypothetical) or they expand the real phenomena into a space that is simply invented (though effective, producing effects, and in the end, possible effectors).

6 A tentative conclusion

In view of a new approach to cybernetics as a way to unify living and mechanical phenomena, which are a matter of fact within the singularity of technological developments, Peirce offers the great tool of abduction to explain the cybernetic phenomenon of feedback loop. Whereas retroaction is the faculty to modify the direction of events, retroduction has a similar power of manipulating the cause, depriving it of its authority. In both cases, the power does not mean "control," but mutual adjustment with environmental challenges. In this cognitive model the origin of the movement is not its *cause*, but it is the *error*—the excess or the defect—that provokes the need for correction, and the invention of a strategy that avoids the repetition of that excess or defect. Without error we do would not arrive at an efficient conclusion, we could not complete a single correct action. And this true for free agents, living beings, as well as cybernetic machines. Abduction introduces an idea of knowledge that doesn't use laws, but auto-modifiable algorithms, that are in systemic relation with the environment and do not claim to be the only possible explanation. Each abductive scenario, remaining hypothetical, allows for others that, although they are mutually exclusive, may lead to equally effective conclusions.

Abduction emancipates from the need to collect *all* data, or an enormous quantity of signs, details and clues. It (the firstness of the qualia) claims to explain the particular and is called upon to signify a particular sequence (of effectors). As opposed to a classical or modern model, the abductive model is pluralistic. Let us imagine diverse Sherlock Holmes with diverse hypotheses, set into action by a single inexplicable fact. If the retroaction provoked by the diverse scenarios converges in similar effective behaviors (anticipation and feedback), it becomes irrelevant to state which hypothesis is true. One fact is essentially the reconstruction of its process that can happen in many ways (based on guess-work). It is a pluralistic model in the sense that the "theory" is the (temporary) convergence of diverse hypotheses. This notion of convergence is the same that Peirce uses to save science from relativism (many theories for the same fact). But it also saves it from the misunderstanding of the correspondence theory-facts: an (evolutionary) law of nature must also be a law of errors.

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Data de envio: 28-10-17
Data de aprovação: 20-11-17