Eugenio Andrade[1]

Natural Abduction: the Bridge between Individuals Choices and the Production of Evolutionary Innovations

Abstract

Defenders of developmental systems theory have shown the need for a new evolutionary synthesis. However this effort requires a metaphysical evolutionary framework in which such an expanded synthesis can be embedded. I propose to develop a Peircean monist ontology by explaining the six characteristics or facets of reality labeled as: A) spontaneity, B) determinism, C) processing of information, D) statistical law, E) internally driven capricious choices and F) tendency to form habits. A special emphasis will be dedicated to characterize the predicates C and E as they provide the clue to the understanding of nature as a continuously open-ended and unpredictable process, where its inherent creativity is analogized to an abductive inference.

Keywords: Evolution, development, Sign, Peirce, Darwin, abduction.

Introduction

Most of the difficulties that students face for understanding specific evolutionary problems, come not from lack of empirical evidence but are originated in our hegemonic mechanistic interpretation of nature, that they unconsciously subscribe to, in which change requires an explanation, since the *a priori* assumption is the inertness, changelessness and timelessness of matter. People still believe that what must be explained is change, when indeed the basic *a priori* assumption should be that everything changes. In this paper, I take as an example the problem of whether evolutionary variations are directed or random in order to show that each one is based on different metaphysical assumptions, internalist and externalist respectively, and show how they can be integrated into a Peircean metaphysical framework. I am concerned with comprehension, understanding, creation of an integrated

[1] Professor
Department of Biology
Universidad Nacional de Colombia
Bogotá, Colombia.
leandradep@unal.edu.co

view, dispatching the traditional mechanistic view. This paper questions the metaphysical and background assumptions that condition the choice of features are to be observed, the way they are observed and measured in order to obtain data, but what is more critical the way data are to be interpreted. **As** an alternative it is proposed the construction of a minimal metaphysical framework based on Peirce that will provide a consistent foundation for an expanded Darwinian synthesis.

Evolutionary variations: Directed or random?

Different views about the origin of evolutionary variations divide traditional Lamarckian (internalist) and Darwinian (externalist) schools. 1. Directed variations. According to Lamarck ([1809] 1986, pp: 126- 128) evolution obeys a *plan of nature* that tends to produce ever more complex forms and allows for secondary modifications dependent on the conditions of life through use and disuse in response to environmental conditions[2]. Lamarck's system was based on an ontological description acknowledging the reality of both an external world ruled by Newtonian mechanics and an inner one that was the locus of the vital principle of heat, inner drives, impulses, and organizing tendencies. Lamarck proposed a series of parallel transformations arising from several events of spontaneous generation that tend to increase organization from insensitive to sensitive and finally to intelligent animals (Lamarck [1809] 1986, pp: 126-128). For Lamarck ontic states are referents of individual descriptions of actual forms that are seen as accidental deviations from a deterministic law given by the *plan of nature*. Considering that at the dawn of XIXth century it was widely accepted a Newtonian determinism it was not surprising that under similar physical conditions spontaneous generation should bring forth similar forms. Nonetheless, whereas simpler o lower living beings are shaped by physical forces, animals in which growing organization includes nervous systems and brain are shaped by habit, but always in full conformity with physical laws. In other words, as the inner organization increases in complexity organisms are ever more capable to counteract external influences, by internal accommodations of its body parts as induced by habits and use and disuse, a tenet that

[2] It is to be reminded that Darwin never denied that Lamarckian inheritance was possible and accepted as a means of modification also the effects of use and disuse (Darwin [1859] 1997, p. 123) (Depew & Weber 1996, p. 126), (Richards 1992, p. 103).

becomes a justification for an internalist stance. This ontological cut between internal (organized life) and external (Newtonian world of discrete particles) was, then, needed to inaugurate the discourse of biology, that in spite of its limitations becomes today one of the elements for an ontological framework that fits an expanded evolutionary synthesis.

2. Random variations. Darwin spoke of chance variations in two senses. First in face of our ignorance of the causes of every individual variation, and second, to point out that there are variations that arise without respect to the needs of the organisms and of the conditions in which they live (Darwin [1859], 1997, pp: 121-123). Non directed random variations in the population became the raw material for natural selection. The Darwinian emphasis on natural selection is congruent with the received preconception about the passivity of matter. If ordering principles do not act from within the only formative factor should be external, were there no external organizing force, no form at all would be expected, since XIXth century physics did not provide any hint about how order could be originated from randomness. Following Depew and Weber (1995), Adam Smith had shown with great elegance that the laws of economy are utterly compatible with the Newtonian view of nature. Darwin adhered to Smith´s externalist “invisible hand” argument that equilibrates supply and demand and fixes the prices in the market where individuals strive to maximize individual benefit. Although natural selection was advanced under the ignorance of the inner structure of organisms, before the cellular theory and the chemical enzymatic theory of living processes were widely diffused and accepted, -not considering the Mendelian laws of heredity and molecular genetics- it served to solve the problem originated in the lack of a physically grounded account of evolution. The law of natural selection, regardless of how bloody and cruel it may be, leads to improvements, adaptations, equilibrium and harmony in the productions of nature.

For present day Neo-Darwinians that recur to statistical models of selection, variations are random in the sense that all of them are equally likely to happen. However, Darwin’s clear cut distinction between individual (local) and population (global) phenomena, made possible an epistemic description in which every change of individual behavior must be contextualized in a given environment. Individuals’ tendencies to reproduce beyond resources and so to spontaneously diverge from the ancestor under the pressure of scarce resources would inevitably arrive to a critical point where some will survive and some others will die. Natural selection balances the relation between resources and population while reduces the amount of available genetic variation in the population. Mental processes that for Descartes were considered the causal agency of order in the material world were then naturalized and replaced by natural selection when it was requested an account for the order observed in the living world. The point is that the causal ordering agency comes from without the organized system both in Cartesian and Darwinian conceptual systems.

However natural selection works because the populations are composed of individuals that act as natural interpreters of external cues that enable them to gather and use environmental information and so survive the harsh conditions of scarcity. If survival can be understood in terms of individuals' knowledge one can assert that Darwin made possible to draw epistemic descriptions that today become, as I will show below, one of the bases for an expanded evolutionary synthesis.

In this paper I will discuss the role of the organisms' individual choices within the immediate local circumstances as a factor of evolution inasmuch as it helps to understand the origin of evolutionary variations, in the context of an expanded evolutionary theory.

Evolutionary variations and Developmental Systems Theory

Developmental Systems Theory (DST) claims that variations are related to inextricable intertwined genetic and environmental factors, mediated by organisms (or developmental systems) according on the one hand to their capacity to buffer genetic and environmental perturbations, and on the other hand, to their responsiveness to environmental factors by means of structurally constrained behavioral, ontogenetic and physiological adjustments. In this context variations are not random, nor directed since they can only be examined considering the complex relationship between genotype, phenotype and environment (Oyama 2000, p.61), (Griffiths & Gray 1994), (Andrade 2004, 2005).

According to Waddington (1961) development is represented as a fall down through a potential gradient. The topography of the epigenetic landscape is not prefixed by initial conditions, but instead it is reconfigured all along epigenesis as a result of interactions between genes, and between organisms and environment, that generate new bifurcating epigenetic routes. However, the dichotomy between genes and environment calls for the introduction of an epigenetic active interface (see figure 1).

