Semiosis as an Emergent Process

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Abstract

In this paper, we intend to discuss if and in what sense semiosis (*meaning process*, cf. C. S. Peirce) can be regarded as an "emergent" process in semiotic systems. It is not our problem here to answer *when* or *how* semiosis emerged in nature. As a prerequisite for the very formulation of these problems, we are rather interested in discussing the conditions which should be fulfilled for semiosis to be characterized as an emergent process. The first step in this work is to summarize a systematic analysis of the variety of emergence theories and concepts, elaborated by Achim Stephan. Along the summary of this analysis, we pose fundamental questions that have to be answered in order to ascribe a precise meaning to the term "emergence" in the context of an understanding of semiosis. After discussing a model for explaining emergence based on Salthe's hierarchical structuralism, which considers three levels at a time in a semiotic system, we present some tentative answers to those questions.

1. Introduction

The Peircean list of categories (Firstness, Secondness, Thirdness) is logically described as a system of classes of irreducible relations (monadic, dyadic, triadic) (see Houser 1997, Brunning 1997). This system is the foundation of his "architectonic" philosophy (Potter 1997, xxviii; Parker 1998, p. 60) and, among other things (see Fisch 1986, p.324), of his model of semiosis (Murphey 1993, pp. 303–306). According to C. S. Peirce, semiosis consists in a relation involving three irreducibly connected terms (Sign-Object-Interpretant), which are its minimal constitutive elements (CP 5.484, MS 318:81, EP 2:171).

> A sign is anything which determines something else (its interpretant) to refer

TRANSACTIONS OF THE CHARLES S. PEIRCE SOCIETY
Vol. 42, No. 1 ©2006

> to an object to which [it] itself refers (its object) in the same way, the interpretant becoming in turn a sign, and so on *ad infinitum*. (CP 2.303)

One of the most remarkable characteristics of Peirce's theory of signs is its dynamical nature. Accordingly, the complex S-O-I can be seen as the focal-factor of a dynamical process (Hausman, 1993, p. 72).

Peirce (see De Tienne 2003, Hulswit 2001, Bergman 2000) also defines a Sign as a medium for the transmission of a *form* or the transference of a *habit* embodied in the Object to the Interpretant, so as to constrain the interpreter's behavior:

> . . . a *Sign* may be defined as a Medium for the communication of a Form. [. . .]. As a *medium,* the Sign is essentially in a triadic relation, to its Object which determines it, and to its Interpretant which it determines. [. . .] That which is communicated from the Object through the Sign to the Interpretant is a Form; that is to say, it is nothing like an existent, but is a power, is the fact that something would happen under certain conditions. (MS 793, p. 1–3; see EP 2:544, n.22 for a slightly different version, drawn from a different variant in MS 793)

In this paper, we intend to discuss if and in what sense semiosis can be regarded as an "emergent" process in semiotic systems. In our research, this problem appeared in the context of investigations about computer simulations of semiotic processes (Gomes et al. 2003a,b; Loula et al. 2005). This was due to the widespread use of the notion of "emergence" in research fields largely based on computer simulations, such as Artificial Life, Cognitive Robotics, and Synthetic Ethology (Cariani 1989; Emmeche 1994, 1997; Ronald et al. 1999; MacLennan 2001; Bedau 2002; Cangelosi and Turner 2002). In these fields, the concept of "emergence" has become so popular that they are often described as dealing with "emergent computation". Surprisingly, little discussion regarding the precise meaning of the terms "emergence", "emergent", and so on, is found in them (cf. Cariani 1989). It is fundamental, however, to ascribe a precise meaning to the concept of emergence and its derivatives whenever they are applied to any domain of phenomena or theories. This is our basic intention here, as it concerns semiotic phenomena.

A systematic approach to this topic seems to be crucial also in the domain of semiotic investigations in themselves, particularly regarding the debates in the context of Peirce's metaphysics and evolutionary cosmology. However, we do not find in these debates (e.g., Parker, 1998; Nöth 1994; Kruse, 1994) any technical or detailed discussion of the possible relationships between the concepts of semiosis and emergence.

It is not our problem in this paper to answer *when* or *how* semiosis emerged in the universe. Rather, we are interested in discussing the conditions which should be fulfilled for semiosis to be characterized as an emergent process. Our arguments presuppose the existence of semiotic systems, which instantiate semiosis, but we don't take a stance regarding the possibility that semiosis may have in some sense preceded such systems.

In the next section, we will summarize a systematic analysis of the variety of emergence theories and concepts developed by Stephan (1998, 1999). This will lead us to pose fundamental questions that have to be answered in order to ascribe a precise meaning to the term "emergence" in the context of an analysis of semiosis. Then, we will employ Salthe's (1985) hierarchical structuralism as a basis for developing a model for explaining the emergence of semiosis in systems which produce, process, and interpret signs. Finally, we will propose some tentative answers to the questions we raised along the presentation of Stephan's analysis.

2. Central Characteristics of Emergentism: What Questions About Semiosis Do They Raise?

Semiosis can be described as an "emergent" process in semiotic systems. But what do we exactly mean by this idea? To provide a clear answer to this question is particularly important, in view of the revitalization of the emergence debate in the 1990s (Kim 1998, 1999; Stephan 1999; Cunningham 2001; Pihlström 2002; El-Hani 2002), which made the term "emergence" and its derivatives much more popular than they had been throughout the whole 20th century. This is particularly true of research on computer models of non-linear dynamical systems, complex systems research, artificial life, cognitive sciences, etc. . . In the case of Alife, for instance, Langton (1989, p. 2) even states that the key concept in this field is that of "emergent behavior".

As the concept of emergence is increasingly used, it becomes more and more important to avoid employing it in vague and imprecise ways, inasmuch as this concept has carried for a long time a burdensome load of confusion about its metaphysical and epistemological aspects. In fact, the price of being careless about the use of this concept is already surfacing in the current debates about emergence, in the form of a certain perplexity about what is really meant by "emergence", "emergent properties", and so on.

In this paper, we intend to apply the concept of emergence to the domain of semiotic phenomena in a precise manner, with the purpose of stimulating a more thoroughgoing dialogue between the philosophical traditions of semiotics and emergentism. For the sake of our arguments, we will employ a systematic analysis of emergence theories and concepts developed by Stephan (1998, 1999). Along the summary of this analysis, we will pose fundamental questions that have to be answered in order to characterize semiosis as an "emergent process".

