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ABSTRACTS

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The Relations Genotype/Phenotype/Environment a Semiotic Contribution to the Evo:Devo Debate

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Seemingly opposite views of evolution, that manifest in the dichotomies, structure/function, genes/environment, random/directed variations, innate/acquired characteristics, instructive/ selective information, self-organization/natural selection, are still hotly debated. This conflict results from the self-referential loop intrinsic to the genotype/phenotype relation and scientists' standpoints determine the choices made to cut open the logical circuit. However, a developmental perspective shows that it is not a matter of an either-or choice, because organisms' phenotype interactions with the environment may lead to unpredictable outcomes. This unpredictability depends on how organisms buffer their openness to their surroundings (or structural closure regulation). Supporters of Developmental Systems Theory (Oyama, 1985/2001), argue that autonomous developmental/evolving systems undergo open ended non programmed change and that genotype (G) and phenotype (P) fluctuations are contextual. Accordingly, I here propose a theoretical framework for describing changes in mutual information content between the pairs G/P, P/E and G/E along a life trajectory at two parallel and interwoven scales: individual life cycle (ontogeny) and species time (phylogeny). This approach allows the establishment of a correspondence between the Peircian six space/time/function relations (Taborsky, 2002), with the weights assigned to genetic, epigenetic, behavioral and environmental informative sources according to their contribution to development and evolution.

Key words: Genotype (G), Phenotype (P), Environment (E), development, evolution, information, self-reference, semiosis.

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Consilience and the History of Biosemiotics

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The methodological concept of consilience was introduced by the English philosopher William Whewell in the 1840s. It should denote the scientific use of complex abductions, which confirm a new hypothesis by showing its coincidence with already established hypotheses and contribute thereby to the unification of science. The influence of Whewell's theory on Charles Darwin was unearthed by Michael Ruse and Paul Thagard in the 1970s; its importance for today's biology was highlighted by a recent debate between the late Stephen Jay Gould and Edward O. Wilson. In the first part of the talk we shall give a semiotic definition of consilience.

From a pragmatic point of view, biosemiotics is the research programme that tries to realize the consilient potential of semiotics and information theory (two names of the same thing) in biology. Results as well as problems that arise during the realization of this potential can be understood philosophically in different ways. One possibility is to interpret biosemiotic consilience in a minimalistic way following the rule: as much methodology as possible, as little ontology as necessary. In the second part of the talk we shall take a short look at the long but hidden tradition of this minimalistic strategy.

The Mind-Body problem - Is dualism back?

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The mind-body problem is about the relationships that exist between mental phenomena such as *feelings and perceptions*, and brain phenomena such as *neuron firings*. Today it is generally assumed that the mind is a natural entity and that mental events are produced by brain events. More precisely, it is widely accepted that *the mind is made of higher-level brain processes that are produced by lower-level brain processes*. Up until now, the models that have been proposed in this field can be divided into three major groups (computational, connectionist and emergent theories) but here it is shown that a new approach is possible and is provided by the idea that the mental world is based on *natural conventions*. More precisely, by the idea that mental objects are assembled from brain components *according to conventional rules*, which means that they are no longer *brain objects* but *brain artifacts*. Such a mechanism implies that feelings and perceptions are not spontaneous side-effects of neural networks, that they do not come into existence spontaneously by emergence, and that they are not the result of computations but of real manufacturing processes. In the framework of the conventional mind, in short, feelings and perceptions are *manufactured artifacts*, whereas according to the other theories they are *spontaneous products* of brain processes.

This may seem a small difference, at first, but in reality it implies a new biological paradigm because modern biology has not yet accepted the existence of other organic codes in life in addition to the genetic code. The experimental evidence, however, has shown that many biological processes are based on codes, because they use molecules that perform two independent recognition processes and these molecules, called *adaptors*, are the qualifying features of the organic codes. Signal transduction, gene splicing, cell adhesion, cell movement, cell compartments, cytoskeleton assembly, histone scaffolding and programmed cell death are all based on molecular adaptors. What is more important, for our purposes, is that all these phenomena play crucial roles in embryonic development, and particularly in the development of the brain. The mechanisms by which neurons and synapses start and stop their movements, for example, employ cell-adhesion and substrate-adhesion molecules that behave like true adaptors and work according to phenomenological rules that have the characteristics of coding rules.

The experimental study of brain development, in short, has brought to light many molecules that behave like adaptors and many empirical rules that have the characteristics of natural conventions, all of which suggests that the development of the brain, like the development of any other anatomical organ, is largely based on the rules of organic codes. This is what gives credibility to the theory of the conventional mind: if the development of the brain is based on organic codes, it is likely that the same is true for the development of the mind. We have therefore a new theoretical framework before us: *feelings and perceptions are manufactured artifacts, and the brain assembles them from neuron firings with a mechanism that is based on codes and codemakers*.

This has a direct consequence for the mind-body problem, because if the mind was made of spontaneous brain products it could never have "rules of its own". Artifacts, on the other hand, can have autonomous properties for two different reasons. One is that the rules of a code are conventions, and these are not dictated by physical or chemical necessity. The second is that a world of artifacts can have "epigenetic" properties that add unexpected features to the coding rules. The autonomy of the mind, in short, is something that spontaneous brain products cannot achieve whereas brain artifacts can. It could be argued that the autonomy of the mind is only an

illusion, but for what we know it could also be a genuine phenomenon, and in this case it may be useful to realize that brain artifacts provide a very natural explanation for it.

The theory of the conventional mind has also implications for the widespread idea that there can be no dualism in life, and in particular no divide between body and mind. Today this is by far the dominant approach to the mind-body problem, because it is taken for granted that the mind evolved *only* by natural selection. And yet there is, in principle, a perfectly natural alternative. If the origin of the mind was an event similar to the origin of life, an event produced by the twin mechanisms of copying and coding, i.e. *by natural selection and by natural conventions*, there would be a divide between body and mind as there is between matter and life. We realize in this way that the mind-body problem cannot be separated from the greater problem of the mechanisms of evolution. The existence of a divide between mind and body depends upon the mechanism that gave origin to the mind, because natural selection can only transform existing objects whereas natural conventions can bring absolute novelties into being. The origin of the mind, however, is a not only a phylogenetic problem but also an ontogenetic one. Body and mind come into existence by embryonic development, and if there is a divide between them it must arise anew in every individual embryo. It is likely therefore that we will have an answer to the mind-body problem only when we discover how the mind comes into being during the embryonic development of the body.

Information theory and biology

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It has been recognized during the last decades that memorizing, communication and processing of information play a paramount role in biology, at any spatial and temporal scale, through a wide range of physical and chemical means. Moreover, it has become more and more apparent that the true divide between the non-living and the living world is precisely that the latter makes extensive use of information, while the former does not. These statements legitimize the concept of *biosemiotics* and provide incentive for its development.

Quite independently, the scientific study of communication engineering led more than half a century ago to the development of *information theory*, and one may wonder why it has been yet so sparsely used in biology. The early attempts made by biologists to use concepts of the 'classical' information theory (as introduced by Shannon in 1948) almost invariably came to a sudden end with the remark that the entity defined by the theory as 'information' is very restrictive with respect to the ordinary meaning of the word, especially insofar as it ignores semantics. They thought that a better fitted 'organic information' should be used instead. However, they were unable to properly define it and they preferred to wait until somebody could do so.

At variance with this opinion, we think that information theory has much more to offer to biologists than most of them believe. That its concept of information is widely impoverished with respect to the common meaning of the word is undeniable. But is it a reason for rejecting it? As regards the definition of fundamental entities in sciences using a mathematical formalism, it often occurs that *less is more*. It turns out that the admittedly restrictive concept used in information theory probably captures the most important features of information, at least as far as engineering applications like memorizing and communication are concerned. Moreover, the simplicity of its definition enabled extremely wide and successful developments. By 'successful' we mean not only that it enabled the onset of information theory as a consistent new science but that it has been experimentally confirmed in a striking manner through the countless engineering applications which arose from information theory. At its beginning, however, information theory appeared as weakly connected with engineering practice, for lack of an available implementation technology. Several decades later, the semi-conductor technology had made such progresses that its implementation became possible and very fruitful. Although almost all the basic concepts of information theory were already contained in Shannon's work, a very valuable collective experience was gained in its applications, which unfortunately is only shared within the community of communication engineers. We believe that the *a priori* rejection of classical information theory deprived the biological community of a wealth of potentially useful concepts and results of fundamental importance. Stated in more adamant words, it amounted to throw out the baby with the bathwater. Among these ill-known results, those related to the protection against errors, and especially the theoretical (and paradoxical) possibility of *errorless communication in the presence of errors*, have been generally overlooked by biologists, as well as the main features of the *error-correcting codes* which implement it. Since the invention of turbo codes in 1993, they practically reach the limit set by information theory, namely, the channel capacity.

