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Impetus, perception, sign, signal, information: growth of a living system from a complex one.

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Abstract:
This paper investigates prerequisites for emergence of semiosis in living systems. It examines conditions for the occurrence of perception and functionality in systems and its consequences for transition of a mere complex system to a living one. In addition, it deals with concepts of signal and information in living systems and makes a clear distinction between sign as a final state of semiosis and signal as a starting point of functional transformation.

Keywords: biosemiotics; complex systems; functionality; living systems; perceptivity; information

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1 Introduction

Concept of sign and its construction, developed by C.S. Pierce is regarded as a starting point in contemporary biosemiotic. However, the majority of works in this scientific field are oriented towards the approach established by Jakob von Uexkull; those works describe rather than explain functions of organisms in terms of construction and interchange of signs. Since contemporary biology is still occupied by paradigm of exclusive use of concepts borrowed from physics, that kind of approach can be very fruitful because it can picturesquely represent a conceptual frame of an alternative approach to explanation of phenomena in biological world, and thus facilitate its acceptance in mainstream biology. However, as a result of frequent oversimplification of Pierce's ideas, and analyses which do not go beyond reviewing basic framework of Peircean semiotics (with constant turning back to proposed triadic nature of sign), conceptual slips are far too common. This situation favors (among other reasons) those other fields of biology, which do not deal directly with biosemiotics and are unready to accept and apply ideas of sign or semiosis in living systems. It would be beyond the scope of this paper to fully cover Pierce's work about character and generation of sign. Moreover, an oversimplified reduction of his concepts to a paragraph definition would be a sort of vulgarization (similar in a way to a definition of number: it can be defined in a few sentences, but that kind of definition is only acceptable in encyclopedias and can be very misleading). Therefore, I will take as granted the reader's knowledge about Peircean notions of Sign, its division onto Icons, Indices, and Symbols, and about Ground, Dynamical/Immediate Object and Dynamical/Immediate/Final Interpretant [1].

Based on these concepts, this paper examines prerequisites for the occurrence of jump from a mere complex system to a living one. In other words, it focuses on the occurrence of perceptivity and functionality in complex systems and on their consequences for the development of a sign. In addition, the final part of the paper deals with (re)formulation of notions of signal and information in living systems.

2 From impetus to perception: a very long journey

It has been emphasized [2] that the key moment which singles out a process of semiosis from the necessity of physical/chemical interactions is the insertion of interpretation. Thus, the arbitrarily determined process of transformation of Dynamical Object into Sign is established. Here, "arbitrary" does not imply complete openness of fields of final states of interpretation, but underlines the absence of the necessity determined by Dynamical Object through which one exclusive modus of transformation of the Object itself, or the complex whose part it is, should be performed. Since we are here analyzing semiosis in living systems, we must first consider the character of the sign formed in such systems. One of the major properties of human made signs is their conventionality, which implies a significant degree of openness. If we analyze all the consequences of that fact, we can see that any kind of interpretation, undoubtedly with significant violation of conventions, can be derived from any kind of sign [3]. However, in living systems the interpretation of signs is not conventional, but structurally determined, which keeps them exclusively on a level of Iconicity. It does not cancel their arbitrariness in the above stated meaning but establishes a very specific situation. First of all, the possibility of their variability is restricted by functionality of changes. In other words, every change in Dynamical Object (or in the Ground itself) which leads to in-

capability of generation of Immediate Object [1] means its complete loss for a system (Observer). That is, unless Observer too changes in the adequate direction. Because of such rigidity, where sign cannot escape its Iconicity and where possibilities of interpretation are limited, I completely agree with Eco's statement [2] that in living systems it is more appropriate to talk about proto-semiotics, than about proper semiotics where sign can take its Indexical, Iconical or Symbolical character. Secondly, in living systems a link between Interpreter and Object is much closer than in the "world" of abstract and conventional signs. By this I do not imply that Iconicity is closer to Being than, e.g. Symbolicity. Both stated categories represent a characterization of Sign, whose essence is in both cases establishing arbitrary nexus between Object and Observer. What I want to draw attention to is that Dynamical Object and Interpreter evolve together. To fully comprehend this, it is necessary to point out the following distinction: we cannot say that Interpreter adds meaning to Dynamical Object as to a passive entity. On the contrary, a system assimilates Dynamical Object and, at the same time, Dynamical Object shapes the system. At the point of intersection Sign emerges in its most narrow definition (as Immediate Object and its Immediate Interpretant). Before continuing this discussion, I will take a brief detour to discuss the meaning of assimilation and how it relates to, what is here somewhat ill-defined as "shaping".