The term "emergence" is often employed in an intuitive and ordinary way, referring to the idea of a "creation of new properties". This idea comes back to one of the original sources of the emergentist thinking, the works of the British psychologist Conwy Lloyd Morgan. As Emmeche and colleagues (1997) show, a discussion of the key concepts in this idea, "novelty", "property", and "creation", can result in an understanding of some of the main issues in emergentism. Nevertheless, this idea is not enough for grasping the concept of emergence, mainly because it is focused on characteristic claims of one type of emergentism, namely, "diachronic emergentism" (see below).

In a technical sense, "emergent" properties can be understood as *a certain class* of higher-level properties related *in a certain way* to the microstructure of *a class of systems*. It is part of the task of an emergence theory to fill in the open clauses in this definition (shown in italics). It should provide, among other things, an account of which systemic properties of a class of systems are to be regarded as "emergent" and offer an explanation of how they relate to the microstructure of such systems. Moreover, it should establish which systems exhibit a certain class of emergent properties. If we extend this definition to encompass processes,[1] a first question to be answered in order to characterize semiosis as an emergent process concerns the demarcation of the class of systems which show semiosis. We can frame it as follows: (1) what is a semiotic system?

There is no unified emergence theory. Rather, emergence theories come in various shapes and flavors. Nevertheless, it is possible to recognize in the diversity of emergence theories a series of central characteristics (Stephan 1999, chapter 3; cf. also Stephan 1998). In the following sections, we will discuss in detail the fundamental tenets of emergentist philosophies, at least in their scientifically-compatible versions. Nevertheless, for some readers already familiar with emergentism, it may be unnecessary to go through all these details. Accordingly, we will present in the next paragraph a brief overview of these basic concepts, so that any reader who wishes to skip the remainder of section 2 and section 3 can follow the argument continuing from section 4.

In scientifically-compatible accounts, emergentism is a naturalistic and physicalistic position, according to which the evolution of physically constituted systems show, from time to time, critical turning points, in which new organizational patterns arise, and, thus, new classes of systems exhibiting novel properties and processes. Among these novel properties and processes, emphasis is given to emergent properties, a particular class of systemic properties (i.e., properties observed at the level of the whole, but not of the parts). Emergent properties are not treated, in a scientifically-compatible emergentist philosophy, as free-floating properties, but rather they are conceived as being grounded on the system's microstructure, by which they are synchronically determined. But, despite synchronic determination, emergentists also treat these properties as irreducible, basically in two different senses: (i) emergent properties can be irreducible because they cannot be analyzed in terms of the behavior of a system's parts (unanalyzability), or (ii) because they depend on the parts' behavior within a system of a given kind, and this behavior, in turn, does not follow from the parts' behavior in isolation or in other (simpler) kinds of system (non-deducibility). This latter concept of irreducibility is related to a rather important but quite controversial idea in emergentism, that of a downward determinative influence of the system as a whole on the behavior of its parts, from which follows the non-deducibility of the latter behavior (downward determination). Finally, another fundamental tenet opposes reductionistic treatments of emergent processes and properties, and, consequently, of the systems exhibiting them, in principle theoretical unpredictability, i.e., the idea that emergent properties or processes are not only novel but also cannot be theoretically predicted before their first appearance. After this overview, we will now delve into a detailed discussion about each of these basic ideas.

First, emergentists should, in a scientific spirit, be committed to *naturalism*, claiming that only natural factors play a causal role in the evolution of the universe. Even though naturalism and materialism (or, for that matter, physicalism) philosophically do not coincide, it is the case that, in the current scientific picture, a naturalistically-minded emergentist should also stick to the idea that all entities consist of physical parts. This thesis can be labeled "*physical monism*": there are, and will always be, only physically constituted entities in the universe, and any emergent property or process is instantiated by systems that are exclusively physically constituted. Therefore, we can pose the following question: (2) are semiotic systems exclusively physically constituted?

A second characteristic mark of emergentism is the notion of *novelty*: new systems, structures, processes, entities, properties, and dispositions are formed in the course of evolution. This idea entails the following question: (3) do semiotic systems constitute a new class of systems, instantiating new structures, processes, properties, dispositions, etc.?

Emergence theories require, thirdly, a distinction between *systemic* and *non-systemic properties*. A property is systemic if and only if it is found at the level of the system as a whole, but not at the level of its parts. Conversely, a non-systemic property is also observed at the parts of the system. If we similarly propose a distinction between systemic and non-systemic processes, the next question can be raised: (4) can semiosis be described as a systemic process?

A fourth characteristic of emergence theories is the assumption of a *hierarchy of levels of existence*. Thus, it is also necessary to answer the following question to convincingly characterize semiosis as an emergent process: (5) how should we describe levels in semiotic systems and, moreover, how do these levels relate to the emergence of semiosis?

A fifth characteristic is the thesis of *synchronic determination*, a corollary of physical monism: a system's properties and behavioral dispositions depend on its microstructure, i.e., on its parts' properties and arrangement; there can be no difference in systemic properties without there being some difference in the properties of the system's parts and/or in their arrangement.[2] The next question to be addressed, then, is the following: (6) in what sense can we say (and explain) that semiosis, as an emergent process in semiotic systems, is synchronically determined by the properties and arrangement of its parts?

Sixthly, although some emergentists (e.g., Popper in Popper & Eccles [1977] 1986) have subscribed to indeterminism, one of the characteristics of emergentism (at least in the classical British tradition[3]) is a belief in *diachronic determination*: the coming into existence of new structures would be a deterministic process governed by natural laws (Stephan 1999, p. 31). This is certainly one feature of classical emergence theories which is incompatible with Peirce's theoretical framework, as he rejected the belief in a deterministic universe (CP 6.201). But this does not preclude the treatment of emergence in connection to a Peircean account of semiosis, as there are also emergence theories committed to indeterminism. It is not necessary at all to be imprisoned in the old British tradition of emergentist thought.

Seventhly, emergentists are committed to the notion of the *irreducibility* of a systemic property designated as "emergent". An eighth important notion used is that of *unpredictability* (in principle). We should, then, pose two more questions: (7) in what sense can we say that semiosis, as observed in semiotic systems, is irreducible? (8) in what sense can we claim that the instantiation of semiosis in semiotic systems is unpredictable in principle?