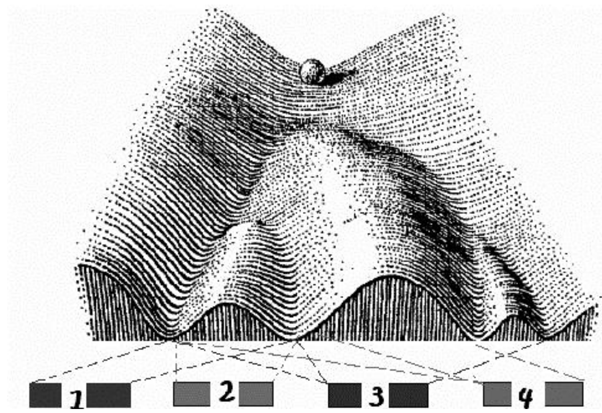

Figure 1. This epigenetic landscape stands for a dynamic interface between genes and environment, where developmental paths open up and are modified along development. The ball in the upper side stands for any undifferentiated system (cells, organism) that possesses many developmental possibilities. The deep valleys stand for stable developmental paths, whereas bifurcating points are unstable since small fluctuations produced either by the environment or by genetic mutations push the system towards one way or the other. This scheme also explains "genetic assimilation", a process by means of which the effects induced by environmental factors could be genetically stabilized, in such a way as to become hereditary features that are manifested in absence of inducing stimuli. Genetic assimilation is made possible by the appearance of mutant genes, cooptation of existing genes, and rewiring of existing genetic networks (Carroll 2005, pp: 122-131) that produce an effect similar to that induced by the environment. (Figure was modified after Waddington, 195, in Slack 2002).

According to this model genes participate in developmental regulation while their expression is regulated by non-linear interactions with environmental factors. Thus, a multitude of stable states in the form of canalized developmental paths is defined. Nonetheless, it can happen that a given developmental system leaves its path and jumps to another that leads to an evolutionary innovation by interaction with certain environmental signals (Waddington, 1961). According to Waddington (1961) "genetic assimilation" is the means by which a phenotypic change, during development, gets fixed in the genotype after several generations, so stabilizing the modification for future generations. It, thus, implies selection for the adapted phenotype, through the fixation of allelic combinations that contribute to the stabilization of the new developmental path. Thence, genetic assimilation buffers genetic and environmental fluctuations within a threshold of stability that, if stepped across would give rise to a new developmental path.

Canalization allows for accumulation of genetic variability in natural populations, and keeps the stability of phenotypes, so shielding variants from the action of natural selection. The accumulation of genetic variants increases evolutionary potential, as environmental conditions change some of these variants can be co-opted for new functions. Therefore, phenotypic modifications, use and disuse included, are prior to genetic accommodation and assimilation (West-Eberhardt, 2003, pp: 147-157; Jablonka & Lamb 1995 pp: 31-37, 1998, 2004 pp: 262-265). The genotype always defines a set of possible developmental paths, however the interactions between organisms and environment are crucial in order to decide which specific path is to be taken.

For Neo-Darwinians ontogeny depends on initial genetic conditions, and is independent of external conditions (closure), whereas for DST there is a close relation between genes and environment, namely that natural selection acts directly on the organism's developmental phenotype and on the epigenetic processes that provide the phenotypic plasticity needed to maintain a functional interaction with the environment. Selection of phenotypes drags genotypes that respond to environmental pressures in a more or less coordinated way, without having to wait for the emergence of the right adaptive mutations by chance (Waddington 1976, pp: 135-144).

DST broadens the genetic concept of heredity to include the action of epigenetic inheritance systems (Jablonka & Lamb 1995 pp: 79-110, 1998, 2004 pp: 113-146). Organisms transmit to their offspring something more than genes, like a number of factors needed for their own making. The ability to evolve is associated with morphogenetic plasticity. Ontogeny regulates phenotypic changes by influencing gene expression according to environmental inducing factors, so that we end up with complex relationships that range from "one genotype to many phenotypes in changing environments" to "many genotypes to one phenotype in a constant environment". Genome must no longer be considered as a fixed program, but as one of the sources of information that, together with a multitude of factors, define evolutionary potential (Oyama 2000, p: 66). Every single factor that contributes to development is an informational source; in consequence, genetic information requires natural interpretation, as it were, in such a way that out of the same genome different forms may arise depending on the context of interactions. Evolution results from an ongoing permanent open construction, not a priori fixed. Form comes about through interpretative processes mediated by developing organisms.

It seems timely to recall that there is no fundamental distinction between innate and learned behavior, since development and behavior results out of organism/environment interactions (Kuo 1922, in Johnston, 2001), (Lehrman 1953, in Johnston, 2001), thence what is defined as ontogenetically innate was learned in the history of the lineage (Riedl 1983, p: 216). Evolutionary processes are based on the organisms' ability to perceive and to create for themselves an image of their surrounding world that enables them to use it for their own benefit.

Peircean categories and Darwinism

The three Peircean categories are needed to describe the categorical structure of all extant phenomena and require specification in differing research fields. Given that Peirce's views subsume Darwin's, I will use Peirce's ontological system as the scaffolding for an expanded and generalized Darwinism. Within these guidelines I will show that the Darwinian triad variation, heredity, selection, can be understood as a realization of universal categories.

> This Darwinian principle is plainly capable of great generalization. Wherever there are large numbers of objects having a tendency to retain certain characters unaltered, however, not being absolute but giving room for chance variations… there will be a gradual tendency to change in directions of departure from them (CP 6.15).

Darwinism as a conceptual system introduced a scheme for understanding reality that surpasses in depth and breadth, mechanical Cartesian ontology in correspondence with Peirce's cartography based on the three categories *firstness*, *secondness* and *thirdness* and the six characteristics or relations derived out of them: A) spontaneity, B) determinism, C) information, D) statistical law, E) tendency to diverge internally driven capricious choices due to and F) tendency to form habits, (Andrade 2007), (Taborsky, 2002, 2006, 2008). By depth I mean that evolutionary theory covers every level of hierarchically organized living systems and by breadth, that the theory can be applied also to cosmological, and also cultural, linguistic, economic and social systems.

A thorough examination of the six relations proposed by Taborsky (2002, 2004) is needed in order to draw the minimal metaphysical evolutionary scheme in which an expanded evolutionary theory would fit. Both the external/internal and individual/population cuts, define a Y-X "Peircean" plane in which the six relations derived from the three categories can be spotted (Andrade, 2007). A relation in this particular case is a facet of an integrated reality that can be characterized by three factors: 1. space (inner local, external local, inner global, external global), 2. Time (present, perfect, progressive) and 3. Mode (potentiality, actuality, necessarily).