Paradoxically, scientists of other disciplines than communication engineering often ignore even the existence of error-correcting codes although they make a daily use of them, e.g., as a necessary ingredient of mobile telephony.

We introduce and comment the basic scheme of a communication which is explicit or more often implicit in the whole engineering literature, consisting of the three blocks ‘source’, ‘channel’ and ‘destination’ and referred to as Shannon's paradigm. We also consider variants of it which may hopefully be useful in biology. Then, we introduce the basic measures of information (proper and mutual) and the quantities which are associated with the blocks of Shannon's paradigm: the entropy of the source and the capacity of the channel. We introduce also the basic functions of source coding (intended to replace an initial message by a shorter one bearing the same information) and channel coding (aimed at protecting a message against transmission errors), and show that the entropy and the capacity acquire an operational significance as defining the limits of what is possible in source- and channel-coding, respectively. We also mention an alternative definition of information seen as a measure of complexity (Kolmogorov, Solomonov, Chaitin . . .). It provides another understanding of information but does not really question the validity of the basic classical results. We believe that Shannon's information is better fitted to the actual application of information theory to sciences like biology.

We also give an outline of error-correcting codes, stressing the essential role of *redundancy* in their operation, a concept far more comprehensive than merely meaning some kind of repetition. It turns out that communication in the presence of errors is extremely important in genetics and evolution. We may think of the genetic process as performing communication through time. Genomes are conserved with astonishing faithfulness through geological ages, although their integrity is threatened by many chemical and physical factors, including radiations for which cell membranes or other phenotypic devices cannot provide any shielding. Only means intrinsic to the genome, i.e., *genomic error-correcting codes*, can explain its faithful conservation for billions of years. Assuming the existence of such genomic error-correcting codes has consequences on the structure of the genomes, hence on the phenotypes. It turns out that many features of the living world and of the way it came into existence, i.e., of biological evolution, are explained by this hypothesis. One can indeed derive from it many properties which fit known features of the living world, including very fundamental ones which are generally accepted as given facts and left unexplained by today's biology.

As it may be at the root of the misunderstanding of information theory by many scientists of other disciplines, we try to investigate the epistemological status of information. The discussion of information theory given in the paper expresses a consensus among information theoretists. On the contrary, we now depart from objectivity to give a rather personal vision of the place information theory can take in sciences. Information is not pure abstraction, nor is it pure physics, but it may be thought of as a bridge between the world of abstraction and that of physics. We tentatively interpret information as a means for embodying abstraction into the physical world. We even think that information has no existence outside its inscription on a physical support. A particularly important and controversial point is the relation of information theory to semantics. Classical information theory deliberately ignores semantics, a position which seems untenable to many as it deprives information of its main *raison d'etre*. We shall try to show that information, although rightfully dealt with as foreign to semantics, actually acts as a container for it. Information then appears as a necessary intermediate between the physical means of memorizing and communication, and the meaning to be conveyed.

The Social Emotions

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In the study of canid play behaviour I find reason to presume that the evolution of feelings can be studied as a contextual phenomenon, which is found widespread in social environments throughout the world of the living. If intersubjective interactions are seen as organismic responses to emotional experiences, an observer can perceive them as clusters of "locally meaningful phenomena" that take place in the common context, the interacting individuals create. We term this context "the social umwelt" and it may be pictured as a game of chess; only here the pieces are the multidimensional organisms, operating in a vast network of interaction. In the biosemiotic method we model such networks as signs relating to each other. When the signs appear meaningful to us, when they relate to us, we perceive them and thus, are able to study them. This perspective upon life, of course, presupposes that living beings are subjects; they have to be approached and studied as such. The network we address is generated and maintained by the feelings of emotions. Feelings come with experience in a similar manner as thought comes with word. And the behaviour we observe are the feelings acted out in an intersubjective sphere, created by each individual engaged in any given encounter. My talk will concern how our investigations can be transformed into an empirical study of the basic biological roots of feelings, in the different social systems of the different species.

The Biosemiotic Paradigm
Is a common philosophy of science reflected description possible?

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Biosemiotics encompasses all living systems from the cell, over bacteria, fungi, plants and animals to humans as sign producers and interpreters. Signs are the basic units for the study of life. Thus biosemiotics transcends the semiotic threshold between man and the rest of the world that Umberto Eco formulated. Of the two main paradigms in semiotics, Saussurian semiology and the Peircian semiotics, it is mostly Peircian semiotics that has been used to developed biosemiotics because it has a theory of signification of non-intentional signs. Biosemiotics is already prefigured in Jakob von Uexküll's Umweltlehre , which Thomas Sebeok fruitfully used to found biosemiotics. Philosophical biologists in Copenhagen and Tartu have influenced the further development of biosemiotics. They see living systems from cells to humans defined by interactions between a digital code in the gene or genotype and an analogue in the whole individual or phenotype. The gene is a code for memory and self-representation the individual living body is a code for action and interaction with the real world and its ecology. Thus life appears to be a communicative interplay of different types of self- and other- descriptions carried by coded molecules. The newest development seems to be a growing agreement on that within the realm of natural laws of physics and chemistry the realm of the living systems is in the self-organization of coded molecules. But there is still disagreements about the process relation between codes, interpretation, biological meaning, signs and signification partly based on disagreement about the ontological frame work in relation to which concepts are defined. Essential seems to be if one can stay within an ordinary materialistic, Darwinian biological functionalist framework or the move to Peircian triadic objective evolutionary idealism is necessary.

Towards a Hierarchical Understanding of Health

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Health, and the lack of it, has to be as old as life itself. This problematic concept, as it is intrinsically related to life, expands throughout the entire biological hierarchy from cells to ecosystems. At all these levels the notion presents numerous problems when defining a healthy system. To current models for multitrophic interactions, in this presentation I intend to superimpose a concomitant process of semiosis (i.e.: communication) that undoubtedly has a causal influence in the systems under consideration. A recurrent theme in ecological studies of biodiversity is the occurrence of resistance and pathogenicity. However these phenomena cannot be fully grasped in terms of trophic interactions because they imply a process of communication and context interpretation.

The hierarchical nature of the interactions that lead to health, virulence and resistance in physiological and ecological systems is a very good example of non-trophic interactions. In a hierarchical view, such notions, *resistance, virulence and health,* should be seen as *subjective categories in ecosystems* which take their meaning depending on which side the observer decides to line up. These three terms can be generalised to include notions such as survival, predation, pathogenicity, invasiveness, function, balance, equilibrium, resilience and different kinds of symbiosis and interactions (mutualisms, amensalisms, parasitisms, comensalisms, antagonisms and protagonisms) etc. The significance of non-trophic interactions in processes that lead to resistance, virulence and health, when seen as subjective categories in a wider gestalt of co-evolution and symbiosis, means that pathogenesis is basically a semiotic process. The wider gestalt may hint to the existence of a sort of "hierarchical health" in ecosystems.

Key words: non-trophic interactions, semiotic interactions, health, resistance, virulence, pathogenicity, semiochemicals, infochemicals, biological hierarchy, context interpretation.

Determinism, Indeterminism and Semiotic Election

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This paper shows how indeterminism can emerge within a deterministic but evolving triad composed by three different sorts of determinism depending on the system's structural, historical and energetic constraints. From a semiotic point of view, Prigogine's bifurcation point is interpreted as a moment when a *semiotic election* takes place. The semiotic perspective allows a vision where the evolving entity is seen as an active participant of its own development. In contrast to traditional standpoints about determinism and indeterminism, this submission belongs to an internalistic viewpoint which takes into account the epistemic horizon of the semiotic agent and its underlying epistemological chance; moreover, the use of Peircean categories allows stating the existence of an ontological chance within the universe.