Finally, the ninth characteristic of emergentism is the idea of *downward causation*: novel structures or new kinds of states of "relatedness" of preexistent objects manifest downward causal efficacy, determining the behavior of a system's parts. Given this idea, yet another question should be raised: (9) is some sort of downward causation involved in semiosis? We will discuss these latter notions in a fine-grained manner in the next section.

3. Varieties of Emergentism: What Questions About Semiosis Do They Raise?

Several different emergence theories have been proposed throughout the 20th century. The characteristic marks discussed above allow one to define several varieties of emergentism, significantly differing from one another in strength (see Stephan 1998; 1999, chapter 4).

For the sake of our arguments, we will consider just three basic varieties of emergentism—*weak*; *synchronic*; and *diachronic* emergentism.[4] Weak emergentism assumes (1) physical monism, (2) a distinction between systemic and non-systemic properties, and (3) synchronic determination. This comprises the minimal conditions for a physicalist emergentist philosophy. Thus, weak emergentism is the common basis for all stronger physicalist emergence theories. However, this view in itself is weak enough to be compatible with reductive physicalism (Stephan 1998, p. 642; 1999, p. 67). Consequently, weak emergentism faces a fundamental problem as regards the basic motivations underlying the efforts of most emergence theorists, who typically take emergentism to be by definition an anti-reductionist stance.

In this work, we intend to characterize semiosis as an emergent process in a stronger sense. Therefore, we have to analyze in more detail the concepts of "irreducibility" and "unpredictability", assumed in stronger forms of emergence theories, committed to synchronic and/or diachronic emergentism.

Synchronic and diachronic emergentism are closely related, being often interwoven in single emergence theories, but, for the sake of clarity, it is important to distinguish between them. Synchronic emergentism is primarily interested in the relationship between a system's properties and its microstructure. The central notion in synchronic emergentism is that of *irreducibility*. Diachronic emergentism, by its turn, is mainly interested in how emergent properties come to be instantiated in evolution, focusing its arguments on the notion of *unpredictability*.

Modes of Irreducibility

By adding to the three tenets of weak emergentism the thesis of the irreducibility of systemic properties, synchronic emergentism yields a doctrine incompatible with reductive physicalism. Stephan (1998, pp. 642–43; 1999, p. 68) distinguishes between two kinds of irreducibility. The first notion is based on the behavioral unanalyzability of systemic properties:

> (I_1) [Irreducibility as unanalyzability] Systemic properties which cannot be analyzed in terms of the behavior of a system's parts are necessarily irreducible.

This notion plays an important role in the debates about qualia and is related to a first condition for reducibility, namely, that a property *P* will be reducible if it follows from the behavior of the system's parts that the system exhibits *P*. Conversely, a systemic property *P* of a system *S* will be irreducible if it does not follow, even in principle, from the behavior of the system's parts that *S* has property *P*.

A second notion of irreducibility is based on the non-deducibility of the behavior of the system's parts:

> (I_2) [Irreducibility of the behavior of the system's parts] A systemic property will be irreducible if it depends on the specific behavior the parts show within a system of a given kind, and this behavior, in turn, does not follow from the parts' behavior in isolation or in other (simpler) kinds of system (cf. Stephan 1998, p. 644).

It is here that the notion of downward causation (DC) enters the scene: there seems to be some downward causal influence of the system where a given emergent property *P* is observed on the behavior of its parts, as we are not able to deduce this behavior from the behaviors of those very same parts in isolation or as parts of different kinds of system. A second condition for reducibility is violated in this case. This condition demands "that the behavior the system's parts show when they are part of the system follows from the behavior they show in isolation or in simpler systems than the system in question" (Stephan 1998, p. 643). It follows from this condition that a systemic property *P* of a system *S* will be irreducible if it does not follow, even in principle, from the behavior of the system's parts in systems simpler than *S* how they will behave in *S*, realizing property *P*.

More recently, Stephan, along with other authors, grasped the notions of irreducibility as unanalyzability and as non-deducibility of the behavior of the system's parts in two conditions for emergence they call "vertical" and "horizontal" (Boogerd *et al.*, in press).

Taking Broad's works (1919, 1925) as a starting point, Boogerd *et al.* (in press) distinguish between two independent conditions for emergence that Broad himself did not explicitly differentiate (Figure 1). A systemic property P_R of a system *R*(*A*,*B*,*C*) is emergent if either of these conditions is fulfilled. The vertical condition captures the situation in which a systemic property P_R is emergent because it is not explainable, even in principle, with reference to the properties of the parts, their relationships within the entire system *R*(*A*,*B*,*C*), the relevant laws of nature, and the required composition principles. The horizontal condition grasps the situation in which a systemic property P_R is emergent because the properties of the parts within the system *R*(*A*,*B*,*C*) cannot be deduced from their properties in isolation or in other wholes, even in principle. Since these two conditions are independent, there are two different possibilities for the occurrence of emergent properties: (i) a systemic property P_R of a system *S* is emergent if it does not follow, even in principle, from the properties of the parts within *S* that *S* has property P_R; and, (ii) a systemic property P_R of a system *S* is emergent, if it does not follow, even in principle, from the properties of the parts in systems different from *S* how they will behave in *S*, realizing P_R.

The vertical condition for emergence expresses in a different way the idea of unanalyzability. Even if we know (i) what properties and relations *A*, *B*, and *C* show within the system *R*(*A*,*B*,*C*), (ii) the relevant laws of nature, and (iii) all necessary composition principles, yet we will not be able to deduce that the system has property P_R. This is a case in which the condition of analyzability is violated, as it does not follow, even in principle, from the behavior of the parts *A*, *B*, and *C* in system *R*(*A*,*B*,*C*) that the system has P_R. This is basically the idea of emergence that appears in most metaphysical discussions, particularly in discussions about qualia (see, *e.g.*, Levine 1983, 1993; Kim 1999). As Boogerd et al. (in press) comment, if some phenomenon is emergent in this sense, it will be fundamental and irreducible, in the sense that it is neither predictable nor explainable in terms of the properties and relations of the system's own constituents.

The horizontal condition for emergence expresses in a different way the idea of irreducibility based on the non-deducibility of the behavior of the system's parts. In this case, if we know the structure of the system *R*(*A*,*B*,*C*), we will be able to explain and predict the behavior of the parts within it, and, also, the instantiation of the systemic property P_R.