Assimilation is incorporation of environmental objects into a cycle of operations, which is essentially closed and continuous [4]. Through assimilation, the environment and operative schemes of organisms are mutually affiliated. Thus, every structure from the environment that interacts with the system is imprinted with systemic forms. To think that this is yet another way to explain semiosis (or proto-semiosis) might result in to an entangled set of incomprehension. Assimilation, which derives from semiosis, is a functional category [2] and as such begins with a sign and ends with readiness for transformation of the environment. In this context, it has one key inherent consequence: imprinting its own organization on the environment. As a result, the environment is, through schematization, divided into operative segments, spatial and temporal, through processes of deletion and emphasizing the differences: inside one segment all the differences, varieties and dynamics are erased and do not exist for the observer, while on the other hand, boundaries between segments are strongly underlined, which sometimes generates opposites inside one continuum of events. The environment formed through such simultaneous operation becomes susceptive to systemic processing, and only then, a system can functionally react to it. Schematization models are the same endogenous factors that determine the system and its patterns of assimilation. Through it, the system repeats the same types of endogenous differentiations while interacting with the environment and imposes them on the environment. This way "everything else" is arranged so that it can be manipulated. Since organism "constructs" environment to fit its own needs, only relevant and meaningful changes can be allowed into that environment. However, that construction cannot be generated exclusively by the system itself. Instead, it necessarily has to follow, what Eco [2] defined as "lines of tendencies". That is exactly what I mean by "shaping", with one difference: he refers to tendencies in Being, while "shaping" is restricted to tendencies that spring from Dynamical Object. One might wonder why we are using this restriction when it is clear that tendencies originate from changes in Being. There is no doubt of that, but the issue here is only the analysis of what goes on inside living systems and that is why we should remember that a change in Being does not imply a change in Dynamical Object. Therefore, only changes in Dynamical Object can be recognizable and can provoke changes in Immediate Object/Interpretant.

[1] at this point, discussion on Ground or Dynamical Object becomes meaningless

[2] whether semiosis must end in functionality in order to avoid transformation into a never-ending chain of sign generation is another issue

If that is so, it is highly inappropriate to claim that a system simply adds patterns to Dynamical Object, thus shaping it into functional norm (and signals- see later) and further operates with those patterns. On the contrary, it is inherently reciprocal process - lines of tendencies from Dynamical Object are also imprinted onto the structure of the system, thus shaping its pattern of assimilation of environment. Dynamical Object in itself is inherently out of our (or any systemic) sight ("sight" as a possibility to directly analyze something), but also, it cannot be considered completely arbitrary, completely Outer. Now, we can return to the problem of co-evolution of Dynamical Object and Interpreter in living systems.

Genetic analysis, where emphasis is on system's development, shows that Perception does not construct signs from Noumen and that in further development it does not detach itself from that same Noumen through process of formalization and abstraction. Quite the contrary, emergence of perception and emergence of Noumen are parallel processes. Only with appearance of perception can overall existence be broken into two categories: *Ding an sich* (in Kantian terms) on the one side and process of semiosis, which commences with Ground, on the other. This observation is not a novelty in philosophy, but it can never be stressed enough, because it ensures prevention of numerous misunderstandings connected with the character of the sign itself where it poses as something equivalent to signal or information or, on the other hand, its existence is negated outside the range of human culture. I will come later to the problem of signal and information and how they relate to the sign, but for the time being I will keep focus on the differences between Impetus and Perception, and will try to make clear their crucial role in appearance of (proto)semiosis in living systems.

Here, Impetus is defined as a category of pre-semiotic world. What generates and fully determines the character of impetus in actual situations are solely collisions and force field. Impetus is an event in the physical/chemical world, which happens necessarily without a possibility to intrude any systemic constraints over it. Surely, it does not imply the absence of all limitations to its activity but implies that in essence, it has a punctual character and that not every single event has its own developmental history. It forms and occurs in a given state and practically disappears that very same moment. However, from such a non-historic situation amazingly complex "macroscopic" structures can spontaneously emerge, with very complex dynamics and ability to sustain themselves using a constant energy input ("dissipative structures"), which was signified by Prigogine [5]. However, they still are not living systems, although in certain cases they are on the very brink of it.