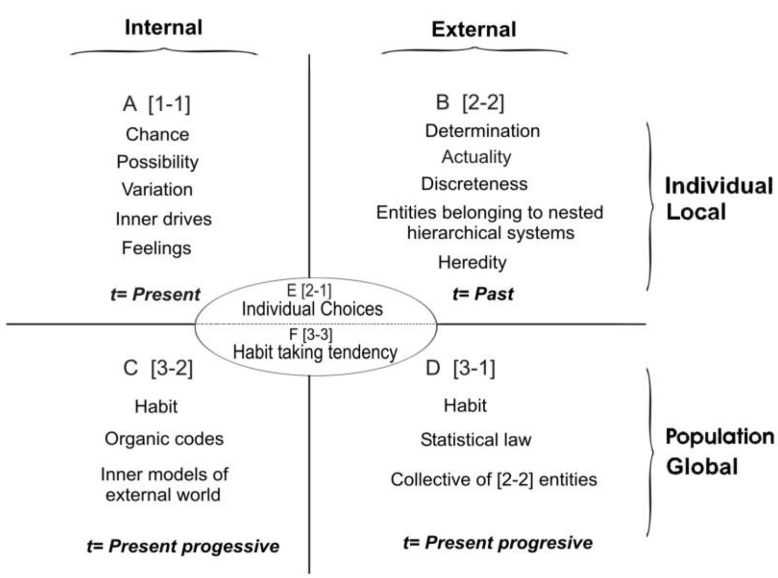

Figure 2. "Peircean" quadrant (modified after Taborsky 2002, 2006, by Andrade 2007). The "vertical" axis refers to the Lamarckian cut (internal left and external right) and the "horizontal" axis to Neodarwinian cut (upper individual and lower

population). This scheme shows that an expanded Darwinism can be seen as a specific case of Peircean ontology founded on the three universal categories (*firstness*, *secondness, thirdness*) and the six derived relations A, B, C, D, E, F. The upper left quadrant A defines an internal /local zone; the upper right quadrant B defines an external /local zone. The lower left quadrant C defines an internal/population (global) domain and the lower right quadrant D defines an external /population (global). Also shown are the intersections E and F.

A) Spontaneity: *firstness as firstness* [1-1] defines the local/internal field at the present time. Within the context of Peirce's ontological system this relation can be understood as available energy, unconstrained informational capacity, chance, spontaneity, potentiality (Taborsky 2002, 2006, 2008). In the case of living entities this relation corresponds also to inner drives, feelings and motivations. This predicate stresses the ontological nature of chance, best understood as a potential or the *input* of an order generating process. This relation points out to the original basic ground of expanding energy or impulse that because of being unconstrained contains all potentiality; it is thus chance as a creative source of all reality.

It is worth reminding that an explicit recognition of this inner space was introduced into biology by Lamarck who advanced the vague notions of *sentiment interieur*, inner drives and organization (Andrade 2007). Lamarck accounted for all these inner activities in terms of a vital fluid of heat, whose existence was later refuted by the mechanical theory of heat, nonetheless his claims can be today understood as self-organizing processes that result out of the dynamics of open far-from-equilibrium systems. This concept of the internal organization is not only found in Lamarck it could be traced back to Aristotle and to several XVIIIth century authors like Kant and Cuvier. The emphasis on Lamarck is presented for two important reasons, first to show the complementarity of this conceptual view with the Darwinian approach looking for the construction of solid integrative framework for an expanded evolutionary theory that would be congruent with Peircean ontology. Second because among all pre-Darwinian authors Lamarck was perhaps the one that insisted the most on a physical account of spontaneous generation the forerunner of today´s concept of self-organization.

B) Determinism: *secondness as secondness* [2-2] defines the local/external field at a past perfect time (Taborsky 2002, 2006, 2008). Within the context of Peirce's ontological system this predicate describes a facet of reality that refers to what is determinate and discrete, best revealed in all sorts of units or entities like particles, atoms, molecules, genes, DNA, proteins, prokaryotic cells, eukaryotic cells, organisms, structural modules, species, communities and so forth that define a nested hierarchical system. Nonetheless, this relation leads to classical reductionism when the lowest levels are seen as determinant factors. What is captured by this predicate is a mechanical description of the so given entity leaving aside the fact that its generation is due to self-organization and its persistence to structural stability and natural selection in a given context of interactions.

C) Processing of Information: ***thirdness as secondness*** [3-2] defines the global/internal field at a continuous ongoing action in the present (Taborsky 2002, 2006, 2008). This relation refers the establishment of a communication network by means of continuous processes of information gathering and internalization of environmental information. This information is encoded, recorded and interpreted by making use of symbolic systems that are shared by a population of discrete entities. Encoded information registers internal representations of the external experienced world. To clarify matters this relation stands for both process of gathering and encoding environmental information (Andrade 2004) and the resultant codes understood as established relationships between symbolic systems. Encoded information not only stabilizes morphological conformations generated by interaction with environmental factors, but also serves to define future propensities, evolving capability, anticipation and innovation. Anticipation is an ability usually associated to an intelligent behavior that can be accounted for by the structural plasticity of the generated entities. When in a given environmental context an evolving structure can adopt more than one functional state, there is more than one possible solution for an unforeseen environmental challenge. Thence, anticipation is an intelligent behavior associated to material systems that are plastic enough to alternate among several conformations that can be coupled to some environmental factors with varying degrees of affinity.

Innovation is generated by combinatory and permutation of existing digital codes. In general digital codes are based on physical, chemical, biological, social interactions that allow the translation from one language into another. This process of translation is also included in the relation [3-2], not the actual physical components that participate in this relation. DNA is the material format of a phylogenetic recorded history, but its meaning and function can only be revealed by a complexity of cellular processes and a higher-order system that makes this information useful. Codes are conventional rules historically established that enable an interpretant system to naturally translate one digital language into another. Therefore, while the translation of information from DNA to proteins is represented by relation [3-2], all kinds of discrete molecules that participate in this encoding and decoding process like DNA sequences, tRNA molecules, and proteins are of the nature of the [2-2] relation. The material description of molecules involved in translation of messenger RNA is independent on the encoded information they conveys. The encoding of this information is conventional given that the genetic code is arbitrary in the sense that the codon-amino acid assignments could have been different than they actually are (Stegman 2004) and also because regardless of the encoded message, the translation follows the same rules.

The notion of codes has been incorporated into biology, but its use has been restricted to DNA genetic code and human linguistic codes in order to account for the origin of life and the emergence of human language respectively. Barbieri (2003, p: 229-237) has pointed out that the emergence of different levels of organization requires the generation of its respective informative codes, to name a few: RNA splicing and processing codes that gave rise to eukaryotic cells, cell to cell adhesion codes that gave rise to multicellular organisms, the alignment of Hox genes that allowed the emergence of bilateral organisms and so on, although the arbitrariness of these codes is yet to be discussed. Thus, it seems that this relation has not been understood because the DNA-centered view of mainstream biology stressed a deterministic interpretation of life, in which evolutionary changes are due to DNA chance mutations and not to organisms´ urge to permanently gather of environmental information. The DNA-centered view restricts the combinatorial power to permutations of nucleotides in DNA and exons in eukaryotic genes and overlooks its amazing power derived from the modularity at every level of organization (Kirschner and Gerhardt 2005). In consequence the notion of codes has been restricted to the elements that are actually engaged in coding and decoding information, not in the information or the effective actions they induce.