Boogerd *et al.* (in press) discuss the resources available for deducing the behavior of the parts within *R*(*A*,*B*,*C*) from other kinds of systems, in order

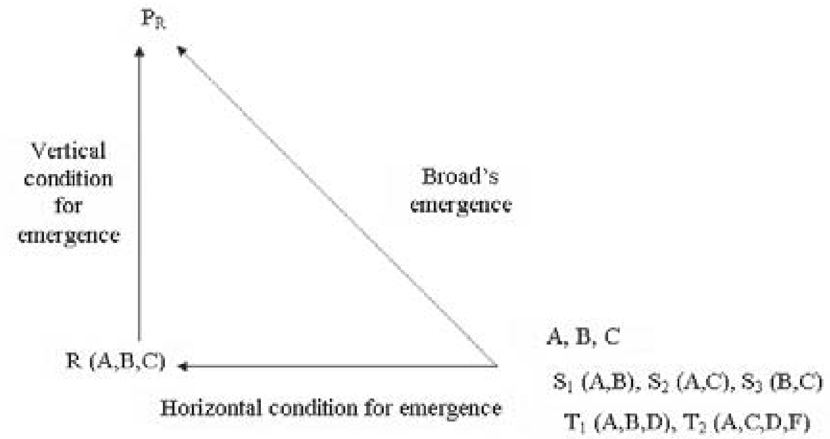

Figure 1: Vertical and horizontal conditions for emergence. *A, B,* and *C* are the parts making up the system *R*(*A,B,C*), which shows P_R, a systemic property. $S_1(A,B)$, $S_2(A,C)$, and $S_3(B,C)$ are simpler systems including these parts. $T_1(A,B,D)$ is a system with the same number of parts, and $T_2(A,C,D,F)$ is a system with more parts than *R*(*A,B,C*). The diagonal arrow represents Broad's idea of emergence. The horizontal and vertical arrows capture the two conditions implicit in Broad that Boogerd *et al.* (in press) made explicit. (From Boogerd *et al.,* in press).

to establish what would be the proper basis for such a deduction. We may deduce the behavior of the parts in *R*(*A,B,C*) from their behavior in systems of greater, equal, or less complexity. As Figure 1 shows, the possible bases for deduction of the parts' behavior in *R*(*A,B,C*) include: (i) more complex systems, such as $T_2(A,C,D,F)$; (ii) systems with the same degree of complexity, such as $T_1(A,B,D)$; (iii) simpler systems, such as $S_1(A,B)$, $S_2(A,C)$, and $S_3(B,C)$; and (iv) the parts *A, B,* and *C* in isolation.[5] Boogerd *et al.* (in press) convincingly argue that only (iii) is an interesting basis for deduction since (iv) trivializes emergence—as, in this case, each and every property of a system would seem to be 'emergent' —, and (i) and (ii) trivialize non-emergence—since, in this case, each and every property of a system would seem to be 'non-emergent'. They conclude that the key case for understanding the horizontal condition for emergence is (iii), in which we attempt to deduce the behavior of *R*(*A,B,C*) or its parts on the basis of less complex systems.

A more fine-grained analysis of the irreducibility concept naturally leads to a reframing of the seventh question raised above: (7) Which interpretation of irreducibility is more adequate to understand Peirce's claims about the irreducibility of semiosis? Furthermore, the explanation of irreducibility as non-deducibility makes it evident that question 9, "is some sort of downward causation involved in semiosis?", should be posed in connection with this particular interpretation. This raises a number of difficult questions, as the problem of downward causation (DC) is the most debated in the contemporary literature on emergence (see, e.g., Schröder 1998; Stephan 1999; Andersen et al. 2000; El-Hani & Emmeche 2000; El-Hani 2002; Hulswit, in press). Therefore, we will not pursue this debate here in all its details. Rather, we will discuss some central ideas and controversies about DC, in order to subsequently consider them with regard to semiotic phenomena.

Downward Causation

Emmeche and colleagues (2000) identified three versions of DC, each making use of a particular way of interpreting the causal mode (or modes) involved in the influence of a whole over its parts: strong, medium, and weak DC. Strong DC interprets the causal influence of a whole over its parts as a case of ordinary, efficient causation. Nevertheless, we need to postulate that there is a sharp distinction between a higher and a lower level, each being constituted by different kinds of substances, if we want to claim that a higher level exerts an efficient causal influence over a lower one (Emmeche et al. 2000; Hulswit, in press). Strong DC implies, thus, substance dualism, and this makes it, in turn, quite untenable in a current scientific understanding of emergence. Moreover, this notion faces a number of other important difficulties. If we consider the standard case in discussions about DC, i.e., "reflexive" and "synchronic" downward causation (Kim 1999), in which some activity or event involving a whole at a time t is a cause of, or has a causal influence on, the events involving its own micro-constituents at that same time t, then a strong account of DC looks like a bizarre metaphysical bootstrapping exercise (see Symons 2002).

Symptomatically, Emmeche and colleagues (2000) emphasize that there are only two viable candidates for a scientifically-compatible account of DC, both related to an interpretation of DC as a case of synchronic formal causation: medium and weak DC. We can summarize the key points in Emmeche and colleagues' arguments for medium DC as follows: (i) a higher-level entity comes into being through the realization of one amongst several possible lower-level states. (ii) In this process, the previous states of the higher level operate as a "factor of selection" (p. 24) for the lower-level states. (iii) The idea of a factor of selection can be made more precise by employing the concept of "boundary conditions", introduced by Polanyi (1968) in the context of biology, particularly in the sense that higher-level entities are boundary conditions for the activity of lower levels, *constraining* which higher-level phenomenon will result from a given lower-level state. (iv) Constraints can be interpreted in terms of the characterization of a higher level by "organizational principles"—law-like regularities—that have a downward effect on the distribution of lower-level events and substances. (v) Medium DC is committed to the thesis of "constitutive irreductionism" (p. 16), namely, the idea that even though higher-level systems are ontologically constituted by lower-level entities, the higher level cannot be reduced to the form or organization of the constituents. (vi) Rather, the higher level must be said to "constitute its own *substance* and not merely to consist of its lower-level constituents" (p. 16, emphasis in the original), or, else, a higher-level entity should be regarded as a "real substantial phenomenon in its own right" (p. 23). (vii) This interpretation of DC may assume either a thesis they call "formal realism of levels" (p. 16), stating that the structure, organization or form of an entity is an objectively existent feature of it, which is irreducible to lower-level forms or substances, or a thesis designated as "substantial realism of levels" (p. 16), claiming that a higher-level entity is defined by a "substantial difference" from lower-level entities. Thus, an important difference between medium and strong DC seems to lie in the necessary commitment of the latter to the thesis of a "substantial realism of levels". Another difference highlighted by Emmeche and colleagues (2000, p. 25) is that "medium DC does not involve the idea of a strict 'efficient' temporal causality from an independent higher level to a lower one".

