Biosemiotics (2013) 6:1–7
DOI 10.1007/s12304-012-9151-7

EDITORIAL

Information in Biosemiotics: Introduction to the Special Issue

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Received: 8 December 2009 / Accepted: 26 February 2012 / Published online: 11 May 2012
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Although semiotics emerged in efforts to scientifically investigate how signs function in language and culture, the 20th century has witnessed efforts to extend semiotic theory into the non-cultural realm, primarily in relation to living systems and computers. Resulting developments have been deployed to extend the scope of semiotics from strictly cultural communication to a "Biosemiotics" that encompasses communication of all living systems from the inside of cells to the whole biosphere. Biosemiotics is thus a research program that attempts to unite the areas of nature, mind, language, human consciousness and society in an evolutionary framework, and which tries to explain the qualitative differences between these as levels of emerging qualities, and to extrapolate its consequence for science and our anthropology.

The science of signs, semiotics, has always been deeply intertwined with the concepts and issues of a broadly-conceived information science, including such concepts as communication, signals, codes, interpretation, and most especially "information" itself. But the concept of information and information science have their own history apart form the concept of sign and semiosis. Indeed, the mathematical concept of information is deeply rooted in the history and philosophy of science, where it has played a key role in changing a mechanistic foundation into one more compatible with evolutionary views of the universe. In his *Critique of Practical Judgment,* Kant realized that on the basis of a mechanical science of nature such as that of Newton, a proper theory of life could not be developed. Rather, living beings must, in Kant's view, be understood as self-organized autonomous systems. Kant

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never really drew the consequences of his discoveries for the rest of his philosophy. First-person experience and awareness and the production of meaning and signification remain outside the scope of mechanicism, as it has developed since Newton. In order to accommodate the developing scientific perspectives including statistical mechanics, modern evolutionary theory, and even quantum and black hole physics, many concepts of "information" developed by researchers from Boltzman to Shannon, Wiener, and Schrödinger have been invoked at a level complementary to matter and energy. By using thermodynamics as the general paradigm of complexity, chance, irreversibility and self-organization, information theory (in this broad sense) provides the essential complement to a purely mechanistic perspective. Specifically, the insights of Schrödinger and Wiener and later Prigogine and Stengers, were the basis for developing an informational and functionalistic approach to "life science".

A crucial problem is thus whether life is a natural and perhaps necessary outgrowth of first principles in physics and chemistry, and, if so, can life be synthesized? And what can minimal life-forms, such as viruses, reveal about life's fundamental properties? The goal of this program is to derive a definition of life that satisfies two criteria: 1. The exclusion criterion should dichotomize the physical universe into living and non-living systems. 2. The inclusion criterion should accommodate all compelling empirical examples of life from viruses over bacteria, protists, algae, flies, and mammals—including the human body.

One natural position in this argument is to distinguish, at least at a working level, living and semiosic systems on the one hand, from non-living and non-semiosic systems on the other, by observing the equivalence of the classes of biological and semiotic systems in the observable universe. Determining whether this an essential equivalence or a contingent accident awaits future developments in biology, artificial life, artificial intelligence, and exo-biology. But on this view, the range of social physical productions like artifacts and technology are included within the broader Biosemiotic world.

The Classical Semiotics Paradigms

We can observe at least two main schools of semiotic theory.

1. A dualistic French structuralistic paradigm, usually called *semiology*, originating in Sausure's work. This paradigm works primarily with intentional signs and the relation between their form and content. The semiological paradigm emphasizes cultural codes in a dualistic paradigm relating sound and meaning but having no interest in how the sign is related to an external world. It is mainly used in linguistics, cultural studies and analysis. It was developed under names such as Louis Hjemslev's (1899–1965) *glossematics*, Roman Jacobsen's (1896–1982) *semiotic linguistics*, Algirdas J. Griemas' *structural semantics*, Roland Barthes' (1915–1980) *text semiotics*, and Umberto Eco's *general semiotics*. Semiologians would usually only take intentional concepts, pictures or figures communicated between self-consciously human as communicational acts as their subject matter. This makes the paradigm in that version an unlikely candidate for biosemiotics. But structuralist approaches are possible outside human culture.

2. The other research school is the triadic, pragmaticistic, transdisciplinary, and evolutionary doctrine originating in the work of Peirce and is called *semiotics*. This is a realistic based paradigm working with the relation between a primary sign—the representament—and the 'object' in the world it refers to of which some are things and how that relation is construed as an Interpretant is foremost seen as constructed by living systems including humans and their cultural systems. It was developed in a more behavioristic and pragmatic direction by Charles Morris (1901–1979), was renewed in the *zoö-* and *bio-semiotic* of Thomas Sebeok (1920–2001) through his reinterpretation of Jacob von Uexkull's *Umweltslehre* in collaboration amongst others with the Copenhagen School of Biosemiotics and the Jacob von Uexküll center in Tartu. This semiotic doctrine also accepts non-consciously-intentional signs in humans and between animals as well as between animals and humans.