Ontogenetic modifications are possible because life is made out of quasi-autonomous modules that can vary while their basic architecture and relations among them are preserved (Kirschner & Gerhardt, 2005, p: 220-224). The living world is not made out of puzzle like pieces that only fit very precise positions, but of a limited set of LEGO plastic ones that can perform more than one function. This explains why variations in spite of being structurally constrained can exhibit nevertheless an amazing plasticity that can be accommodated to a wide range of environmental circumstances. In this combinatorial power and phenotypic plasticity together, lie the possibility of creating internal models of the external reality before it is decided which one will be employed to cope with a specific environmental challenge. The *Umwelt* building abilities of organisms (Von Uexküll [1940] 1982) are associated with relations A (spontaneity) and C (processing of information) that directly address the inner aspect of reality (subjectivity) in their individual and collective forms, respectively. Organisms are, thence, real subjects (Baldwin 1896) and *Umwelt* builders (Hoffmeyer 1996, p: 54-58). The higher organisms` complexity are, the more complex and abundant are the internal models that must be sorted out before testing a specific one.

D) Statistical law: *thirdness as firstness* [3-1] defines the population/external field at a continuous ongoing action in the present. This relation statistically describes populations of atoms, molecules, genes, DNA, proteins, prokaryotic cells, eukaryotic cells, organisms, structural modules, species, and communities, respectively. Populations are described by a statistical distribution of a given parameter gauged for every individual in the population. In the case of populations of organisms, regularities are expressed as averages and dispersion values for a specific feature in the population that are thought of as outcomes of natural selection. In this sense, this is a well-known relation fully incorporated into mainstream biology, since for Darwinian natural selection shifts the average values for a given parameter as the population progresses towards adaptive states. Moreover natural selection may also sharpen, widen, flatten and divide the dispersion values encompassed by the bell shaped curves.

E) **Internally driven capricious choices**: *secondness as firstness* [2-1] defines the spatial internal/external, local (individual)/global (population) and the temporal present/past/present progressive interface. This relation describes actions that convert analog codes into digital ones and vise-versa (Hoffmeyer & Emmeche 1991), by means of establishing a connecting network. I equate this relation a tendency to diverge depending on individual's choices that can be understood only when looked upon in the context of other relations and as associated to *thirdness*. Peirce (C.P. 6.302) tried to reconcile the Lamarckian and Darwinian views of evolution by using as an example Clarence King's theory that proposed that evolutionary variations are neither random, nor directed, but instead generated by the organisms' tendency to adapt to a changing local environment (Aalto 2004). King opposed a gradualist view of change, arguing that drastic changes in the environment trigger rapid morphological modifications in plastic species. In today's language he was undoubtedly referring to phenotypic plasticity. Peirce did not neglect the importance of natural selection though he thought it required an internal election mechanism associated with the organism's mental activity that acts under the pressure of selective conditions. This Neo-Lamarckian mechanism leads to developmental differentiation processes oriented to specific goals that bring forth ever greater diversification and adaptation to local conditions.

This mode of evolution oriented to specific goals by means of external pressures and habit modification, reconciles chance and necessity (Peirce 1891). As individual organisms strive to anticipate daily challenges; the population of individual minds strives to reach a state of regularity and generality by harmonically integrating the diversity of tendencies that are constantly arising. Nutrition is a simple example of individual election mediated by specific recognition of adequate food stuff (C.P. 6.238-71). Intelligent responses lead to more or less correct choices and habit fixation that contribute to perpetuate life processes. Living systems learn by experience in accordance with a general process to develop habits and, given that matter (*effete mind*) is strictly ruled by habits (Peirce, CP 4.551), the universe as a whole evolves according to the same law. What from an externalist point of view is matter, is nothing more than 'consciousness' or 'living feeling' from an internalist point of view, that is to say that the emergence of mechanical laws are due to the acquisition of habits. Thence, it is thus badly needed to integrate internal external, individual populations relations in order to understand evolution.

The point is again that natural selection, as an external action, requires the prior existence of internally driven capricious choices. Nonetheless, natural selection favors phenotypes that are able to respond to changing conditions. To acknowledge that organisms execute intentional behaviors in matters related with the immediate conditions of life does not conflict with the idea of an open-ended and unpredictable evolution, in other words evolutionary unpredictability is founded on the existence of creative intentional responses at the individual level. Individual elections were clearly explained by Baldwin (1896) as he put forward a new factor in evolution named “organic selection”. According to Levins and Lewontin (1985, pp: 99-101) organisms determine what is relevant, alter the external world as they interact with it, transduce the physical signals that reach them from the outside world, transform the statistical pattern of environmental variation in the external world and modify their surviving strategies, so generating the conditions of their own selection. Organisms are not objects of selection, but the subjects of a cognitive subject-object relation. Natural selection shapes the population statistical regularity of a multitude of individual’s choices, by favoring the organic and genetic constitution of plastic individuals that manage to modify their surviving strategies. Therefore individual elections are at the base of evolutionary process since survival is for individuals that manage to develop adequate strategies oriented to exploit the environment in their own benefit.

F) Habit: *thirdness as thirdness* [3-3] is a property of every informational dynamical system, and it is here used to define the internal-local/external-global interface. This relation corresponds to a continuity and regularity that is responsible for habit taking, a predicate yet to be introduced, justified and formalized in order to understand that the law-like character of natural selection is a consequence of this relation.

> If the laws of nature are results of evolution, this evolution must proceed according to some principle, and this principle will itself be of the nature of a law. But it must be such a law that it can evolve or develop itself. (…) Evidently

> it must be a tendency toward generalization, - a generalizing tendency. But any fundamental universal tendency ought to manifest itself in nature. Where shall we look for it? (…) But we must search for this generalizing tendency rather in such departments of nature where 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. Now the generalizing tendency is the great law of mind, the law of association, the law of habit taking. We also find in all active protoplasm a tendency to take habits. Hence I was led to the hypothesis that the laws of the universe have been formed under a universal tendency of all things toward generalization and habit taking. (Peirce C.P. 7.515).

This relation is currently disregarded since scientists take for granted the existence of universal, eternal and unchanging natural laws and very seldom inquire about their origin. The current concept of natural laws shared by scientists is at best a limiting ideal case of an evolving law. Self-organization is the closest we have to a Peircean concept of an evolving law. According to Kauffman (2000, pp: 197-219), self-organization is a universal law that rules the constant exploration of forms and processes in the “adjacent possible”, so broadening the space of semiosis to the entire history of the cosmos that makes propagative organization wholly dependent on energy extraction. Agents spot their particular sources of energy by interpreting the information they manage to gather about their surroundings. The inherent unpredictability of the outcome of organisms’ action would lead to view habit as a blind final cause. Short (2002, 2007) argues a non-mechanistic interpretation of natural selection that is nontrivially teleological as he explains the differences between “selection of concrete genetic variants” and “selection for an abstract type of feature” within a Neo-Darwinian framework.

> Patterns of outcome, whether biological or thermodynamic, cannot be explained by tracing causal chains, even were that possible. They are *explicanda* of a special kind. The form of their explanation, in statistical

> mechanics or by natural selection, is not captured by statistical variants of the covering-law model or related models of explanation. In them as in classical teleology, types of outcome are cited to explain why there are outcomes of those types. But only when types are explanatory by being ''selected for'', as in explanations of animal and human behavior as well as in Darwin's theory of natural selection, but not in statistical mechanics, is the explanation teleological. Darwin's theory is nontrivially teleological. (Short 2002).