In turn, Emmeche and colleagues' (2000) treatment of weak DC can be summarized in terms of the following arguments: (i) in the weak version, DC is interpreted in terms of a "formal realism of levels", as explained above, and "constitutive reductionism" (p. 16), the idea that a higher-level entity ontologically consists of lower-level entities organized in a certain way. (ii) Higher-level forms or organization are irreducible to the lower level, but the higher-level is not a "real substantial phenomenon", i.e., it does not add any substance to the entities at the lower level. (iii) In contrast to the medium version, weak DC does not admit the interpretation of boundary conditions as constraints. (iv) If we employ phase-space terminology, we will be able to explain weak DC as the conception of higher-level entities as attractors for the dynamics of lower levels. Accordingly, the higher level is thought of as being characterized by formal causes of the self-organization of constituents on a lower level. (v) The relative stability of an attractor is taken to be identical to the downward "governing" of lower-level entities, i.e., the attractor functions as a "whole" at a higher level affecting the processes that constitute it (p. 28). (vi) The attractor also functions as a whole in another sense of the word, given that it is a general *type*, of which the single phase-space points in its basin are *tokens* (p. 29).

Even though Emmeche and colleagues' contribution to the debates about DC has a lot of merit, particularly because it stressed a diversity of DC accounts that has been often neglected and, moreover, tried to make advances in organizing the variety of such accounts, their typology faces a number of problems. But this is not an exclusive feature of their work; rather, many attempts to explain DC available in the literature are confronted with important difficulties (see Hulswit, in press).[6] Particularly, the distinctions between strong, medium, and weak DC should be further clarified. For instance, it seems necessary to explain in more detail in what sense strong and medium DC differ as regards the idea that a higher-level entity is a "substantial" phenomenon, or, else, how one would differentiate medium versions committed to the thesis of a "substantial realism of levels" from strong DC. For the sake of our arguments, we will simply work below with an interpretation which comes close to medium DC by interpreting boundary conditions as constraints, but, at the same time, departs from it, by resolutely rejecting "constitutive irreductionism". It also comes close, thus, to weak DC. We will not try, however, to classify our account in terms of Emmeche and colleagues' typology. We will rather concentrate on explaining how we will conceive here the relationship between DC and constraints.

In order to do so, we will begin by considering that, when lower-level entities are composing a higher-level system, the set of possible relations among them is constrained, as the system causes its components to have a much more ordered distribution in spacetime than they would have in its absence. This is true in the case of both entities and processes, since processes also make the elements involved in them assume a particular distribution in spacetime. We can take a first step, then, towards explaining why the same lower-level entity can show different behaviors depending on the higher-level system it is part of.[7] The parts are, so as to say, "enslaved" by a particular pattern of constraints on their relations which is characteristic of systems of a given kind.

The "causes" in DC can be treated, in these terms, as higher-level general organizational principles which constrain particular lower-level processes (the "effect"), given that the particular relations the parts of a system of a given kind can be engaged in depend on how the system's structures and processes are organized. In this framework, DC can be interpreted as a "formal cause" by recasting the notion of higher-level "constraints" (or "constraining conditions"), much discussed in works about the nature of complex systems (e.g. Salthe 1985), in terms of Aristotle's set of causal concepts (see Emmeche et al. 2000, El-Hani & Pereira 2000, El-Hani & Emmeche 2000, El-Hani & Videira 2001).

As Emmeche and colleagues (2000) argue, the notion of "boundary conditions" can be used for characterizing these higher-level constraints (see also Van Gulick 1993). Polanyi (1968) argued that a living system, as a naturally designed entity, works under the control of two principles: The higher one is the principle of design or organization of the system, and this harnesses the lower one, which consists in the physical-chemical processes on which the system relies. As the physical-chemical processes at the lower level are harnessed, the components come to perform functions contributing to the maintenance of the dynamical stability of the system as a whole. The (higher-level) constraining conditions are related to the higher-level organizational principles, which restrain the activity of the components at the lower level, selecting among the set of states that could be realized by the lower level that one which will be actually realized at a given time *t*.

Hulswit (in press) recently argued that most of the discussions about DC do not really refer to causation, but rather to downward *explanation* or *determination*. He correctly pointed out that the meanings usually ascribed to the supposedly causal influence of the higher on the lower level are not clearly related to our intuitive use of the verb "to cause" (in the sense of 'bringing about'). This can be seen as a result of an impoverishment of the meaning of the term "cause" in modern science, due to the fact that classical physics critically appraised, and, ultimately, denied a number of theses related to Aristotelian philosophy, many of them concerned with the principle of causality (El-Hani & Videira 2001). Ultimately, only two of the four Aristotelian causal modes, efficient and final causes, ended up being taken into account in the meaning of the term "cause" in most modern languages.

Symptomatically, the Greek word translated as "cause" in Aristotle's works does not mean "cause" in the modern sense (Ross [1923]1995, p. 75; Lear 1988, p. 15). For Aristotle, a "cause" was not only an antecedent event sufficient to produce an effect or the goal of a given action, but *the basis or ground of something*. He stated that we understand something when we know why it is what it is, and the primary cause provides the grounds for our understanding of the 'why' of things being what they are (*Physics* II.3, 194b17–20. Aristotle 1995:332). And, moreover, he identified the why or the primary cause of a thing with its form. In his view, the form provides us with the best understanding of what a thing most truly is and why it is the way it is (Lear 1988:27).

It is in this sense that Aristotle claimed that form (and also matter) could be treated as having the aspect of causes—in terms of his formal and material causal modes. It is not surprising, then, that, if we stick to our currently intuitive ideas about causation, as Hulswit does, Aristotle's causal modes and, therefore, interpretations of DC which appeal to ideas such as that of formal causes seem more similar to modes of explanation than to modes of causation.