Metabolic pathways from wiring diagrams to semantic networks

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Our view of the cell's interior has undergone a peculiar and largely unreflected transformation during the last few decades. The classical biochemistry before 1980s focused on metabolites and their flows – i.e. on small and abundant molecules accessible to state-of-the-art methods of the time. This can be demonstrated on the iconography of the classical Metabolic Pathways map (curiously resembling a wiring diagram of a pre-digital era radio receiver). Metabolites represent sharp nodes of the network, while enzymes are "bystanders" who, in fact, could well be omitted without any harm to the structure of the chart itself. Consequently, progress of enzymology and molecular biology led to a shift in focus towards enzymes, and later towards genes encoding them. Systematic efforts to catalogize all available knowledge have been undertaken, resulting in complex terminological projects (such as the E.C. enzyme nomenclature) and later in complex genome maps. Such maps became the standard icon of the time, and currently degenerated into a common item of laboratory wall decoration. Nowadays, the focus is shifting again – towards regulatory aspects of the cellular economy. This is reflected e.g. by the current Gene Ontology project. With "systems biology" progressing from a rather abstract program to a workable research concept, we can expect that the genome map posters will sooner or later be replaced by "data flow diagrams" depicting the network of information processing within a live cell, i.e. a semantic (or semiotic?) network.

Nonalgorithmic order

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The communication concerns the patterns of intelligent behaviour, i.e. the temporal and the spatial organization of the artefacts of life and human culture. – Let us compare a physical structure, as a crystal lattice, and an artefact of human culture, e.g., an art composition, or a common household object, like a chair. Both are apparently negentropic, i.e. display an orderly pattern. Yet, upon careful observation, it turns out that the artefacts' order, unlike that of physical structures, cannot be handled in an algorithmic manner.

Some provisional theses:

1. Intelligent dynamics does not find its stable solutions within the phase space it occupies, but rather in its context.
2. The patterns of intelligent order are not based on considerations of geometrical symmetry or energetic stability. They, hence, can never be explained in terms of physical causality.
3. The patterns of intelligent organization cannot be reduced to any of the familiar natural distributions as: linear, Brownian, Gaussian or chaotic (fractal).
4. There is no algorithm underlying these patterns. Moreover, they are entirely constituted by acts of subjective life necessities or human free will.
5. This doesn't make these nonalgorithmic patterns arbitrary and unsystematic. On the contrary, they are more stable and orderly than the physical structures.
6. Nonalgorithmic patterns are referential, i.e. based on the communication with the context within which they emerge.
7. Referentiality is an accomplishment of the vacant ontological positions – paradoxical, yet well familiar agents, to be discussed at length in the communication text.

Downward Determination in Semiotic Processes

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The emergence of semiosis in semiotic systems can be understood as resulting from fundamental interactions in a triadically organized hierarchical process. To grasp these interactions, we developed a model for explaining the emergence of semiosis (*sensu* C.S.Peirce) grounded on Salthe's hierarchical structuralism. We applied this model to establish, in a general sense, a set of theoretical constraints for explaining the instantiation of different kinds of semiosis (iconic, indexical, symbolic) in semiotic systems. In the context of this model, we face, however, some fundamental philosophical problems, as, for instance, the well-known problem of downward causation (DC), namely, the problem of the nature of the influence of a system over its components. In this paper, we discuss this problem within the framework of the multi-level approach to the emergence of semiosis in semiotic systems we developed. Most discussions about DC do not really concern causation, but mainly explanation or determination. Symptomatically, the terms usually employed to refer to the downward influence of a system over its parts, such as 'restrain', 'select', 'organize', 'structure', 'determine' are not equivalent to 'cause' at all, at least in the sense ascribed to this term in modern science and philosophy. One possibility is to face this problem by broadening the very notion of causation, as Emmeche and colleagues (2000) proposed. Another possibility is to move from a conceptual formulation of types of causation other than efficient causation to a formulation of types of determination other than causation. We explore this avenue in this paper. In this move, it is fundamental to clarify the theoretical meaning of 'determination', considering a key difference between the ideas of 'determining' and 'causing'. The former mainly involves the idea of 'necessity' (in the sense of 'it could not be otherwise' or, in a weaker form, 'it would not tend to be otherwise'), while the latter concerns, since the advent of modern science, mostly the idea of 'bringing about' a certain event. In this paper, we articulate this movement from DC to 'downward determination' (DD), explaining the latter in terms of constraints that the condition of being included in a given kind of system imposes to the behavior of the parts. We explore Peirce's distinction between 'logical' and 'causal' determination in order to explain DD as a kind of logical determination, expressed in terms of the material implication. We also clarify the nature of the *relata* in DD, by claiming that what *determines*, at the level of a system as a whole, is a general principle of organization (an universal), while what *is determined*, at the level of the parts, is a set of particular concrete events. To illustrate and, also, develop in a more precise manner these ideas, we employ a case study, namely, that of lipid rafts in cell membranes and its role in signal transduction.

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Towards a biosemiotic concept of function and semiotic causation

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Within philosophy of biology the notion of function has been analyzed extensively in the literature from the point of view of physiology as well as evolutionary biology, but functional ascriptions has only recently been considered within a biosemiotic context, and not yet in any sufficient detail (cf. Sign Systems Studies 30(1), 15-32, 2002; and contributions by Andres Luure, 2003 and Georg Topfer, 2004 to the Gatherings in Biosemiotics). This paper attempts to investigate further how to relate biofunction, within an organicist tradition, to (a) current discussions of causality and emergence in complex multi-level systems, (b) Peircean ideas about causation and determination, (c) the distinction between non-biological complex self-organizing systems and genuine living systems. How can we conceive of the relation between functional processes and semiosis – is one kind of process more basic (historically, logically) than the other? What is their ontological and conceptual relation? What are the implications of an organicist perspective emphasizing the different ontologies of machines and organisms for this question? Some of the inspiration and theoretical background for the present analysis derives from an ongoing project on information systems in biology (by C.N. El-Hani & J. Queiroz).

On manufactured life and the biology of the impossible

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The question What is life? has no unanimous answer. This is particularly evident if we reflect on "artificial" forms of life such as manufactured organisms -either robots, virtual creatures or genetically modified organisms. Against the most extended trend during the 20th century, of trying to look for an "essence" of living beings in their genetic endowment and the capacities derived from it, other perspectives move around the concept of autonomy. The theory of autopoiesis (Maturana & Varela 1973) proposes the concept of biological autonomy as a central notion for the scientific and philosophical explanation of life, opposed to the image of life grounded on genetic information (in which, in their view, organisms are taken to be allopoietic, that is to say, manufactured by something external to them).

This notion of autonomy has certain relation with the recently proposed Parity Thesis (Griffiths & Gray 1994) in that genes have no privileged role to explain life, so that all developmental resources are equally important as causes of the organism. Internalists, on their part, claim that more attention is needed for the self-construction processes generating a multicellular organism in development. Pere Alberch (1989) emphasized the importance of rules of construction by appealing to the appearance of teratologies or "monsters" in nature. He argued that even these "non-adapted" creatures follow certain rules, therefore we cannot expect to obtain "anything" in nature. We could consider that, unlike those natural monsters, monsters of reason (or of the sleep of reason) are those creatures manufactured following artificial rules or genetic recipes.

In the last decades we have witness long debates on whether artificial organisms can be considered alive. In general, there has been a consensus to answer "no", because these creatures are not truly autonomous. In a recent work, Habermas (2002) reminded us of the Aristotelian distinction between what is "grown" and what is "made" (or manufactured), and considered that genetically designed beings could not be autonomous. These kind of criticisms to technologies of genetic modification are problematic because: 1) they ignore the Parity Thesis and consider that the genetic endowment constitutes some sort "essence" of the organism; 2) they consider that genetically modified humans, as "made organisms", have lost autonomy. However, no manufactured life form exists as yet. Of all existing organisms, regardless of how manipulated they are (genetically modified ones, hybrids, chimeras...) and to the extent that they are alive, we cannot say that their autonomy has been generated in an artificial way; it is their autonomous being that has been manipulated within the limits of its viability. It is possible that natural constraints guiding natural evolution can be bent through deliberate intervention. It is difficult to devise a classification of all the new forms that will exist, but we should reflect on the fact that, for the time being, existing manipulated forms have an original autonomy that should be taken into account.