In order to build itself and function properly, a living system must possess an interactive web amongst its elements. For a long time, this thought was both the beginning and the end of functionalist reflections on living. From its birth in XIX century, the idea of functional harmony as a result of gradual evolutional adjustment has been one of the basic starting points in most biological researches. Though mostly tacitly or inadvertently applied it seems self-explanatory enough, so that it can seem trivial to make it into a problem. Because of such an undeveloped view on their own objects of research and apparent overlapping of phenomena in question, contemporary biologists readily and uncritically accept conceptual and notional innovations from cybernetics, information theory and theory of complex, dynamical systems. Nowadays, it is impossible to speak about genetics, evolution or physiology without mentioning coding, transmission or inheritance of information. An older term "interaction" today is frequently replaced with terms "communication" or "informational flow". It follows that common wisdom of cellular events can be formulated as follows: in common space there are elements that encode, mutually transmit and receive, and then decode information thus constituting a functional system. In this picture, DNA is a master

regulator, which, with the rest of cellular machinery controls all processes in the cell. Indeed, that space is viewed as divided into functionally dependent compartments, but that compartmentalization is realized only through spatial boundaries or analytically construed metabolic pathways. Spatial compartments appear in the form of organelles or specific localizations of specific enzymes (e.g. membranous enzymes) or in the form of metabolism as a system of orderly and well-arranged pathways. In such a picture, where the term -"metabolic pathway" is only a heuristic principle, it is evident that one of the first questions would be how order is gained from such (let me use this somewhat fashionable term) "chaos". To aid the answer, another physical concept was borrowed - noise. The main trend in contemporary research of "complex systems" (as living systems are often quoted) became self-enclosed into analysis of networks, nodes and noise among them. According to Shannon [6], noise can be defined as a physical process that interferes with transmission of a message. As Ashby [7] noticed noise could not be defined as some absolute category; we can talk about noise only when the recipient of information specifies which information wants to "hear" and which to ignore. In scientific disciplines which deal with the so- called intracellular noise, this very important notice is ignored and noise has been regarded as any random behavior within a living cell [8] due to which the entire discipline loses its ground. Change the focus to biosemiotic perspective and many assumed problems will disappear since it becomes clear that every perceptive system constructs its environment and that all interactions for the system can occur only in such reduced range of observable changes. This matter has been dealt with elsewhere frequently enough [9,10], so I will not review such statements but will try to analyze prerequisites for the occurrence of perceptivity. In order to talk about the environmental segmentation by a system, we must take a step back and look at the initial intuition of living systems, or more precisely on the observation that they are composed of arranged network of their elements. If we leave the mainstream paradigm and shift the focus from network to a notion of "arrangement", we will soon be able to unmask the mentioned prerequisites.

Fusing chains of transformations into a more or less stable complex, a mere aggregate of molecules is transformed into a self-sustainable system. Prigogine showed that such transformation could occur spontaneously. The occurrence of arranged complexes of transformations is also the key moment when rudiments of two new conditions simultaneously emerge (since they are conditioned by each other): system/environment distinction and environmental segmentation. This is not yet perception in its full sense but prerequisites for favoring certain environmental segments are formed, based on their relation to influences that originate beyond a given complex. Moreover, with formation of proto-perceptivity, causality (as a category of simple, isolated sequences of events) already starts receding and in its stead a new ruling principle appears- functionality (as a systemic category). Of course, causality does not disappear, and it always resides within functionality, but in such systems, it is no longer a major and only governing principle. In that way, physical/chemical processes are encapsulated into a purposeful dimension, which (among other consequences whose analysis would be beyond the scope of this paper) results in setting the frame for functionally meaningful perception of environment. Through such functional schematism, environment is compartmentalized into segregated, but not isolated, wholes. First of all, what does not hold functional value for perceptive system remains beyond the range of (proto)perception. Generated in that way, the already reduced environment continues to be receptively schematized into different value-frames, where each one, has absolute character in its domain. Through purposefulness, schematism is imposed on environment and thus allows regulation based on parameters ("parameters" are generated as a result of schematization and they do not exists outside functionality). That way, processes and their regulations are freed from a constant pressure of