However while subscribing to Short´s view I want to remark the fact that natural selection owes its existence to self-organization that qualifies as the most general explanation of Peircian habit so far. Natural selection requires the prior existence of a population in which every individual is subject to arbitrary somatic or phenotypic adjustments as explained by developmental systems theory.

The introduction of characteristics E (tendency to diverge due to internally driven capricious choices) and F (habit forming tendency), will definitively foster the understanding of the existing relations among the different facets of reality for instance, internal dynamics, chance and indetermination can all be accepted provided we simultaneously assumed the existence of organization laws responsible for regularity and continuity in evolutionary time (*thirdness*).

Evolution and development are processes of sign interpretation

The history of science teaches how different kinds of entities were identified and defined from subatomic particles to organisms; today's challenge is to understand them in their context of interrelations and to integrate them within a monistic[3] dynamic framework. Dualism is incompatible with evolutionary thought for it fails to integrate physical, biological and mental processes. Conceptual and ideological preconceptions have force us to talk

[3] Monism states that the ultimate ground of reality, whatever it might be, is a manifestation of a *continuum* which in its permanent transformation and organization manifests as energy, matter, life or mind. It is a monism that is based on processes not on a fundamental subtle substance. To base natural phenomena on processes instead on substances or particles is the only way to overcome the traditional Cartesian dichotomy.

about matter and mind as if they were separate independent substances, by preventing us from coining a new word that stands for the *continuum* “energy-matter-life-mind”. The Cartesian anthropocentric idea of mind became an almost insurmountable obstacle that prevents us from overcoming dualisms; nonetheless we must try to conceive reality as a whole that can be approached through seamless continuity of the above referred characteristics. There is nothing supernatural in life and mind, since the so called living and mental processes involved in organisms’ individuation correspond to far-from-equilibrium non-deterministic open systems that develop in particular contexts.

Natural processes have directionality in the sense that *thirdness* requires *secondness*, and *secondness* requires *firstness*. But the sequential order of categories did not and does not apply, nonetheless the general von Baerian law according to which developmental systems go from the more general to the most specific, holds because the iterative interpretation of signs makes the output (interpretant) ever more differentiated and individuated (see figure 3). In the beginning there were a formless chaos, a purely random universe, a state of disorder and indetermination without any tendency or detectable regularity, a state of energy radiation at equilibrium. That was sheer pure *firstness*, a state of homogeneous timelessness out of which order came about. The emergence of order required the rupture of this symmetry, presumably 100.000 years after the Big Bang as a result of the expansion of the universe (Chaisson 2001, p.130). The formation of energy gradients made possible the intervention of habit, as the seed of generalizing tendencies in the form of local organization of matter. A random innovation came out of chaos and produced a reaction that preserved its state in a form of ever more genuine *secondness*. Organismic life crystallized on earth as a result of chemical and physical processes four billion years ago, and very likely elsewhere in the universe. From then onwards ever more sophisticated interactions were selected in a Darwinian way, so creating the co-evolutionary unfolding of the biosphere that brought forth complex systems like human language and thought.

The question of whether semiosis is universal or instead restricted to living systems would be clarified as it is recognized the existence of both analog (iconic, indexical) and digital (symbolic) sign actions in the living world, whereas physical and chemical (subatomic, atomic, molecular) systems are restricted to analog sign actions (iconic, indexical). The creative and combinatorial power of subatomic particles and between atoms themselves is produced by specific interactions (attractive and repulsive forces, chemical affinities, stereo chemical complementarity, etc) with mediating particles in the context of a population of particles. It is very likely that actually existing material arrays of subatomic particles were produced by combinatorial rules with the intervention of other particles that played the role of a third and not just by random collision among them or lucky coincidence. Every newly generated particle could then have played the mediating role for the generation of new aggregates and so forth. The identification of such non arbitrary analog codes are sufficient to justify Peircean pansemiosis as a universal cosmic phenomenon that manifests itself without any doubt with higher specificity and intensity in living systems as they make use in addition to symbolic codes.

Firstness is associated to an entropic factor and *thirdness* to an antientropic factor related to a Maxwell demon[4] like activity (Esposito 1980, p. 169), and not to a pre-established harmony or an infinite divine intelligence (CP 6.132) (Esposito 1980, p. 131). Both the antientropic principle, the tendency to adopt habits, and the entropic principle, the tendency to breakdown habits (Andrade 2003, pp: 127-137) are necessary for the understanding of Nature. Mind action is twofold, it moves from chaos to order by developing regularities and habit taking, but it also destroys habits, so preventing evolution and change from getting exhausted and becoming frozen.

Signs can be said to be functional sets built up out of three relations (Taborsky 2002, 2006, 2008). All existent forms, living or inert, are signs that can be expressed as: 1. *Input* → 3. *Mediation* → 2. *Output*. In figure 3, it is shown how the interpretant (*output*) becomes the mediating sign in the next iteration, so that sign and interpretant evolve together with each iteration until the final interpretant fully captures the specificity of the object. As mentioned above the iterative interpretation of signs makes the interpretant (*output*) ever more differentiated and individuated.

[4]Maxwellian demons were paradoxically assumed to create local order out of molecular disorder and random movement by means of work actions executed in accord with information about position and velocity of individual molecules that bounce in a closed chamber. According to Zurek (1990) it is physically realistic and feasible to conceive an Information Gathering and Using System if three conditions are met: 1. far-from-equilibrium, 2. openness, 3. inner structure that enables the creation of a memory record. For a detailed explanation see Andrade (2003, pp: 121-133).

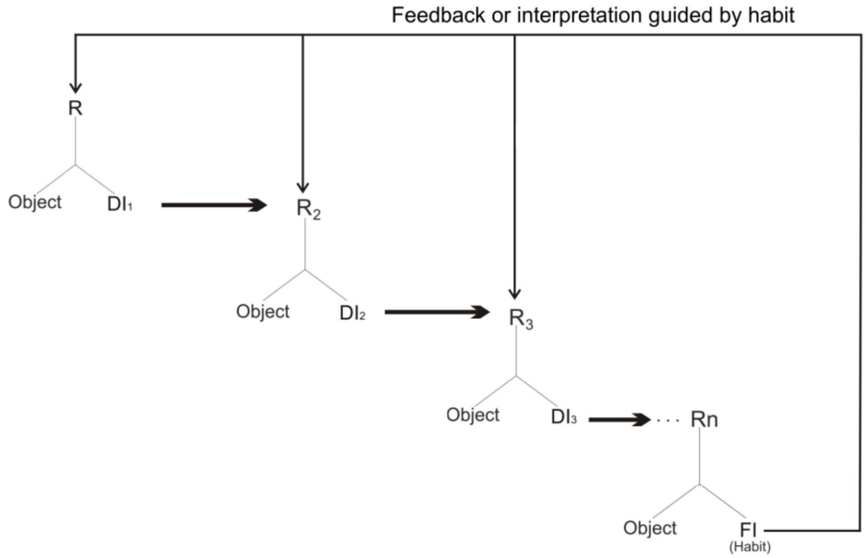

Figure 3. Sign is a triad of irreducible relations between object (O), sign or representamen (R) and interpretant (I). As the sign iterates itself, the dynamical interpretant (DI) becomes a new sign or representamen that mediates between the object (*in put*) and the new interpretant (*out put*), that becomes a new sign or representamen, and so on until the final interpretant (FI) is produced.