We will not use this line of reasoning, however, as a basis for counteracting Hulswit's arguments. We will rather explore his remarks to the effect that, although verbs usually related to the causing activity of a higher level in DC, such as "to restrain", "to select", "to organize", "to structure", "to determine", etc., may be understood as being related to "causing", they are not equivalent to "causing", in the modern sense. If we accept this line of reasoning, it will be an important task to try to understand what is the relationship between such "activities" ascribed to the higher level and "causing", so as to illuminate a pathway to a reinterpretation of DC.

It seems to us that the important relationship in this case lies in the fact that in considering either DC or our intuitive ideas about causation, we are dealing with some kind of *determination*. As Hulswit (in press) stresses, the main difference between "determining" and "causing" is that the former primarily involves necessitation (in the sense of "it could not be otherwise") while the latter primarily involves the idea of "bringing about".

We suggest here, then, even though in a preliminary way, that we should move from a notion of "downward causation" to one of *downward (formal) determination*. Instead of proposing that an understanding of the influence of wholes over parts demands causal categories other than efficient causation, we will rather claim that such an understanding requires other kinds of determination than just causation. For the sake of our arguments, consider, first, that most of the debates about DC are already about determination or explanation rather than causation. Second, that a similar move has been made in the case of another determinative but mereological relation, namely, physical realization (and, thus, supervenience), that cannot be properly accounted for as "causal" (see Kim 1993). Thus, it is largely accepted in other current philosophical debates, such as those about supervenience, the introduction of non-causal determinative relations.

Anyway, as much as in the case of DC, a proper explanation of downward determination will demand a clear theory about the relata at stake and the connections between this kind of determination and other basic categories, such as "law" and "cause" itself. We shall leave, however, this line of investigation to subsequent works, in which we will attempt to clearly define two basic kinds of determination, causal and logical, in a Peircean framework. For the time being, given the arguments presented above, we can reformulate the ninth question as follows: (9) can we describe any sort of downward determinative relation in semiosis?

Unpredictability

It is now time to turn to diachronic emergentism, which can be treated swiftly here. This variety of emergentism is concerned with the doctrine of "emergent evolution". All diachronic theories of emergence are ultimately grounded on the thesis that "novelties" occur in evolution, opposing any sort of preformationist position. But merely the addition of the thesis of novelty does not turn a weak emergence theory into a strong one. Strong forms of diachronic emergentism demand the thesis of the "in principle theoretical unpredictability" of novel properties or structures.[8] The notion of "genuine novelty" then enters the scene, as one claims that a given property or structure is not only novel but also could not be theoretically predicted before its first appearance.

A systemic property can be unpredictable in this sense for two different reasons (Stephan 1998, p. 645): (i) because the microstructure of the system exemplifying it for the first time in evolution is unpredictable; (ii) because it is irreducible, and, in this case, it does not matter if the system's microstructure is predictable or not. As the second case does not offer any additional gains beyond those obtained in the treatment of irreducibility, we will focus our discussion on the unpredictability of the structures of semiotic systems and processes. We can reformulate, then, the eighth question raised in the previous section as follows: (8) is the structure of semiotic systems or processes in principle theoretically unpredictable?

Now, we should turn to our tentative answers to the questions we raised along the discussion of emergentism and its varieties. Nevertheless, to do so, we should first present a general model for explaining the emergence of semiosis in semiotic systems we developed by taking as a starting point Salthe's hierarchical structuralism (Queiroz & El-Hani 2004). We will devote the next section to this task.

4. Levels of Semiosis: A General Model

Salthe's (1985) "hierarchical structuralism" was conceived as a coherent and heuristically powerful way of representing natural entities. A fundamental element in hierarchical structuralism is the "basic triadic system", clearly influenced by Peirce. This system plays a fundamental role in this approach, aiming at the discovery of general rules and principles of constraint within which the laws of nature must operate.

According to the basic triadic system, to describe the fundamental interactions of a given entity or process in a hierarchy, we need (i) to consider it at the level where we actually observe it ("focal level"); (ii) to investigate it in terms of its relations with the parts described at the next lower level; and (iii) to take into account entities or processes at the next higher level, in which the entities or processes observed at the focal level are embedded. In Salthe's triadic system, both the lower and the higher levels have constraining influences over the dynamics of the entities and/or processes at the focal level. These constraints allow us to explain the emergence of entities or processes (*e.g.*, semiosis) at the focal level.

At the lower level, the constraining conditions amount to the "initiating conditions" for the emergent process, while constraints at the higher level are related to the role of a selective environment played by the entities at this level, establishing the boundary conditions that coordinate or regulate the dynamics at the focal level.[9]

In this model, an emergent process at the focal level is explained as the product of an interaction between processes taking place at the next lower and higher levels.[10] The phenomena observed at the focal level should be ". . . among the possibilities engendered by permutations of possible initiating conditions established at the next lower level" (Salthe 1985, p.101). Nevertheless, processes at the focal level are embedded in a higher-level environment that plays a role as important as that of the lower level and its initiating conditions. Through the temporal evolution of the systems at the focal level, this environment or context selects among the states potentially engendered by the components those that will be effectively actualized. As Salthe (id. ibid.) puts it, "what actually will emerge will be guided by combinations of boundary conditions imposed by the next higher level". These boundary conditions can be treated, as discussed in section 3, as exerting a downward determinative influence on the behavior of a system's parts at the lower level, in conformity with the notion of 'downward determination' sketched above. Figure 2 shows a scheme of the determinative relationships in Salthe's basic triadic system.

For the sake of our arguments, let us begin by taking as the "focal level" that level in which a given semiotic process is observed. Semiotic processes

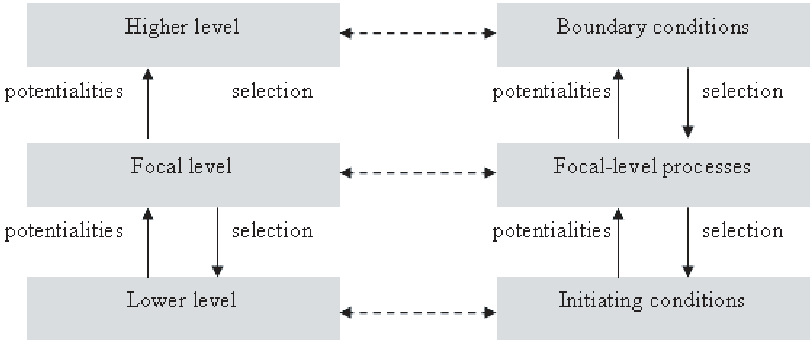

Figure 2: A scheme of the determinative relationships in Salthe's basic triadic system. The focal level is not only constrained by boundary conditions established by the higher level, but also establishes the potentialities for constituting the latter. In turn, when the focal level is constituted from potentialities established by the lower level, a selection process is also taking place, since among these potentialities some will be selected in order to constitute a given focal-level process.

at the focal level are described here as chains of triads. We can treat, then, the interaction between semiotic processes at the focal level, potential determinative relations between elements at the immediately lower level ("micro-semiotic level"), and semiotic processes at the immediately higher level ("macro-semiotic level"). In the latter, networks of chains of triads which embed the semiotic process at the focal level are described.