RNAs as code makers
A biosemiotic view of RNAi and cell immunity

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The development of the immune system as it is known in vertebrates, relies on the highly coordinated program of cell differentiation achieved by such multicell organisms. This paper discusses the acquisition of an immune response by means of cell function specialization (recognizers, presenters, killers) in the light of biosemiosis. In particular, it will be argued that self/nonself differentiation raises in multicell organisms by a switch of organic codes and operating logics. In fact, double-stranded RNA molecules that induce a highly specific and selective mRNA degradation in non vertebrates, bring about an ubiquitary silencing of transcription and translation in differentiated vertebrate cells. This last response requires elements which are common to cell immunity, the so called interferon response machinery which is responsible by preserving cell genomes from mobile DNA fragments often generated during viral infetion. This particular phenomena will be extensively discussed to show the general point of how a major evolutionary change - invertebrates to vertebrates, in this particular case – relies on the acquisition and fixation of new organic codes. The pattern of cell differentiation required for the constitution of vertebrates immune system will only be possible whenever, in evolution, cells are able to discriminate self from nonself. That systemic skill will ultimately require the development of representational elements of the "foreigner" entities inside the "familiar" cells. The way double-stranded RNA is dealt with in non differentiated or non vertebrate cells compared with what happens in differentiated vertebrate cells is therefor a canonical example of logical switch by natural conventions. The ability of performing artificial assembling of natural materials which is distinctive of living things in the biosemiotics perspective will be also examined in the light of other compatible theoretical frameworks, namely: the theory of levels, the theory of tinkering and the complex systems' view on biological time.

Keywords – Cell immunity, RNAi, Organic codes, Natural conventions, semiotics, tinkering, Dynamic Ontology

Semiosis, the common currency of landscapes

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Landscape ecology is a discipline that mainly focuses on the relationships between spatial patterns and processes of the ecological systems. It diverges from the ecosystemic ecology for the prevailing importance assigned to the forms of the components of environmental matrices. The landscape appears as a complex system and geography, aesthetic, environmental psychology, cognition, ecology are some of the disciplines that recognize the landscape as a coherent subject of investigation. The aim of this contribution is to find common properties or attributes that could integrate such separate knowledge. From the landscape ecology it emerges that size, shape, and spatial configuration of environmental patches like woodlots or fragments of prairie, have a strong influence on distribution, abundance and dynamics of many organisms (plants, animals and microbes), but very few evidences are found about the mechanisms.

An ecosystemic and a cognitive approach are the two faces of the same coin, but often have inspired different theoretical and applied investigations. If a cognitive approach is adopted, spatial configurations have to be considered not fixed structures (patterns) shared between the species, but morphological characters ready to change according the species-specific perception.

Coherently to this vision, there are at least two levels at which the landscape can be considered as a perceiving entity. A first level adopts that every species has a "private" distinct surrounding or Umwelt. A second level assumes that for every species the living functions, to be performed, require specific spatial configurations (The eco-field hypothesis, Farina & Belgrano 2004).

Bio and cultural sensors are the tools by which a semiosis closure is triggered between the organism and the perceived "landscapes". The perceived attributes are both structural (f.i., shape, internal heterogeneity, etc.) either functional (f.i., connectivity, friction, safety, mystery, therapeutic, etc.). Theories like prospect and refuges (Appleton 1996) and affordance (Gibson 1986) can be reconsidered, between the plethora of the cognitive theories, as parts of the common theory of the eco-field. This represents a promising commencement to manage the landscape as a semantic affair.

Examining the Vital Signs of Biosemiotics

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Confusion reigns both among and beyond the cognoscenti, as to whether semiotics is an approach, or field, or discipline, or method, or theory, or science, or a disease.

– Thomas Sebeok

2005 marks the fifth consecutive year we have been meeting together since our initial Gatherings in Biosemiotics at the University of Copenhagen in 2001. It also marks twelve years since the publication of Hoffmeyer's seminal *Signs of Meaning in the Universe*, twenty-eight years since the historic meeting between Thomas Sebeok and Thure von Uexküll in Vienna, ninety-one years since the death of Charles Sanders Peirce, twenty five hundred years since the first recorded use of the word *semeion* by Hippocartes, two million years since the arrival of *homo habilis*, 3.5 billion years since the appearance of the first prokaryote, and approximately fifteen billion years since the collapse of the singularity into what would subsequently become entities, relationships, interaction and signs. Having joined the discussion only at the most recent of this abbreviated history of events, I will take the opportunity this year to review some of the developments that have occurred under the aegis of *biosemiotics* since the convention of that first Gatherings a mere four years ago; to examine whether or not we have yet come up with a unified program (or even a unified framework) for falsifiable empirical study; and to continue to pursue the question regarding how to "formalize" biosemiotics from a well-justified domain of inquiry into the kind of empirically testable research program that would validate its status within the rest of the scientific community.

Increasing Fittedness:
Ecology, Aesthetics and Ecosemiotics

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According to its original definition, ecosemiotics is a study of sign processes concerned with how natural signs mediate between organism and environment. However, it is claimed that there is "a very low 'semiotic threshold' between signs and non-signs" and that ecosemiotics may be required to "reject such a threshold altogether." (Winfried Nöth. Sign_Systems Studies_ 26, 1998). New studies of plant neurology indicate clear semiotic thresholds in organism-environment relations, when feedback relations between plant, plant and other plants and environment are considered as the primary source of information and signification. This proposition was originally put forward by Gregory Bateson some thirty years ago.

A second issue is that of 'ecological aesthetics.' For example, managers of national parks are mandated to ensure that the landscape of the park is aesthetically pleasing to the public, but are also mandated to ensure sustainability. The two requirements do not always match, but as yet, there appears to be no account of this dilemma in semiotic terms. This paper considers how _over-coding_ definitions of information (as in the "use and effect" approach to signification) has undervalued communicative feedback in ecosystems Second, it argues that understanding the _under-coding_ of human perception of landscape, and of aesthetics in general, can remove those dilemmas arising between aesthetics and sustainability that confront national park managers and their cohort of researchers. Attention to semiotic misunderstanding of over-coding and under-coding increases, in turn, understanding of ecosystem fittedness. These points once again, are drawn from Gregory Bateson's discussion of aesthetics.

What is biological information?
A transdisciplinary view

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In order to give an answer to this question an approach is advocated that is neither a bottom-up approach nor a top-down approach. What is needed is a transdisciplinary view mediating both bottom-up and top-down approaches. Transdisciplinarity is provided by resorting to cross-disciplines like Evolutionary Systems Theory (the forerunner of which is General System Theory as shaped by the Austrian biologist Ludwig von Bertalanffy) and Unified Theory of Information which, in turn, are based upon philosophical considerations.

Transdisciplinarity thus mediates between the scientific treatment of concrete information processes in the biotic realm and the scientific treatment of concrete information processes in different realms like the physical or the the socio-cultural one. It does so by undertaking generalisations which start from the particular at either side and are directed towards the universal comprising both biology and different disciplines and by producing reverse trains of thought that arrive at the specialised as well.

In a framework like that the answer to the question will contain something that is shared by all the disciplines theorising information processes in different realms and it will contain something that is unique because it belongs to biology only. Both determinations, however, will have to be reconciled, related to each other, thought in-one – in a way in which the general and the specific are mediated dialectically enabling unity-through-diversity. The answer will also discuss different biosemiotic approaches put forward by, e.g., Emmeche and Barbieri.

Epigenetic mechanisms following mammalian fertilization reveal basic principles of constructivist epistemology

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Recent findings in molecular cell biology of mammalian reproduction offer the possibility of a biosemiotic interpretation concerning those epigenetic mechanisms taking place during the oocyte-to-embryo transition, thus showing that even on this basic level of life "information" from outside (input) is not just **re**ceived passively, but has to be "constructed" by the **per**ceiving organism.
When applying Krampen's (1997) general model of semiosis to the biological process of mammalian fertilization, a structural analogy with the course of perception in human beings becomes obvious: the oocyte – a single-celled mammalian organism capable of creating *Umwelt* – extracts "information" from its environment. As soon as the pronucleus of the spermatozoon is incorporated into the oocyte, active and specific transformations are performed on the paternal genome. By exchanging certain proteins the chromatin structure is altered and a significant and selective demethylation of the paternal genome takes place. The latter is involved in a recently better understood mechanism called imprinting elucidating the creative role of the zygote organism as an interpreter. All these epigenetic modifications are realized by maternal means and do alter the content of "information" given by the paternal genome. Moreover, putting the received signal into shape in the mentioned way is a necessary condition for successful mammalian reproduction as the limited developmental potential of parthenogenetic embryos shows. Therefore, the activation of the embryonic genome seems to reveal basic patterns of constructivist epistemology.
The proposed interpretation could be 1) a valid argument for evolutionary epistemology since basic mechanisms of human perception can even be found in a single-celled organism. Thus, development of human cognition can be postulated to have started in a single cell – ontogenetically as well as phylogenetically. 2) As obviously the found principles are not an exclusive feature of perception performed by persons, but a general characteristic of cellular life, "construction of information" seems to be a basic quality of life itself. 3) This conclusion reflects the benefit of a biosemiotic analysis for overcoming genetic reductionism: the importance of a subject that is able to arrange and interpret its genome must be highly esteemed.