outer changes in two basic ways: (i) a certain range of environmental changes becomes irrelevant and thus invisible for the system itself, and (ii) within types of changes which keep functional importance for the system and thus remain perceptively visible for it, a contextually dependant value-based differentiation takes place. At the same time, the existence of purposeful schematizations, in contrast to strict programming (this paradigm of algorithmic programming today is too often considered to be a way in which organisms function), fixates only the effect of a process but not its route. Sugar uptake and degradation in microorganisms, for instance, is necessary to provide energy, but it is never predetermined in which pathway it will be conducted; there is only a spectrum of total possibilities. That way there is always a chance to substitute one medium (for a given sub-purpose) with another functional equivalent, without having to change other parts of the system. With such openness for fluidity of activating functionally equivalent mechanisms while achieving the purpose, a great flexibility and robustness are gained, necessary for survival of organisms in a highly changeable environment. It should be clear by now why purposeful systems could not be framed into cybernetic paradigm according to which, as noted by Luhmann [11], every single state of environment corresponds with one definable state of the system. Moreover, in analyzing functional systems, there is a common misapprehension about universality of the principle of transitivity [11, 4]. According to this principle, relations between values are considered as relations of absolute measures, or advantages, and every single hierarchical relation between two values is regarded as complete. So if A is greater or in advantage in comparison with B, and if the same applies to B and C relation, it follows that A must be greater or in advantage of C. However, transitivity is not so universal in systemic regulations because of encapsulation of causal relations into a purposeful dimension. Then a certain factor can have its own meaning, independent of the context in which we, as observers, consider it, if this factor or value is stated as a purpose of a process.

This survey does not exhaust all consequences of functionality as an organizing principle, but further analysis in that direction would lead far from the subject of this paper. However, even from such an incomplete analysis we can derive two key conclusions. After the occurrence of arranged complexes of transformations, further development of a (living) system starts to separate itself from physical/chemical necessities. In that manner the internal structure of system gradually constructs its own prerequisites for the development, which become determined in accordance with systemic assignment of meanings. Therefore, it cannot be stated (as is usually the case in theory of autopoiesis) that there is one (or more) underlying organizational principle(s) and that the only difference between systems is the level of their complexity and composition of structural "carriers". In that case, the reduction of biology to chemistry, chemistry to physics and so on (until we reach level of pure ideas), could be legitimately performed. Therefore, it is necessary to clearly underline that, what is termed "organization", results from the possibility of systemic elements to interact in specific manner, and vice versa, interactions of elements are to a great extent determined by systemic context (organization). Only when a system establishes itself as an autonomous and self-reproducing entity, we can refer to organization as something *a priori* given for all systemic elements (i.e. for its structure). However, it should be emphasized that normative apriority is not a form of eternal ontological principle; quite the contrary, it has varied through evolution. This statement might seem to be *contradictio in adjecto* , but only if apriority is perceived as a purely formal condition. If we define apriority with regard to systemic elements, which are generated and dissolved within the same general context, that objection is no longer valid. Secondly, it should be clear that if major characteristic of semiosis is its arbitrariness, i.e. its assimilation of environment into system of indicators, which an observer could further

manipulate, than it is justified to talk about semiosis in living systems. Within such complex system of transformations, impetus still plays an important role but (at least when it comes to perceptively constructed segment of environment) that uncatchable event is transformed into Ground. This way, Ground grows into nexus of two fundamental categories of reality: system with its construction of environment on the one side, and on the other - environment in itself (Noumen). Such nexus is not some kind of stationary, demarcation line where Here and There are absolutely definable. It is formed with every intersection between the above stated opposite directions: lines of tendencies in Being and tendencies for assimilation of Being.

After this initial moment, a highly complex process of transformation commences, where qualia in Ground is transformed into quality [2]. Through this process, variations of Dynamical Object are gradually canceled, a vast majority of its specifics are erased and associated with functional schemes and thus an Immediate Object is constructed. It is now composed from parameters and indicators, which are arranged in a manner that provides possibilities of manipulation. A very clear distinction can be made between impetus as a starting point of semiotic interpretation where it is Ground, Qualia, from which a sign is to be constructed, which is followed by arbitrary system of meaningful transformations, and impetus which in non-semiotic complex stands as a final cause of necessary transformation. Still, there is one more hidden important characteristic of signs in biological systems. It has been stated several times that system assimilates environment engulfing it with its own operative schemes. It can imply equality of sign and signal in living systems, which would mean mixing up two very different processes. Therefore it is necessary to make a crystal-clear distinction between sign as a final state of semiosis and signal as a starting point of functional transformation.