The micro-semiotic level concerns the relations of determination that may take place within each triad S-O-I. The relations of determination provide the way the elements in a triad are arranged in semiosis. According to Peirce, the Interpretant is determined by the Object through the mediation of the Sign (I is determined by O through S) (MS 318:81). This is a result from two determinative relations: the determination of the Sign by the Object relatively to the Interpretant (O determines S relatively to I), and the determination of the Interpretant by the Sign relatively to the Object (S determines I relatively to O) (De Tienne 1992).

At the micro-semiotic level, we consider that, given the relative positions of S, O, and I, a triad $t_i = (S_i, O_i, I_i)$ can only be defined as such in the context of a chain of triads $T = \{\ldots, t_{i-1}, t_i, t_{i+1}, \ldots\}$ (see Gomes et al. 2003a, b, 2005). Semiosis, as a Sign in action, entails the instantiation of chains of triads. As Savan (1986, p. 134) argues, an Interpretant is both the third term of a given triadic relation and the first term (Sign) of a subsequent triadic relation. This is the reason why semiosis cannot be defined as an isolated triad; it necessarily involves chains of triads (see Merrell 1995) (see Figure 3).

In short, given the framework of Salthe's hierarchical structuralism, we should analyze semiosis by considering three levels at a time. Each chain of triads will be located at a focal level, and, correspondingly, we will talk about

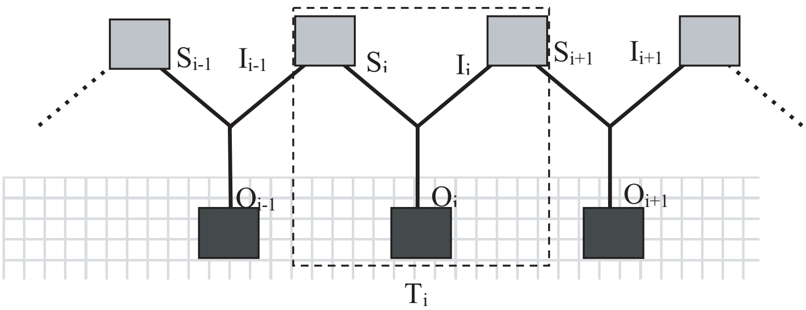

Figure 3: Scheme showing that a triad can only be defined within a chain of triads. The grid at the bottom part of the figure shows that O_{i-1}, O_i, and O_{i+1} are Immediate Objects of the same Dynamical Object.

focal-level semiotic processes. Micro-level semiotic processes will involve the relations of determination within each triad. Macro-level semiotic processes, in turn, will involve networks of chains of triads, in which each individual chain is embedded. Focal-level semiosis will emerge as a process through the interaction between micro- and macro-semiotic processes, i.e., between the relations of determination within each triad and the embedment of each individual chain in a whole network of Sign processes.

Following Salthe's explanation of constraints, micro-semiosis establishes the initiating conditions for focal-level semiotic processes. Here, we should consider a distinction made by Peirce as regards the nature of the Object:

> We must distinguish between the Immediate Object—i.e., the Object as represented in the sign—and [. . .] the Dynamical Object, which, from the nature of things, the Sign *cannot* express, which it can only *indicate* and leave the interpreter to find out by *collateral experience*. (CP 8.314. Emphasis in the original)

Or else:

> . . . we have to distinguish the Immediate Object, which is the Object as the Sign itself represents it, and whose Being is thus dependent upon the Representation of it in the Sign, from the Dynamical Object, which is the Reality which by some means contrives to determine the Sign to its Representation. (CP 4.536)

The Immediate Object of a Sign is, thus, the Object as it is immediately given to the Sign, the Dynamical Object in its semiotically available form. The Dynamical Object, in turn, is something which the Sign can only indicate, something that the interpreter should find out by collateral experience (see also EP 2:498; CP 8.178). Furthermore, each chain of triads always indicates the same Dynamical Object, through a series of Immediate Objects, as represented in each triad (see Figure 3). The possibilities of indicating a Dynamical Object are constrained by the relations of determination within each triad. That is, the way O determines S relatively to I, and S determines I relatively to O, and then how I is determined by O through S leads to a number of potential ways in which a Dynamical Object may be indicated in focal-level semiosis, i.e., to a set of *potential* triadic relations between Immediate Objects, Signs, and Interpretants.

We need to consider, thus, the distinction between *potentiality* and *actuality* in the context of our analysis. For this purpose, we introduce the definitions of *potential* Signs, Objects, and Interpretants. A "potential Sign" is something that *may* be a Sign of an Object to an Interpretant, i.e., it may stand for that Object to an Interpretant. A "potential Object" is, in turn, something that *may* be the Object of a Sign to an Interpretant. And, finally, a "potential Interpretant" is something that *may* be the Interpretant of a Sign, i.e., it may stand for that Sign. The micro-semiotic level is the domain of potential Signs, Objects, and Interpretants.

We should consider, then, a whole set W of possible determinative relations between these three elements, which can generate, in turn, a set of possible triads. These triads cannot be fixed, however, by the micro-semiotic level, since it establishes only the initiating conditions for chains of triads at the focal level. To fix a chain of triads, and, consequently, the individual triads which are defined within its context, boundary conditions established by the macro-semiotic level should also play their selective role. That is, networks of chains of triads constitute a semiotic environment or context which plays a fundamental selective role for the actualization of potential chains of triads. Chains of triads are actualized at the focal level by a selection of those triads which will be effectively actualized amongst those potentially engendered at the micro-semiotic level. After all, as we saw above, a triad $t_i = (S_i, O_i, I_i)$ cannot be defined atomistically, in isolation, but only when embedded within higher-level structures and/or processes, including both chains of triads $T = \{\ldots, t_{i-1}, t_i, t_{i+1}, \ldots\}$ and networks of chains of triads $S_T = \{T_1, T_2, T_3, \ldots, T_n\}$. In short, these structures and/or processes provide the context for the actualization of potential determinative relations within each chain.