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Language and Nature

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Our thought is bound up with the hidden logical structures of language. We are used to divide the tradition of inquiry into semantics of language into two lines: the ideal language represented directly in the natural languages (from Frege to Carnap, and Wittgenstein in the 'Tractatus') and the hidden language represented indirectly in the same languages (the ordinary language philosophers like Wittgenstein in his later notes, Austin, Ryle and Strawson). The basic difference between the mother tongue and the foreign language is that the speaker of the mother tongue feels his speech easy and unforced because the logico-semantic grounds of the morphemes fuse together with the sound images of them, while the speaker of a foreign language finds his speech more difficult because the both parts of the morphemes seem not to cohere, respectively. The discrepancy mainly derives from the fact that the speaker instinctively tries to apply the logico-semantic structures of his mother tongue to the foreign language spoken, often noticing that the morphemes in both types of languages don't match. Of course, there are many other agents in the discrepancy, for instance the syntactic and phonological dissimilarities.

Once, the speaker has worked for about a decade designing a 'logical grammar' on the basis of his mother tongue, Finnish. The investigation dealt with the 150 most frequent verbs in Finnish. The methodological procedure was that of phenomenology; it was assumed that there must be a basic a priori system of the logical system, the users of Finnish applying it all the time in their speech. The Husserlian thesis of the objectivity of the contents of mind (< Gr. sg. *noema*) held true. The main system of the investigation of the logico-semantic units in Finnish (and presumably in all other languages and the underpinning logic of them) contained three chief components arranged in a semantic hierarchy: CAUS (or causative), PROC (or 'processive'), and STAT ('stative'). The semantics of a certain verb was defined as causative if it implied an agent (true or imagined). Such a verb is for instance *nostaa* in Finnish and the equivalent of it in English, *to raise*. If the verb described contains a causative component, then it must imply the processive and stative ones, as well. The formula x CAUS (y PROC (y STAT z)) can be expressed also in the paraphrase: 'The argument x causes that the argument y changes so that it will be in the state z.' The meanings are to be defined only in a context: in a text or a sentence. Presuming that we the verb *raise* appears in a sentence "The enterprise raised the price of its favourite product," the interpretation must be expressed in the paraphrase as follows, 'The argument x, a certain enterprise, caused that the argument y, the price of its favourite product, changed that it was in the state z (being higher than before).' If we say, "The price arose" (or in Finnish: "*Hinta nousi*"), the formula should be as follows: x PROC (x STAT y). It is paraphrased, 'A change took place so that it was in the state of y, i.e. higher', respectively. The sentence, "The price of the product is higher" (in Finnish: "*Tuotteen hinta on korkeampi*), presumes the formula x STAT y and the paraphrase 'argument x, the price of the product, is in the state y (being higher).' To differentiate all the meanings of the 150 most frequent Finnish verbs, 144 of second, third, or even fourth grade subcomponents were needed. A handout for colleagues possibly more interested in the details of the investigation will be available. The formula CAUS (PROC (STAT)) with its variants applies to all languages. The semantics of single morphemes (comp. for instance the verbs *run*, *laufen* and *courir*) can vary from language to language and very often does it; all languages have, though, their bedrock in common. In the speaker's mind, the community implies that the logico-semantic underpinning of language represents nature. The reasons for the claim will be presented more precisely in the lecture. Nature is thought to be everything what is given, as if a priori. Thus, the human body, the things and organisms form nature. The human consciousness produces meanings and the solid bedrock of the meanings is – as stated above – the logico-semantic core in our interpretations. A different thing is how the core, for its part, is put into action in interpretations. Philosophical questions, not discussed here in detail, will be more focused in the lecture.

The Mediating Role of Sign Processes in the Dynamics of Becoming

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While cybernetic approaches in the investigation of dynamics of becoming tend to emphasise mechanisms underlying the formation of new organisations and organisational levels, they usually miss the role of the larger context, within which such formations occur. However, complex systems, particularly living systems, which are products of this dynamics can be said to have 'goals', which emerge out of the system-context interactions. Furthermore, such complex systems can also be said to possess a 'model' of themselves and the contexts they are embedded in, such that they can anticipate the necessary actions to achieve their 'goals'. As such, the dynamics of becoming cannot be considered separate from the becoming of the 'model', which defines the Umwelt by mediating between the system and its context. The becoming of the 'model' is basically a semiotic process.

The aim of this paper is to propose a more extensive approach than the purely cybernetic alternatives, by accounting for the intricate relations between a living system, its context, and its emerging 'goals' and 'model'. Particular emphasis will be given to the special role of semiosis as a mode of interaction that preserves the relative autonomy of the involved systems.

The pretty carabids in a small world

Inferring biological resemblances from the "small world network"
An attempt

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The carabid beetles belonging to the genus *Carabus* (Coleoptera, Carabidae) are popular for their conspicuous sculptures placed on elytrae (see Ghiretti, 1996). Thanks to these elytral features, that are often esthetically appreciated, the taxonomical status of particular specimen is often easily determined by experienced collectors. Interestingly, unrelated species from different subgenera often show the horizontal congruence in semetic image (Kleisner&Markoš, 2005). The entire design of elytral sculpture depends on development of primary intervals. The main semetic motifs were recognized in number of eight between the entire genus. Using the extant data sample (615 species from 108 subgenera) for analysis, we asked whether these data reveal characters of small world network. In such a case, the existence of horizontally congruent semetic motifs should not be so surprising. We believe that we found such correlations. Our attempt would be taken as a further step towards a better understanding of phenomena like formal analogy, homoplasy, mimicry, and congruence of meaning among organisms in general.

Semiotics and Physics

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The importance, scope, and ambitions of semiotics must be compared to the ones of physics. These represent two principal ways to scientifically approach the world. Physics is a study of quantities, semiotics is a study of diversity. Physics is about natural laws, semiotics is about codes. Ontologically, semiotic systems represent a special case of physical systems. Methodologically, physical approach is a special case of semiotic approach. Therefore, as a science, semiotics is more general than physics. Accordingly, semiotic models can describe features that are beyond reach of physical models due to the more restricted methodological requirements of the latter. The "measuring devices" of semiotics are alive — which is a sine qua non in order to detect meanings. Thus, the two principal ways to scientifically approach living systems are biophysics and biosemiotics. Accordingly, semiotic (including biosemiotic) systems can be studied both physically (e.g., using statistical methods) and semiotically (e.g., considering the uniqueness of the system under study).
A review of existing biosemiotic literature shows that it includes both semiotic and physical studies of biosemiotic systems.

The art of tools and the tools of art

A zoosemiotic approach to the fabrication and the use of tools for aesthetic purposes

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The males of *Hilara sartor*, while performing a courting dance around one only female, carry a sort of big balloon produced by an anal secretion. Some species of spiders offer food to the female by packaging a prey. Satin bowerbirds are well-known for decorating the inside of their pergolate with flowers, objects and blue colours, and for receiving the female by holding another flower in their beak. Woodpeckers' mating songs are produced by beating repeatedly their beak on a tree. Cetaceans move their pectoral flippers up and down in accompaniment with songs. Grasshoppers perform their mating songs by rubbing one wing against the other. And so forth.

To speak of animal art in general, and of architecture and music in particular, involves a whole set of behavioural patterns related with the fabrication and construction of tools. Sebeok, in fact, in the chapter on "Architectural signs" in *The Play of Musement*, considers this aspect as even more important than the actual construction of buildings. Sebeok wonders to what extent we may ascribe an aesthetic quality to such objects.

> In ethological jargon, the question becomes: how does tool-using behaviour become ritualised […]? Or, in semiotic parlance: how does a tool, with a primary amplifying function, acquire a superimposed sign-function […]? The answer to this question, at this stage in the development of both ethology and diachronic semiotics, is precisely the same as to the deceptively innocent one, 'What passes in the mind of a bowerbird when he builds and decorates his bower?'. Frisch replies […], 'naturally, I cannot answer [this] question. No one can'. His denial notwithstanding, Frisch proceeds to declare his conviction that in these birds, no less than in chimpanzees, 'not only insight into the consequences of their actions but also evidence of aesthetic feelings can be found' (Sebeok 1981: 245-246).