According to Hoffmeyer (1996, p: 20), ontogeny is a process of sign interpretation, in which the potentiality of genetic information (*input*) is realized into specific developmental pathways (*output*). The fertilized egg (sign or representamen) selects a few of the many possible pathways by constantly controlling gene expression in a given cellular context, so that given the same genetic information and environment, interpretation would tend to be repeated according to the same guidelines, although new interpretations may occur opening up new developmental routes that become variations upon which natural selection will act. Likewise, evolution is also a process of sign interpretation (Hoffmeyer 1996, p:22). The ecological niche offers a multitude of possibilities and opportunities to the population (*firstness*), but only very few are selected, in a move that yields, in the next generation, a population with a fitter genetic composition (*secondness*). The key point is that this operation is mediated by the organisms' interpretation of their surroundings. The new genetic composition defines the set of possible ontogenies that might develop in the next generation. In consequence evolution and development are tightly entailed in an unbroken loop. Environmental action is twofold, it acts as an informative factor of development and also as a filter, but in either case the environment is the product of organisms' construction (Andrade 2009, pp: 357-360). I do not pretend to ignore that there can be large scale perturbations or catastrophes that are not constructs or the organisms and should nevertheless be considered as part of the environment.

Natural abduction

In epistemology the origin of new hypotheses is explained by abduction, a form of inference in which guessing is goal oriented by experience towards the specification of a particular end, while taking chances and making the best of ignorance. Observed cases trigger the formulation of a set of tentative hypotheses and habit guides the election of the particular one that is going to be tested. A Popperian conjecture (Popper 1968, p: 240-248) that fails, to demonstrate its internal coherence and its ability to solve a specific problem in a better way than previously existing theories, is rejected. Accepted hypotheses provide new explanatory rules that reinterpret observed data, and orient future research that might provide a mathematical formal model. In an analogous manner, natural abduction is the process through which organisms elaborate a possible response to environmental changing conditions by using all existing structural resources accumulated and selected along evolutionary processes. This is congruent with Jacob's "tinkering" model of evolution. According to Jacob (1977), evolution does not conform to an engineer's plan in which every single detail was preordained to fit a specific function, but rather it works out like a tinkerer with what it has at hand in order to build up a workable contraption.

> In contrast to the engineer, evolution does not produce innovations from scratch. It works on what already exists, either transforming a system to give it a new function or combining several systems to produce a more complex one. Natural selection has no analogy with any aspect of [conscious] human behavior. If one wanted to use a comparison, however, one would have to say that this process resembles not engineering but tinkering, *bricolage* as we say

> in French. While the engineer's work relies on his having the raw materials and the tools that exactly fit his project, the tinkerer manages with odds and ends. Often without even knowing what he is going to produce, he uses whatever he finds around him, old cardboard boxes, pieces of string, fragments of wood of metal, to make some kind of workable object. As pointed by Claude Levi Strauss, none of the materials at the tinkerer's disposal has a precise and definite function. Each can be used in different ways. (Jacob, 1977).

That is, that existing structures selected for a particular function are forced to perform new functions in a new context. If organ A (fins) is used for task B (to swim), and if task B is similar to task C (to crawl on dry land), then organ A can be used to perform task C. The tentative hypothesis or abduction is that if task B is similar to task C, therefore, if A then C. In consequence fins will develop into legs as it is assumed to have occurred when ancient fishes conquered dry land.

Abductive inference is the simultaneous expression of predicates E, "internally driven capricious elections" and F, "tendency to form habits". Relation E opens up new possibilities, while F makes possible further abductive responses. Following Peirce (CP 2.372-388; 5.171; 6.470-473; 7.202-203) abduction plays the most important role in the generation and evolution of knowledge.

It is important to clarify what is meant by abduction and the reasons why evolution does not work solely by deduction and induction. Evolution by natural deduction would be equivalent to the execution of a program that retrieves as its output a form which was somehow prefixed or encoded in the initial conditions, not a real novelty, just mere following of coded instructions. Evolution by deduction is the standpoint of preformism, regardless of whether it works in accord to a natural plan (Lamarckians) or in compliance to a fixed genetic program (Neo-Darwinians). On the other hand, evolution by natural induction is like a classical Darwinian process that starts with a wide diversity of forms out of which only those that match the rules imposed by a determinate environment will survive and generate offspring.

Neither induction, nor deduction, account for the origin of new hypotheses, in an analogous manner evolution cannot rely exclusively on blind chance exploration of the entire morphospace, and not either on deterministic definition of the right configuration. Instead, the origin of evolutionary variations depends on random biased search of a limited morphospace (the set of forms that are really attainable at a defined time in what Kauffman (2000, p. 197-219) defines as the “adjacent possible”). Likewise, abduction is based on selection of internal states (genetic and epigenetic) that function as representation of their external world, oriented by guessing and intuitions that lead to venture an alternative that can be right or wrong, in the former case there is survival in the second death. Individual chance events are always contextualized by specific local environmental conditions and structurally constrained, as a specific action is decided by a population of agents, their outcomes can be shown to follow a statistical law (D) in which the dispersion around the average value results out of independent target aiming trials. Thus, phenotypic adjustments (physiological, developmental and behavioral) are like choices, though structurally constrained and based on gathered environmental information, oriented to minimize the risk of uncertainty.

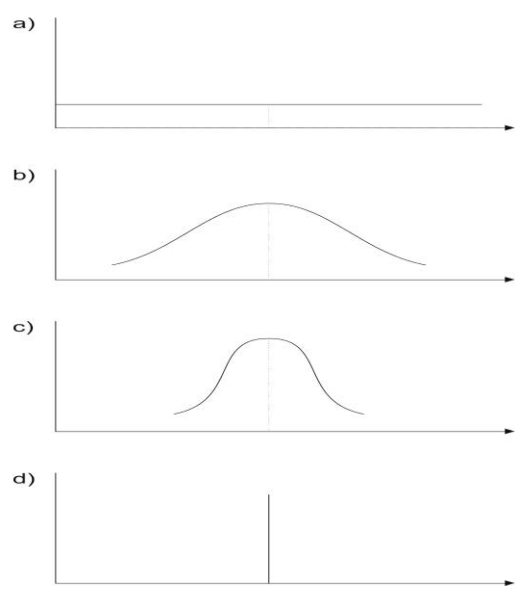

Figure 4. Evolution from randomness and chaos to regularity of habit formation, is represented by a series of graphics where the "y" axis corresponds to the probability of a given event and the "x" axis to different possible events. a) Randomness (all events are equally likely). b) Statistical distribution in which all values tend to vary around an average with a wide range of random variations. c) Statistical distribution in which the variation range is reduced. d) Limiting unreachable state where everything functions according to a deterministic law.