3 Ground and Sign vs. Signal and Information

Transmission and processing of information is performed by signals. They are material processes which can be registered and by which data about changes in state of observed system or course of processes within it, can be transmitted. In living systems, we certainly cannot talk about transmission of data, but it is legitimate to consider signals as values assigned to certain physical or chemical "carriers" which are characterized by a defined set of parameters. Therefore, in signals we should distinguish between material carrier, certain values of that carrier and informational parameters that are transmitted by these values. Only the first category can be considered absolute. Values of the carrier and especially informational parameters are, on the other hand, greatly dependent on the interpreter. Distinction is often made between analogous and discrete signals, and consequently between analogous and discrete information. According to that opinion, in analogous signals informational parameters can have any value within certain boundaries, while parameters in discrete signals can take only discrete values, also within certain boundaries. However, that distinction cannot be regarded as completely true, at least in living systems. It has already been noticed that in order to perceive signals, a system should already have the ability of perception. Therefore, it already schematizes environment into segments, and every segment is associated with functional operations. These segments enclose a certain range of changes into one operative whole, impose boundaries and erase all differences within them. As a result, the system is able only to grasp its environment in strokes, instead of point-by-point coordination, which means that signals (as systemic categories) cannot, *stricto sensu* , be analogous. In other words: signals are completely defined by perceptive distribution of parameters, and they can only exist

within a context of systemic, functional transformations. However, signal is not yet information.

There are numerous definitions of information, but the majority of them agree that in order to be seen as information an event has to provoke activation of a system and generation of a certain set of outputs [see for example 6, 12, 13]. In other words, information should be considered to be a systemic functional category with input/output schematization as the main characteristic of its flow. As a result, there is only transmission of final results among functional processes [3] which means that system's functionality is based on interactions of totalities: subsystems don't enter into each other, and results of the Other are never investigated in the light of the background processes, but they are always taken as given products. Only in a closed cycle of such transformations, we can talk about information or flow of information; and this is the main reason why we cannot equate sign and signal. Creation of sign is essentially a private process, which grows from interaction of Object and Interpreter; sign can become public only if it is established through a widespread system of conventions. On the other hand signal and information are systemic categories (public by definition) developed from an already established system of signs [4]. In other words, semiosis is the prerequisite on which the world of information can be superimposed. Indeed, it is true that in any actual case in living systems, the moment when interpretation of impetus is finished and a sign is established, is the very moment when transformation of the sign into a signal for further action takes place, but it doesn't mean their equality. The fact that signs in living systems are structurally determined and therefore, a pathway of their processing is substantially rigid and framed into narrowly defined schemes of action, should not lead us to believe that semiosis equals functional transformations. In living systems, these two domains are inherent to each other, but they remain just that - two domains.

4 References

[1] Pierce, C.P. *Collected Papers* ; Harvard University Press: Cambridge **1934-48**

[2] Eco, U. *Kant e L'Ornitorinco* ; Serbian translation by Radosavljevic, M.; Modrec, S. Paideia: Beograd **2000** ; pp. 57-111.

[3] Wittgenstein, L. *Philosophical Investigations* ; Basil Blackwell & Mott: Oxford **1953**

[4] Piaget, J. *Introduction a l'epistemologie genetique. 2) La pense physique* ; Serbian translation by Janjic D. Izdavacka knjizarnica Zorana Stojanovica: Novi Sad **1996** ; pp. 83-101.

[5] Prigogine, I.; Stengers, I. *La Nouvelle Alliance* ; Croatian translation by Zdjelar, R. Globus: Zagreb **1979**

[6] Shannon, C.E. A Mathematical Theory of Communication. *The Bell System Technical Journal* **1948** , 27, 379-423.

[7] Ashby, W.R. *An Introduction to Cybernetics* ; Chapman & Hall LTD: London **1957** ; p. 186.

[8] Rao, C.V.; Wolf, D.M.; Arkin, A.P. Control, exploitation and tolerance of intracellular noise. *Nature* **2002** , 420, 231-237.

[9] Hoffmeyer, J. Biosemiotics: Towards a New Synthesis in Biology. *European Journal for Semiotic Studies* **1997** , 9(2), 355-376

[3] some intermediate steps can also serve as outputs, but it is not contradictory to the above statement, since we are talking about perceptual construction of environment and its consequences; therefore, if from our perspective some process is intermediate, it does not mean that the recipient of that signal has the same perspective

[4] it should be highly emphasized that the existence of a mere group of signs is not enough for development of information; that group should be structured into an arranged system of regularities

[10] Kull, K. Biosemiotics in the twentieth century: a view from biology. *Semiotica* **1999** , 127(1/4), 385-414

[11] Luhmann N. *Soziale Systeme. Grundriß einer allgemeinen Theorie* ; Serbian translation by Topic L. Izdavacka knjizarnica Zorana Stojanovica: Novi Sad **2001**

[12] Nauta, D. Jr. *The Meaning of Information* ; Mouton: Paris **1970**

[13] Wiener, N. *Cybernetics, or Control and Communication in the Animal and the Machine, 2nd revised and enlarged edition* ; MIT Press and Wiley: New York, London **1961**