Can artifacts be aesthetic? The present paper attempts a zoosemiotic approach to the fabrication and use of tools by non-human animals for aesthetic-related purposes. Numerous examples are provided, according to different degrees of (humanly perceived) complexity: a) the body itself (or a part of it) as a utensil; b) ready-made, nature-provided tools (like the famous flat stone on which many birds break nuts); and c) ad hoc-fabricated tools.

Key words: zoosemiotics, architecture, music, tools, aesthetics

Signal Recognition Modules Interacting in Time and Space: A Biosemiotic Reconfiguration of Genomics and Proteomics

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While a great percentage of contemporary biomedical research is focused on the elucidation of regulatory signaling pathways (at all levels of the biological hierarchy) it is done so in the absence of a general theoretical framework and vocabulary that makes the conceptualization of dynamic signaling systems *as such* the point of reference. The objective of this talk will be to explore the prospect for extrapolating from current research findings to just such a wider, signaling-system oriented theoretical framework. I will suggest that, for example, if we look at the dynamics of protein interaction domains across developmental time and space, then the structure of the coding regions of eurkaryotic DNA as the ordering of potential protein interaction domains, becomes seen as only one (indeterminate) means for biasing which domain will interact with what other domain, where and when. Time-permitting, I will explore the prospects for a more integrated, signaling-theoretic model – at least up to the cellular level.

Managing uncertainty of events by semiosis in living system

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Uncertainty of events is a serious problem for living systems. Living systems, such as cells and organisms, are cognizers, which participate in a larger system. Events occur to such cognizers depending on how they sense and act against a current situation, and therefore, sensation-and-action, i.e. *cognition*, affect all types of events actually occurring, and the probabilities. This probabilistic aspect affects their survivability in the environment. Discriminative cognitions can reduce the uncertainty of events occurring to the cognizer, and selective cognitions concerning which state it shifts to, among many possible options, affect event outcomes. However, empirical, physical laws suggest that discrimination is possible only within locality. Living systems are not omnipotent like Maxwell's demon. How can such local discriminators as living systems sense and act in a discriminative and selective way, effectively, to maintain an appropriate relationship with the environment? One remarkable strategy, adopted by living systems, is the use of signs or codes. In this talk, I explicate the mechanism of enhancing probabilities of favorable events by use of signs or codes, using the cognizers-system model (Nakajima, 1999, *J. Theor. Biol*. 200, 77-95).

The argument suggests that living systems can discriminate things beyond their locality, mediated though discrimination of local things that exhibit a behavioral correlation with non-local things. This mediated discrimination of non-local things, underlying semiosis as a basic principle, plays an essential role in the adaptation of living systems to the environment. To develop such a qualitative theory into a quantitative one applicable to empirical testing, I examine the effect of semiotic abilities of an organism on the probability that the organism encounters with its prey or natural enemies, using a quantitative model of the encounter probability derived from the cognizers-system model (Nakajima, 2003, *J. Theor. Biol.,* 221, 39-51). The probabilities or frequencies can be given against the number of prey or natural enemies, known as *functional response* in population ecology. I interpret results obtained from the theoretical model by comparing the results with empirical data of the functional responses of several species with various degrees of semiotic abilities, ranging from less semiotic species (planktonic invertebrates) to highly semiotic one (vertebrate).

The Specificity Enigma: From Mechanics to Poiesis

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Biological specificity is usually described in terms of the lock-and-key metaphor. However, this metaphor is to a certain extent misleading and does not grasp the complexity underlying biological specificity. The failure lock-and-key metaphor makes it difficult to understand immune recognition. This is the reason why immune specificity has been described as the "Specificity Enigma." In this presentation, I would like to point at three important differences between biological specificity and mechanical specificity, and suggest an alternative biosemiotics lens through which immune specificity can be considered.

Keywords: Biological specificity/immune specificity, the lock-and-key metaphor, meaning making, the cognitive paradigm is immunology, semiotics.

The Semiotic and Cognitive Architecture Necessary for Meaning Production in Invertebrates

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This paper is a continuation of the author's exploration into the production of meaning. Donald R. Griffin in an afterword to *The Cognitive Animal* (Bekoff, M., Allen C., Burghardt, M. 2002. Cambridge, Mass. MIT pp.471-473) laid down a challenge for those working in field of animal behaviour. He believed that one "significant aspect of cognition has received relatively little attention […] the question of subjective consciousness---what is life like for the animal itself." (ibid, 41). Recently the majority of researchers have been preoccupied with neuroethology, i.e. the hard-wiring and treating the question of awareness as if it were something akin to a circuit board. The author of this paper has sought to go beyond this reductionist approach, and instead seen thi s research as the foundation for rethinking about basic conceptions of meaning and communication. He would like to propose that meaning be divided into two types or categories, one which is associated with signalling systems (quantitative) and a second one which involves the memory of signals at a higher level of processing (qualitiative) . One can see this in the neuroanatomy of an insect olfaction sensory system. The reception of a pheromone is different from that of a plant odorant or odorant of a prey. The pheromone though exocrinal is received as if it were endocrinal. It is segregated and processed in such a way that little awareness or representation occurs, whereas the processing of general olfactory information requires selectivity at higher levels and much deeper plasticity. The paper will draw upon the latest research in the field of insect cognition and use it to develop working models of meaning conception necessary for bi oargumentation systems and for applications in robot design.

Key words: Neuroethology, meaning typology, olfaction, bioargumentation

The musical code between nature and nurture: biosemiotic and ecological claims

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Music theory has a long tradition of objectivation of music as something "out there"—as a kind of artefact. It has at its disposal an extensive body of descriptive terms which try to uncover the structure of the music in terms of its acoustic qualities and parameters (melody, rhythm, harmony and timbre). These descriptions, though commonly used, do not reflect the psychological reality of music-as-perceived. Music users (both naive and expert) cope with music in ways that reflect basic information processing strategies that are partly wired-in and partly acquired. The extent to which this processing is innate or acquired—the nature/nurture debate—has coloured much theorising about music and dealing with music. As a result, there have been a lot of contributions that made hypothetical claims but with little empirical evidence. This is changing very rapidly now, as researchers in cognitive sciences, experimental psychology, behavioural neurology, ethology and neuroimaging are advancing the scientific understanding of dealing with music. The development of new technological tools for imaging neural processing mechanisms—electroencephalography (EEG), magnetoencephalography (MEG), positron emission tomography (PET), transcranial magnetic stimulation (TMS), functional magnetic resonance imaging (fMRI), regional cerebral blood flow (rCBF) and event-related potential (ERP)—provides empirical evidence for claims that were hypothetical and speculative up to now.

This paper joins these developments. It brings together empirical findings and argues for new paradigms in thinking about music, leaning heavily on the biosemiotic and ecosemiotic approach to music cognition. As such it stresses the necessity for uncovering musical dispositions—competences which are shared by all human beings—as well as the complementary concepts of learning and adaptation. Music, on this view, relies on innate characteristics (the Mendelian "gene pool") as well as on acquired characteristics (the Dawkinsean "meme pool") with as major question the relation between biological biases and culture-specific experiences. Music, in fact, is not only a product of our biology, but also of our social interactions, and the consensual view is that music is cultural rather than natural. This position is challenged in this paper. There are, in fact, anatomical markers of specific musical abilities, both at the level of brain functioning (neuroimaging studies) and at the level of brain structure (neuromorphological studies). It has been shown, further, that enhanced music experience and training can provoke structural and functional (brain activation patterns) changes in the brain, involving short term as well as long term adaptations. The brain, on this view, can be considered as a structurally adaptive device, which relies both on "innate" or "hard-wired" competences (nativist claim) as on abilities which are the outcome of maturation and enculturation (empiricist claim). As to the first, there is a vast body of "anatomical" evidence from neuroimaging and music and brain studies that points in the direction of a kind of modularity of the brain with specific brain areas being responsible for specific musical functions (domain-specific competences). Moreover, there is "experimental" and "behavioural" evidence from young infants' studies (perception of frequency, timing, timbre of sound and relational information processing, besides capacities to perceive significant structural and affective features of musical sound and exploratory competences) that are converging towards the same nativist claim. The level of acquisition, on the other hand, is more challenging as it is related to the concepts of learning and adaptation. But even at this level, there is empirical evidence now, as musical learning can be expressed in terms of cortical plasticity with functional and structural

changes in synaptic connectivity and brain tissue. The musical brain, as it comes to be viewed, demonstrates a dynamic organisation and responds with considerable flexibility to new challenges of the environment end this throughout its entire life. To the extent that these plastic changes are related to the acquisition of new memories and skills as a consequence of perceptions and motor action, it is possible to conceive of dealing with music in ecological terms as organism-environment interaction.