The above figure shows how individual choices form a continuum that lies between pure chance and absolute determination. Due to the individuals' aim at hitting an arbitrary chosen specific target, a statistical distribution emerges in the population. When there is no informational guiding in every individual choice, all outcomes would be equally likely, as shown in the ideal case "a", random uniform distribution. The other limiting case is determinism or the situation where the output is always the same, a situation that Peirce explained as the result of extreme habit fixation by learning. The choice of target that defines the average value cannot be computed from the input since there is always an element of free choice between different outcomes as was explained above in reference to relation E (tendency to diverge due to internally driven capricious choices) and also congruent with figure 1. Real life situations correspond to cases "b"and "c", where there is always an element of both chance and necessity, since creativity is made possible by individual's effort to choose a new action that if selected would define the average value of a new statistical distribution.

It is impossible to explain absolute randomness (figure 4, case a) because to account for something is to uncover the order it may possess, if a random sequence of events is shown to have some regularity, it ceases to be random. Likewise, the opposite extreme of determinism given by absolute generality (figure 4, case d) cannot be explained either, since it would assume in the *explanandum* the existence of a still more general law that would be the *explanans*. Only intermediary cases (figure 4, cases b, and c) between chance and complete determination can be explained in reference to other cases that are also a mixture of chance and determination. The explanation can be formulated in relation to Peircean categories, so to speak that laws can be explained because some amount of randomness remains. Chance constantly breaks down frozen habits and regularities while new habits and habit change are always being generated making use of random fluctuations. In the long term randomness decreases, as potentiality wanes, order, stability and predictability wax.

Interpretation is always mediated by habit, which is reinforced at every iteration (see figure 3), making of abduction an inference that is ever getting closer to the “truth”. The fact that uncertainty decreases in local contexts, makes that the possibility of error (fallibility) never be completely eliminated. Natural abduction refers to the fact that phenotypic adjustments (physiologic, ontogenetic, behavioral) are not random, but directed to solve, by means of all structural resources produced in evolutionary time, a problem posed by the conditions of life, in an analogous way to the learner’s elaborate internal representations and suggests conjectures by using existing theories, tending towards the solution of a conceptual problem.

Abduction plays with similarities that trigger new interactions between already existing units, what is new is the interaction, not the entities or the structural motifs involved in that specific interaction. The dynamics of epigenetic landscapes are made up, both, of stable *chreods* that constitute channels of developmental pathways (see figure 1), and of innovations that happen at the unstable bifurcation points where a decision is taken, partly by chance (developmental noise), partly by “reasons” that belong exclusively to the developing systems. To understand the organisms’ reasons is to understand their *Umwelts* as something that we as humans can imagine but never really grasp since we are unable to put ourselves in the center of someone else’s *Umwelt*. Once the path is taken, if it proves to be the successful choice, it will be selected for and stabilized along evolution. Environmentally induced phenotypes could become stable by natural selection of genotypes that stabilize individual somatic adjustments (phenotypic accommodation) (West-Eberhardt 2003, p. 157) by means of genetic assimilation (Waddington 1961). The point is that phenotypic (analog) adjustments by interaction with environmental factors are prior to genetic (digital) encoding, in the same manner that abduction is prior to formal theories that are to be tested by induction and deduction. Decisions are the outcome of abductions based on the agents’ created internal representations about the immediate circumstances.

Peirce metaphorically stated:

> Besides, you cannot seriously think that every little chicken that is hatched has to rummage through all possible theories until it lights upon the good idea of picking up something and eating it (Peirce n.d.:Ms. 475 quoted by Harrowitz 1988, p: 196).

The above quotation serves to solve a recurrent question in evolutionary biology in reference to how the space of all possible configurations (morphospace) and all genetic permutations (genetic space) are explored before the good one is picked up. Considering that the space of possibilities is astronomically immense in real time it is physically impossible to expect an exhaustive exploration by random search[5].

In the context of organisms, these exploratory biases may be characterized as abductions. Contrary to Dawkins evolution is not totally blind but instead works by making something analogous to abductive inferences.

I argue that the Darwinian triad, [Variation (V) (*input*) → Natural selection (S) (mediation) → Heredity (H) (*output*)], that identifies the core of Darwinian theory is a specific case of the more general Peircean triad, [Firstness (*input*) → Thirdness (mediation) → Secondness (*output*)] (Andrade 2007). As mentioned above evolution can be represented as a series of iterations where the output becomes the mediator in the next iteration and so on (figure 3). I will show that each component of the Darwinian graph V, H and S, can be likewise be conceived as a graph, that can be used to build up of a higher order isomorph graph that provides a schema for an expanded evolutionary new synthesis.

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[5] Levinthal (1968) expressed this problem as the protein folding paradox. If a protein were to attain its correctly folded configuration by sequentially sampling all the possible conformations, it would require a time longer than the age of the universe to arrive at its correct native conformation, even if all possible conformations were sampled at nanosecond or picosecond rates. Considering the very large number of degrees of freedom in an unfolded polypeptide chain of 100 residues that will have 99 peptide bonds and therefore 198 different phi and psi bond angles, and if each bond angles can be in one of three stable conformations, the protein may misfold into 3^{198} different conformations. However the "paradox" is that most proteins fold spontaneously on a millisecond or even microsecond time scale, given that within the cytoplasmic environment the explorations of the native protein structure are biased and guided by local interactions, some configurations are preferred by thermal stability from which a random exploration of neighboring more stable forms are selected and fixed.

1. Variation as a manifestation of *firstness* can be accounted for by the triad: [Inner drive (*input*) → Statistical law (mediation) → from random to biased search (*output)*]. This biased search is the abduction that mediates the subsequent iterations that produce variants that go from pure randomness to more or less, oriented or biased towards specific environmental cues (Andrade 2004) (see figures 4 and 5).

2. Heredity as a manifestation of *secondness* can be accounted for by the triad: [Reaction to the environment (*input*) → Gathering, processing and encoding of environmental information → Genetic accommodation and assimilation (*output*)]. The subsequent iterations will be mediated by genetic information that fixes genetic hereditary content, in the long run as a final output.

3. Natural selection as a manifestation of *thirdness* can be accounted for by the triad: [Statistical law (*input*) → Tendency to form habits (mediation) → Gathering, processing and encoding of environmental information (*output*)]. Further iterations mediated by gathering, processing and encoding of environmental information will tend to produce new internal representations that streamline the reproduction and ontogeny of individualized entities and at evolutionary time make possible the emergence of new levels of organization.

The integration of the triads (1.2.3) generates a higher order triad that describes the process of abduction: [More or less biased search (*input*) → Tendency to form habits (mediation) → Genetic hereditary content (*output*)]. This last triad describes that as it is progressively iterated "random search" becomes a "biased search" that never reaches the point of an immediate, directed "reaction to the environment" (see figure 4). This "biased search" is best seen as the relations E and F, "individual choices" and "tendency to take habits" acting together. "Individual elections" are half way between the chance of "random search" and the determination imposed by the "reaction to the environment", because they are abductions or inferences made by using previous knowledge that enable organisms to cope with new observations or environmental factors in a truly creative way that is permanently happening in evolution. Evolution would be a series of diverging continuous unpredictable creations and explorations, neither blind nor directed, of an extraordinary realm of possibilities performed by a population of agents that are forced to decide in hazardous situations due to scarcity of resources, time pressure and what is more important with uncompleted information about their immediate environment, but nonetheless capable of interpreting their surroundings and creating internal representations of it. This learning ability allows the production of functional responses to pressing challenges. Abductions manifest in the form of individual choices that become the dynamical input of processes of sign interpretation like development and evolution. Darwinian natural selection preserves the agents that made the adequate abductions in local conditions and becomes the expression of an organizing tendency to form and preserve habits by converting statistical regularities into informational codes.