This latter school was reflected in the development of *Biosemiotics* that followed with a natural focus on these areas within the living world. The flow of the focus of biosemiotic theory can be seen originally at the behavioral level through animal communication; then to the neural, hormonal, and immunological systems of large metazoans; and finally to the bio-molecular and biochemical level of non-intentional signs including signs between organs and cells in the body called *endosemiotics* (for example, a special area of *immunosemiotics* deals with the immunological code, immunological memory and recognition). Biosemiotics also deal with signs in plants in *phytosemiotics* and with bacterial communication.

Schools of Biosemiotics

As biosemiotics is trying to finish building its disciplinary matrix it becomes clear that there are interesting disagreements about what it takes to produce signification and what part information plays in this process. There seems to be difficulties to reach general agreement on central terms due to differences in philosophical frameworks especially in the stipulation on ontology and epistemology and their relational interdependence.

1. The perspective rooted in general systems theory and cybernetics points to key evolutionary developments and inquires about their informational bases. One of those is the nature and origin of living systems, and another that of semiotic systems. While scientific debate and advancement in the origins of life continues, still there is a more-or-less common-sense meaning to what is a "living system". But this community characterizes a "semiotic system" as an entity which manifests or embodies "semantic relations". Semantic relations in turn are particular regularities, which result from and produce some form of "meaningfulness" implied by *interpretation* processes.

That such concepts can not be found in the information and computer sciences, indicates the outreach which the systems sciences make toward semiotics. And indeed, the core question for systems theory thus emerges as a question of Biosemiotics: to what extent are the classes of biological and semiotic systems identical or

distinct? Can an informational approach explain the peculiarities of living systems, such as for instance Gregory Bateson worked towards?

As a point of departure, it is possible to articulate at least the outline or structure of a "standard view", which sees information in physical processes as structure- or form-giving in physical systems, resulting from sometimes complex physical and chemical processes, and typically involving spontaneous symmetry breaking and other forms of physical emergence. Operationally, information is then cast as the existence of a set of (physical) distinctions (differences) within a particular frame of reference or scale, which it is possible to make into physical observables. Thereby the generation, storage, and transmission of information is universal in physical processes, starting even cosmologically with symmetry-breaking of the fundamental forces, up to the structures we see in the physical world and the whole range of complex systems and pre-biotic physical and chemical processes, which create physical structure in the world. To this point, the role of subjects and first person consciousness for interpretation and meaning is avoided

Semiotic systems (such as, presumably, proto-organisms) then harness the observable distinctions as sign vehicles. When combined with a range of other requirements involving the presence of energetically consistent, meta-stable states, memory structures, and rule-following coding relations generated through evolutionary processes of variation and selective retention, these tokens are incorporated into a range of biological processes related to thermodynamic metabolic control, reproduction, and self-repair. Through these evolutionary processes emerge a series of increasingly complex semiotic systems, resulting in control processes sufficient for primitive agency, then life, ecosystems, multi-cellularity, and ultimately neuronal cognition. Still how the emergence of experiencing consciousness and its qualia is possible from an ontological base of energy, matter and information still awaits a good theory.

2. Then there are the Peircean biosemioticians who, to varying degrees, want to build their foundation on his semiotic philosophy and metaphysics. Most of them try to modify Peirce to make him more compatible with the received view of science (since his three phaneroscopic categories, hylozoic view of matter and mind, and Agapistic integrative view of science and religion are difficult for scientists to absorb). Some have stressed the organicistic view with its theory of emergence based on so-called Complexity Science with its concept of CAS (complex adaptive system) as a solution. The term CAS means an open system in a thermodynamic gradient (far from the equilibrium, which Prigogine identified as dissipative structures) with many strongly-coupled degrees of freedom, non-linear connections, and feedback mechanisms. They often exhibit hysteresis and, therefore, have pre-stages to memory functions. They also often have a hierarchical (or "heterarchical") complexity, dynamic networks locally differentiating, and have emergent and holistic properties

Complexity science has moved science away from a linear mechanistic view of the world to one based on nonlinear dynamics, evolutionary development, and systems thinking. But, it is still far from explaining how life and signification could emerge through physical and chemical evolution. One of the basic questions here is if a Peircean biosemiotics can function without the Peircean philosophical foundation in

Firstness and Synechism and without a theory of how pre-semiotic nature functions in such a way that life and semiosis are possible. Because this emergent jump from a physical and chemical world to living systems with individuality is still a central mystery to modern science, so is the phase shift from information to meaning. Furthermore, if that is necessary, then can such a change in the philosophical foundation be done in a scientifically acceptable way? Or is it science that has to adapt to a new foundation? Finally, should such a theory concerning one end of the evolutionary scale be able to support a reasonable theory of how human linguistic self-consciousness—in the other end of the scale—could develop and what that actually is (if there is a Scala Natura at all)?