Music, further, is not only a sound-time phenomenon—with sounding events which are organised in time—, but a phenomenon of subjective human experience with levels of processing that range from direct reactivity to more elaborate reactions to the sound. It is argued that there is a continuum between phylogenetically older mechanisms of processing and newer ones, as well as ontogenetical developments such as perceptual learning and the acquisition of the musical code. The latter, especially, is dependent upon general predispositions (universals) and idiosyncratic reactions to the sounds.

As to the universals, there are cognitive claims which underlie all kinds of music processing and cognitive processing in general, and which raise the question of the specificity of musical competence (general or domain-specific) and its relations which other competences (e.g. music and language). There are two major approaches to this question: an ethological and a neurobiological one. The first provides descriptions of musical behaviours in general (ethnological and anthropological studies), the second looks for anatomical markers of specific musical abilities.

This brings us to a final question. Does music have adaptive or survival value? Scholars disagree on this topic, but there is an argument from developmental perspective which claims that music can be helpful in life regulation and arousal modulation. This is exemplified most typically in maternal music and nurturing: caregivers across cultures speak to infants in a sing-song manner, and use a special-purpose repertoire of lullabies and play songs. They demonstrate performance alterations (raised pitch level, decreased tempo and emotive voice quality). Besides, there is evidence from physiological research that music can provoke bodily reactions to the sounds. Most prominent among them are autonomous changes (nervous system), hormone release (oxytocine, testosterone), the mechanisms of raising or lowering the arousal level, and even mood regulation and induction of emotions. The extent to which these reactions or innate are acquired, however, is still a topic of discussion.

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Robots, insects, and emergence

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Swarm robotics is a new approach that explores the emergent behaviour of collections of simple robots. It is biologically inspired by social insects and involves simple reactive robots that are autonomous, and that can communicate only locally, not globally. One of the main mechanisms underlying emergent behaviour of robots in these studies is that of stigmergy. Individual robots respond to the changes that other robots have made to the environment, with the result that apparently cooperative behaviour arises. In this paper we will discuss the nature of such indirect communication, focusing on the differences between living systems and robots.

The Touch of the World

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Since the beginning of biosemiotics, the sensorimotor meaning of physical substance was discussed (1). The new biological approach had supposed extension and impenetrability to be motor-related ***local signs***. These allowed personal forces to meet other substance, preventing the body from occupying the same space at the same time.
To come in the right touch with the physical world, a fundamental precondition was proposed: the generation of a common spatio-temporal framework for all ***local signs***. By this spatio-temporal argument, the touch of the world became a melody of forces (= Bewegungsmelodie). Substance was understood as a composition, generated by a sequence of perception and action related motor forces in spatio-temporal order.
Until now there is few investigation in the framework of this ***spacialization of local signs***, which allows the subject to compose the action guiding extension and impenetrability of matter. The related fallcies in human environmental touch were not focused before 1963 (2), but on the basis of spatial illusions in vision and touch. Though, ***local signs*** have to fit the extension and impenetrability of substance. It was Emil v. Skramlik, an early follower of the environmental concept of J. v. Uexküll, who investigated the related formation of space. The ***spacialization*** Uexküll had proposed in his "Theoretische Biologie" (4), was unveiled in Skramlik's "Psychophysiologie der Tastsinne". There he described the measurable framework of ***spacialization***, which allows human activity to fit the common human environment (3).

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A Biosemiotic Scala Naturae?

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The paper discusses the epistemological and ontological problems involved in constructing the phases in a Hoffmeyerian "natural history of signs". The core biosemiotic idea that the science of biology is impossible without semiotic notions immediately leads to the question of which signs appear in which fields of biology. Jesper Hoffmeyer already many years ago called for a "natural history of signs" to study this question - making the assumption that we should expect a semiotic evolution to be part of biological evolution, so that more complex sign types and sign processes appear during biological evolution. The construction of such a natural history of signs entails certain problems, however. The overall methodological question of biosemiotics - how are signs to be discerned in natural processes - is partitioned into more more detailed questions. How is anthropomorphism in a bad sense of the word avoided (if we should take Peirce's audicious claim that nature in some sense undertake inferences and arguments, then how should we methodologically confirm that)? Which signs, if any, need the support of consciousness? What is the biosemiotic "missing link"? Which type of training will it take to construct such a evolutionary ladder of sign types? Rather than being a particular question for biosemiotics, the issue of a biosemiotic Scala Naturae rather forms an extensive research program demanding the participation of a group of researchers from different areas.
Outline of a biosemiotic Scala Naturae regarding organisms with respect to semiotic ability

"Searle threshold" - conscious, deliberate, intentional communication actions – linguistics

"Eco threshold" - linguistics and other human sign systems, involving signs not necessarily supported by conscious, deliberate acts (semiotics defined as that which may be used to lie – the emergence of fooling?) – human sciences

the "biosemiotic missing link" - probably consisting of several sub-thresholds?

Some candidates:
- "Deacon threshold"
- "Chomsky threshold" - syntax module?
- "Lakoff threshold" - metaphors? (but is there any clear limit between metaphor and concept extension?)
"Husserl threshold " - intersubjectivity?
- diagrammatical reasoning?
- hypostatic abstraction?

"Merleau-Ponty threshold" - multicellular bodies with central nervous system (and probably consciousness), symbol processing, moveable perception organs integrating sensori-motor system, "interanimalité" and environment mapping - higher zoology

"Uexküll threshold" - active information gathering, functional circle – zoology

- Multicellular threshold - threshold between unicellular and multicellular organisms (plants,

funghi, animals, respectively) - pertaining to the introduction of stable intercellular semiosis (’intercellularité’) and cell differentiation ? A biological "wisdom of the crowds"?

- threshold between prokaryotes and eukaryotes - the DNA in the former is not separated from the protoplasm so that it may communicate more freely to other prokaryotes?

- Categorical perception threshold-– simple categorization by ”active sites” on the surface of macromolecules as in E.coli pursuing sugar– (the emergence of being fooled)

- ”Kauffman threshold” – the introduction of ”autonomous agents” defined by self-stabilising autocatalytic cycles

“Sebeok threshold” - semiotic processes proper – biology

”Deacon (2) threshold” – introduction of pre-biotic natural selection on ”autocells”

“Peirce threshold” - protosemiotic processes - all of the universe

Biosemiotics as a science and as an existential philosophy

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In earlier gatherings, I have suggested the method of biosemiotic naturalism for *biosemiotics as science*, i.e. that its concepts should refer only to the objects of our external experience. This proposal has not gained much acceptance from my fellow biosemioticians. One reason for that might be that initial *motives* for biosemiotics are ultimately political or existential consisting of the idea that many environmental, psychopathological, and social problems are conceptually originated from the culturally dominating (quasi)-Cartesian dualism of body and soul. In order to overcome these problems, we should thus try to surpass or reunite the dualisms of matter and mind, natural and mental/semiotic, natural and cultural/political/human, or mechanical and telelogical. This is not a simple project, because these dualisms are not typical only to western modern world-view. There is some probably universal human experiential support to these divisions, the support that probably transgresses even the borders of humanity. This common experiential base is an experience of frustration in context where a planned action does not happen to reach its desired result — when an experience about the difference between imagined or anticipated 'ideal' world ('mind') and 'hard reality' ('body') concretely appears.

The standard biosemiotic solution to overcome dualisms seems to be to suggest some kind of 'experiential biology' or metaphysics of 'qualitative organicism' (Emmeche 2000, 2001). The idea about experiential biology etc. is valuable as a *control* for what is done in biology and biosemiotics. However, I will argue that experiential biology does not redeem us from our implicit Cartesianism, but quite contrary, it more likely doubles it. It is humanism (and hermeneutics) that maintains Cartesian distinctions by distinguishing itself from nature and natural science. Although we should naturalize at least the basic semiotic concepts in biosemiotic biology (or science), it does not lead to the metaphysical claim that mentalist concepts and their objects were not real. Our everyday life is deeply dependent on their validity — most of our necessary self-knowledge is mediated by our inner feelings, emotions, etc. But humanist (or religious) tradition has given the *privilege* or foundational status to such inner intuitions, and that Platonic-Cartesian idea has led to many disastrous doctrines and practices in education, developmental aid, psychotherapy, and 'personal training'.