Conclusion: Evolutionary Open-endedness and Uncertainty

Evolutionary uncertainty about the future is a direct consequence of having to live with incomplete information about the environment. This insufficient information is the result of two facts: 1. the cost of information gathering, 2. finiteness of recording capacity. Any living system must invest energy in order to explore and gather information about its immediate environment; an investment that is rewarded as new sources of energy are spotted. Information about the possible sources of available energy is communicated in the form of signs that organisms learn to interpret adequately. There can never be an informational inner model of the environment that is complete in its description because of the exploration cost that forces the organisms to decide how much gathered information is enough. In addition, the finiteness of the perception range permitted by the senses and recording capacity depends on the structural complexity of the receptor's organs that makes that available information always incomplete. All these factors assure that agents always face some degree of uncertainty, so making abduction necessarily risky, nonetheless to take chances is the only way to keep functionally active and therefore to evolve.

The idea of evolution by abduction stresses the point that novelty does not come out of nothing but by establishing unpredictable yet locally functional interactions between existing entities. In fact the notion of interactions abounds in modern biology; an interaction implies a specific recognition followed by a structural adjustment in a specific local environment. For instance proteins and RNA exhibit alternative folded native states, cells present a potential towards differentiating along diverse paths and exhibit alternative structures as they differentiate, and individual organisms present plastic physiological and behavioral states in response to the environment. It can, thence, be stated that living entities, in fact, are forced to capriciously choose or decide, in the sense that organic structures oscillate between different conformations, and which one will be stabilized depends on how the agent interacts with environmental factors. Interactions are driven by the need to capture free energy (see above relation A or [1-1]).

The relation between ignorance and indetermination would lead to a pragmatic indeterminism that we are forced to adopt in the face of the complex diversity of the world that we cannot directly explore. This indetermination that evolution keeps for itself is due to the fact that it operates by abduction. With the purpose of improving the theory of natural selection Margaleff (1996, p. 122) stated:

> Basically it is a matter of examining whether decision processes that define who will survive and who will die are really uniform. There is a suspicion that organisms themselves, depending upon the degree of organization, can modify decision processes that were very simple in the past, making them more complicated along evolution. In this manner there would be an evolution in the forms of natural selection, and therefore, an evolution of evolution, that is coherent with information's surprising capacity to fold back on itself. (Margalef 1996, p. 122).

As the outcomes of abductions become more specific, decision processes become more directed and complicated along evolution. The information's surprising capacity to fold back on itself is best explained by sign iteration in which the interpretant becomes the mediating sign in the next iteration (see figure 3).

The analogy between the origin of new ideas and evolutionary novelties is best founded on the idea that evolutionary variations operate as an analog of abductive inference. The problem lies in the fact that evolutionary variations are assumed to be random whereas the emergence of new ideas is assumed to be the outcome of conscious effort oriented to solve specific problems. Neo-Darwinians claim that biological production of new evolutionary variations is both mathematically random and independent of organisms' needs (blind), by contrast if the evolution of new ideas is goal-directed it would fit into the Neo-Darwinian scheme. However I think that this argument stems from a well rooted prejudice that no longer holds. This argument ignores the fact that the very idea of blind random variations (mutations) cannot account for evolution, for they occur within the context of phenotypic adjustments that are directed and structurally constrained. In the same vein, the evolution of ideas is not directed either, this prejudice has to do with the fact that the role played by abduction has been overlooked by classical epistemology more concerned with how theories were validated, not with how they were created. Besides, it is necessary to question the way we perceive ourselves through the lens of an idealized rationality that prevents us from understanding that our decisions are made with incomplete and insufficient information so that we are surprised by undesired and unforeseen side effects. In our Cartesian idealization of rationality, we came to believe that we are in possession of an exclusively human faculty whereas, in fact, abduction is a form of inference tightly entangled to inductive and deductive thinking. The point is that abductive inferences are not exclusively human, since they are performed by living beings that try out the best possible response to challenging conditions (Andrade 2009, p:374). What might be exclusively dependent on a more complex brain organization are inductive and deductive forms of inference, that enable the elaboration of a more complex and abstracts abductions in the case of humans, but all three (abduction, induction, deduction) are embedded in the permanent semiotic interpretations of signs that occurs in living nature.

The incomplete certainty offered by science fortunately always leaves freedom for innovation, heuristic creativity, analog search, intuition and symbiosis among different and diverging branches of knowledge and everything that rekindles the proliferation of hypotheses. To venture a hypothesis to be submitted to the harsh test of academic rigor of a scientific community is the only way to broaden the horizon of knowledge.

Likewise, in economy the incomplete handling of information, e.g. about the market, forbids the dominance of fully deductive inferences; all prescriptions are founded on statistical tendencies and frequently fail. However, the inductivist way would certainly not be feasible, since to try out one by one all possible solutions, would be extremely costly in terms of energy expense and time. Darwin established the analogy between the economy of nature and human economy, yet to be developed. This great breakthrough fits better with the idea that natural agents act and choose by abduction, risking their lives in order to gather limited information out of the environment. Abduction is partially blind, but capable of being guided by habit. It is worth the risk of pursuing specific ends. Although agents tend to minimize risks at the local level, the outcome seldom coincides with the aimed target, since both aims and targets change constantly. Therefore, natural abduction must be constantly iterated and natural selection as an expression of habit forming tendency must be allowed to fix adequate behaviors. One of the reasons the scientific status of economy is disputed comes from not understanding the role of abduction in the generation of knowledge. But if we interpret the game in which economic agents are engaged, as one of abductive inferences about their conditions of life oriented to decision making, may they be transient and local, we would capture the scientific status of economy and, in a better way, that of biology (Andrade 2009, p: 375).

Darwin chose a fruitful analogy when he decided to compare living organisms with economic agents, an idea that freed evolutionary theories from the goal-directedness of Lamarckism, since individual decisions are like abductive inferences that open up a panoply of possibilities in the population that are to be tested by natural selection. Cognition is always mediated by signs that are to be interpreted, therefore the set of data that serves as *inputs* for an abductive inference are never found in "pure state" instead, they are determined by the interpretance systems *sensu* Salthe (1993, p.16), that is the categories of the observer's systems like modes of perception, previous theories and so on. Likewise evolution takes place within interrelations of mutual dependence in which the selected habits of diverse entities are interlocked. Contexts and habits belong to the general, for they confer regularities to the forms of action and perception. The concrete articulation to the diverse contexts determines the field of possible hypotheses. Abduction obeys a logic determined by a hierarchy of contexts and so on *ad infinitum*. Abductive logic is the common ground of the evolution of ideas and the evolution of life forms, and is associated with an element of indetermination and free will that has been targeted by the opponents of evolution. Evolution does not obey to a wholly deductive logic, its logic is the logic of abduction, instead of conforming to a predetermined natural plan, it constantly produces ever more specific and differentiated forms that bifurcate in unpredictable ways.

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