3. A new paradigm, called Code-semiotics, has been proposed for the level of the free-living cells, and in particular for the cells that appeared in the first three billion years of evolution. The Code model develops a natural concept of "meaning" (the common sense of the concept of meaning is changed) that avoids using the concept of interpretation in free-living cells and in all systems that do not build internal representations of the world. In effect, it introduces into biosemiotics a dualistic, structuralist, code-based approach, which is close to the way many information and computer scientists think. But it does not explicitly use their work, maybe because its concept of "sign" competes with the informational concept. As in the systems model, here the first semiotic system in the history of life was the apparatus of protein synthesis (the ribotype), but Code-semioticians do not hold that that apparatus needs interpretation, because the rules of the genetic code are virtually the same in all living systems. More precisely, a semiotic system is defined as a set of signs and "meanings" linked by the conventions of a code. Signs, meanings and conventions, however, do not come into existence of their own. There is always an "agent" that produces them, and that agent can be referred to as a "codemaker" because it is always an act of coding that gives origin to semiosis. The first agents of life (the first codemakers) were molecules independent of mind and subjectivity, but were nevertheless "creative", because they created a world of proteins that could not exist without a genetic code.

The Code model states that the necessary and sufficient condition for something to be a semiosis is that A provides a conventional association between B and C, where A is a set of adaptors and B and C are the objects of two independent worlds. Thus a semiotic system is a triad of signs, "meanings" and code that are all produced by the same agent, i.e., by the same codemakeing molecule. In the first metazoan neural animals, the connections between sensory inputs and motor outputs were probably simple nerve-reflex arches, but these could not evolve much because complex hard-wired circuits were necessarily slow and cumbersome. The animals had to "invent" a new solution to signal-processing, and the only way was the manufacturing of new objects by a new code. This was possible because the neurons of the intermediate brain are natural "adaptors" (they perform two independent recognition processes) so they were already suited to generate a code. The new "objects" that they produced were representations and feelings, and subjectivity was the overall result of this process, because one is a "subject" only when it has access to an internal word of its own making. Semiosis appeared therefore at the origin of life, whereas mind and

interpretation came much later. The Code model starts with a definition of semiosis that does not depend on mind, and describes an evolution of semiosis that eventually gave origin to mind and interpretation. The emergence of mind was associated with the origin of a third type of semiosis which is called interpretive semiosis (like the Peircean type), but remained also dependent on the first two types (manufacturing and signalling semiosis). Thus mind did first emerge at a very high hierarchical level, in sharp contrast with the hylozoic ontology of Peirce's semiotics. Interpretation is regarded as a process that depends primarily on representations, in addition to memory and learning, and its origin is linked to the origin of perceptions and feelings, i.e., to the origin of subjectivity and mind, the explanation of which seems to be outside the subject area of the theory. As such code-semiotics seems to be a new kind of structuralist approach.

The Project of This Issue

In this special issue of *Biosemiotics*, we present papers which seek to explicate the relationships, scientific, conceptual, methodological, philosophical, or historical, between the concepts of "information" proper, and those of "semiotics" proper, in the context of biology and living systems.

We offer to the research community a collection of challenges on the following points:

- In non-biotic, proto-semiotic systems, what is the nature and operation of "information content" or "information processing"? Is it simply that semiotics requires information, but not vice versa?
- What does it mean, if anything, to store, process, or transmit information without semiosis and with?
- In evolutionary history, where does information storage and processing first occur? Or are information, signification, and interpretation just synonyms?
- To the extent that life and meaning are coextensive, must it be the case that life and information use also are?
- How can a code can exists as an objective phenomena in the form of a thing like a molecule that connects the two different areas in such a way that molecules come to 'mean' something?
- How are the syntactic, semantic, and pragmatic senses of "information" implicated in this debate? If, on the standard view, information is simple difference, while meaning is a difference that makes a difference, is simple rhetorical rigor sufficient to gain illumination and clarity? What about differences which *may*, but *need not*, make a difference?
- How are the physical, biological, cognitive, and computational uses of "information" coextensive or entrained in each other, and how should they be invoked to gain coherence?
- Similarly, how are the physical, biological, cognitive, and computational uses of "semiosis" coextensive or entrained in each other, and how should they be invoked to gain coherence?
- Are externalist vs. internalist perspectives and the invocation of an epistemic cut useful or distractions?

- To what extent does a departure from the standard view result in proto-semiosis or pan-semiosis, and what is at stake in that movement?
- Can biosemiotics present a compromise where life and semiosis coinside, but without explaining the emergence of life and mind through pre-biotic semiosis in nature in some sort of pan-semiotics?