I will suggest that instead of trusting to our inner intuitions, objects of our internal experience should not be given any special status in relation to objects of external experience that are intellectually or cognitively more controllable. Perhaps, the biosemiotic naturalism could be applied even in existential philosophy so that the initial dualism in experience could be removed from the experiential structure of self-consciousness and that the thought about action and action itself could be assimilated if desired. Perhaps this existential project, if feasible, could produce a new concrete awareness about self as a living body (or as a lineage of living bodies?) and not as a non-material soul or mind *in* the body. This might make us able to free ourselves the pathological consequences of quasi-Cartesian thinking.

Perhaps even naturalism can be existentialism.

The Neuro Heuristic paradigm

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The possible strategies that we could use in trying to comprehend cerebral functioning hinge on the subsequent problems arising from interdisciplinary studies of molecular, cellular, individual and social behavior. Many disciplines have an interest, and an important contribution to make, in obtaining an acceptable solution: philosophy, psychology, neuroscience, pharmacology, physics, Artificial Intelligence, engineering, computer science and mathematics. Whilst such interdisciplinarity makes the problem more exciting it also makes it more difficult. The languages of various scientific disciplines have to be used, and appeals to the knowledge bases in those disciplines also made. Scientific thought as we know it today, is based upon the assumption of an objective, external world. This conviction is supported by a rationale which calls upon mechanical laws of causal efficacy and determinism.

The information processing effected by the brain appears then as a result of an accordance between Nature ("bottom-up") and Nurture ("top-down"). Research strategy based on the "bottom-up" information flow, the preferred view by neurobiologists, seems potentially necessary and sufficient; however it is not wholly viable to actual experimentation considering the impossibility of simultaneously examining, even in a primitive species, all cellular elements of the brain and all variables that affect those elements. The "top-down" strategy with the assistance of "dark boxes" is easier to bring to fulfillment but insufficient and irrelevant in understanding the mechanisms coordinating the local networks of cellular elements. It seems therefore that a fusion of the "bottom-up" and "top-down" mechanisms is needed, leading to a distinct approach to the Neurosciences. Let us call it Neuro-Heuristics, or Neuristics, issued from the Greek terms neuron (nerve) and heuriskein (to find, to discover). Its definition corresponds to that branch of Science aimed at exploring the assumptions of the Neurosciences through an ongoing process continuously renewed at each successive step of the advancement towards understanding the brain in its entirety.

In this framework, the "result" cannot be simply positive or negative because the process itself cannot be reduced to proficiency as such. The accent here is on the dynamic and no reducible characteristic of this approach. It is important at this point to make a distinction from Bergson's psychophysical interactionism. In Bergson's perspective the transition to a successive stage is dependent upon the vital impulse which appears at each stage. Therefore, it is the vital impulse which is the activating agent of transition between the stages. In our perspective, the change occurs when an essentially new and unexpected combination develops from the preexisting properties. At the dawn of the XXIst century, such an approach can reap benefits from the new sciences and technologies which promote the emergence of new concepts; molecular biological studies and computer science can be an integral and crucial extension to the field of Neuroscience.

From Umwelt to Mitwelt

Natural laws vs. rule-governed sign-mediated interactions (rsi's)

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Background: Within the last decade, thousands of biologically oriented studies have described communication processes between organisms. This communication goes beyond that between members of the same organismic kingdoms to include that between members of different organismic kingdoms. In fact, life on our planet is entirely dependent upon functioning symbiotic communication communities. Moreover, the fundamental biological processes within an organism represent communication processes *in and between* cells. As a consequence of the *pragmatic turn,* pragmatic action theory views communication processes as sign-mediated interactions in which sign use by interaction partners follows fundamental syntactic, semantic and pragmatic rules.

Results: As sign-using individuals exhibit a relationship to following or not-following these rules, the rsi's of living individuals differ fundamentally from cause-and-effect reactions *with* and *between* non-living matter, which exclusively underlie natural laws. Organisms cannot develop such a "to follow or not follow" relationship with natural laws but underlie them in the strict sense. The *Umwelt concept* cannot do justice to the fundamental differences between natural laws and rsi's because this concept reduces rsi's to the information transmission *effect* and therefore to a level of coding and decoding via an individual organism's physiological sensory organs (i.e. a level that adheres to natural laws). The *intersubjective-communicative* character of the rsi's, and therefore the relationship to following or not-following *commonly shared rules of sign-use*, does not manifest itself here. In investigating communication processes *in and between* organisms, it is therefore sensible to supplement the *Umwelt concept* with a *Mitwelt concept*. The *Mitwelt concept* underlines the difference between the cause-and-effect reactions in natural laws and rsi's: *Umwelt* thus becomes a helpful term in investigating those physiological influences on organisms that are not components of rsi's. *Mitwelt* is a term for the integrative investigation of all rsi's of organisms, i.e. all intra-, inter- and meta-organismic communication processes and their history.

Conclusions: In order to understand *all* rsi's, which in their totality enable the *symbiotic interdependence of all life*, the *3rd person perspective* (as a cognitive simulation of a quasi-extraterrestrial observer) should develop into a 1st/2nd person *perspective of a performative participants*. This change in perspective replaces an antiquated, discriminatory methodological ideal with the certainty that all scientific communities as well as the general public - which legitimizes this research and draws benefits from it - are *actual participants* in this symbiotic interdependency.

Key words: communication, symbiotic interdependence, natural laws, rule-governed sign-mediated interactions (rsi's), Umwelt, Mitwelt, performative participants.

Emotions as Signs in the Interaction between Humans and Animals

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The interaction between humans and animals is based to a high extend on verbal (or acoustic) and nonverbal communication. This communication may be considered as a result of conditioning, as far as it is practiced with animals which have learned to understand or interpret the corresponding 'language' or code. But a communication is also possible with non-trained animals (especially with domesticated species), there must be something universal in the interspecific understanding. In verbal communication, it is mainly the prosody of the human voice that shows significant differences to the animal. In nonverbal communication, elements of body-language like gesture, facial expression etc. act as channels for interaction, for a transmission of meaning. But both prosody and body-language are transporting something more than a formal code: the emotional state of the transmitter.

The research of emotions is rather heterogeneous up to now (opposition nature-nurture), and concerning the interspecific interaction it stands at its very beginning. With the help of empirical data in the tradition of ethological research methods and with semiotics as a theoretical base I will try to link perspectives of Sciences and Humanities and show the relevance of emotions as signs in the interspecific communication.

Semiosis aspects of ecosystems of the invasive *Caulerpa taxifolia*

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Many different ecosystems have intrinsic mechanisms that maintain composition and functions within limits. We also tend to think of ecosystems as fixed ecological units with distinct boundaries. By studying each of these areas, we can make important and interesting discoveries about who lives where and why and about how conditions are established and maintained there. According to J. Lovelock in his Gaia Hypothesis, we also can make important discoveries about how organisms interact with each other, what kind of biosemiosis, or other forms of communications are exchanged within the ecosystem in order to maintain a form of homeostasis achieved by nature if left undisturbed, this also depends on active feedback processes operated automatically and unconsciously by the biota. As F.E. Clements has put it, "every landscape has a characteristic "climax" community toward which it will develop if free from external interference. The climax community, he believed, represents the maximum state of complexity and stability possible for a given set of environmental conditions. From the Gaia hypothesis "we might infer also that even though nature has self-correcting mechanisms, there may be thresholds of disruption beyond which it may not be able to recover". Such an example of this was the anthropogenic intrusion of *C. taxifolia* in the Mediterranean. Its exceptional properties include a wide range of genetically modified characteristics originally not present in the strain. It was captively bred and was exposed for many years to chemicals and ultraviolet light. Obviously, this exposure to extreme abiotic stressors have altered and switched ON genes that have not been previously expressed or active in wild type strains found across the Pacific. We all wonder now whether nature would be able to adapt to these genetic changes in the ecosystem? Obviously, we have the tendency to think that with the introduction of this new type of creature might put to an end of the homeostasis, or it would deeply affect the global equilibrium of the system. In such a case, it will self-organize in a new way, probably at a higher level of organisation. Otherwise it could cause the destruction of whole ecosystems. Because this particular mutant is able to grow with such a great success in all ecosystems, this might lead to a crash; for example, to a globally lower level of organisation, into a self-sustaining steno-populations. One of the purposes of having a wide variety of species and ecosystems, is the increased system effectiveness possible with specialization, division of labor, and more kinds of control and regulatory circuits. However, with this modified strain, the ecosystem dynamics are disturbed in a way that it would bring a sort of collapse in the system. What could be the extension of this collapse on an ecosystemic level?