Considering the dynamics of semiotic processes at the focal level, we can say that the temporal evolution of such processes is determined by events of actualization of potential chains of triads and potential triads. Triads are actualized, realizing a specific chain at the focal level, through the operation of two constraints. First, potential determinative relations (*initiating conditions*) at the micro-semiotic level constrain the universe of potential chains of triads, given that the whole set W of potential determinative relations between potential Signs, Objects, and Interpretants is always smaller than the universe U of *all* potentially existent triads. That is, given the initiating conditions established at the micro-semiotic level, a given chain of triads realized at time *t* will be among the elements of a set $W = U\text{–}x$ of potential chains of triads that might be

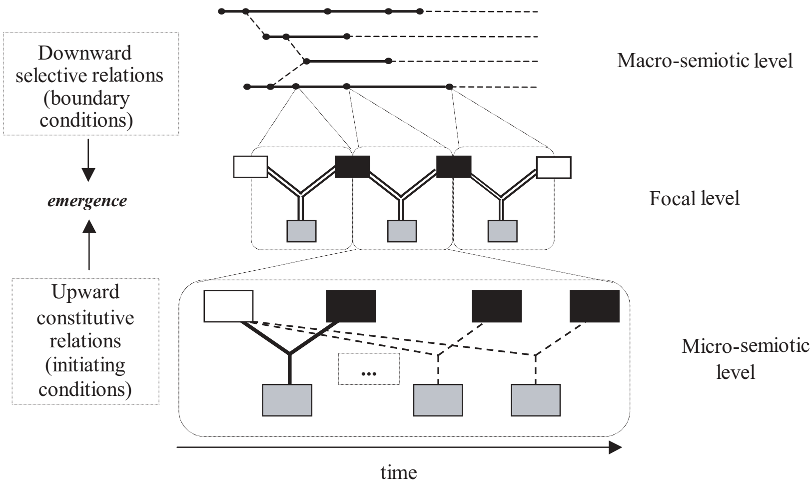

Figure 4: A model of semiosis in three levels. The upward arrow shows the constitutive relation from individual triads to chains of triads, corresponding to Salthe's initiating conditions. The downward arrow shows selective relations from networks of chains of triads to chains of triads, corresponding to Salthe's boundary conditions.

actualized at *t*.[11] Then, a second kind of constraint acts on the set W , namely, the boundary conditions established by the macro-semiotic level, in the context of which a given chain of triads will be effectively realized. The boundary conditions will select, among all the potential chains of triads which could be realized from the set W of potential determinative relations S-O-I, a specific chain $T_i = \{\ldots, t_{i-1}, t_i, t_{i+1}, \ldots\}$ to be actualized.[12]

It is in this sense that the emergence of semiotic processes at the focal level, in which chains of triads are actualized, is explained in this model as resulting from an interaction between the potentialities established by the micro-semiotic level and the selective, regulatory influence of the macro-semiotic level. The general ideas involved in this model of semiosis in three levels are shown in Figure 4.

5. Answering the Questions About Semiosis

What Is a Semiotic System?

Let us consider, first, the following question: (1) what is a semiotic system? First of all, we should offer a definition of 'system', in more general terms. A system is usually defined as a set of elements that maintain relations with one another (von Bertalanffy 1973, p. 55; Pessoa Jr. 1996, p. 30). By 'elements' we mean primitive entities which are found at each instant in one among several possible states. Elements establish 'relations' when the state of an element depends on the state of another one. Some definitions of system include other items, such as Bunge's (1977) definition, in which a system *x* is defined by its composition—the set of its components —, structure—the set of relations between its components —, and environment—the set of other systems with which *x* establishes relations.

A significantly related but slightly more refined way of defining systems is found in dynamical systems theory, in which systems are conceived as sets of interdependent variables. By "variable" we mean some entity that can change, i.e., that can be in different states at different times—it is obvious that the concepts of "variable" and "elements", as stated here, are quite similar. The state of a system is simply the state or value of all its variables at a given time *t*. The behavior of a system, in turn, consists of transitions between states (Van Gelder 1998, p. 616).

Now we can turn to a definition of what is a "semiotic system". Fetzer (1988) called "semiotic system" a system that produces, transmits, receives, and interprets Signs of different kinds. Such systems can be regarded as the embodiment of semiotic processes (see CP 5.314).[13] Fetzer considers that what makes a system "semiotic" is the fact that its behavior is ". . . causally affected by the presence of a sign because that sign stands for something else iconically, indexically, or symbolically, for that system. Those things for which signs stand, moreover, may include abstract, theoretical, non-observable, or non-existent objects and properties, which may be incapable of exerting any causal influence on a system themselves" (Fetzer 1997, p.358).

Semiosis can be defined as a self-corrective process involving cooperative interaction between three components, S-O-I. Therefore, as a straightforward consequence of the nature of semiosis, semiotic systems show self-corrective behavior, or some kind of goal-directed activity (see Ransdell 1977, p.162). They are capable of using Signs as media for the transmission of a form or the transference of a habit embodied in the Object to the Interpretant, so as to constrain the interpreter's behavior (EP 2:544, n.22; see also EP 2:391, EP 2:477).

Are Semiotic Systems Exclusively Physically Constituted?

A second question concerns the nature of semiotic systems: (2) are they exclusively physically constituted? Semiotic processes can only be realized through physical implementation or instantiation (see Ransdell 1977). Therefore, semiotic systems should be physically embodied (Emmeche 2003; Deacon 1999). If a Sign is to have any active mode of being, it must be physically instantiated.[14] Peirce considered the material qualities of the Sign as the characters that belong to the Sign in itself: "Since a sign is not identical with the thing signified, but differs from the latter in some respects, it must plainly have some characters which belong to it in itself, and have nothing to do with its representative function. These I call the material qualities of the sign" (CP 5.287).[15]

Are Semiotic Systems New?

A third question asks (3) whether semiotic systems can be regarded as forming a new class of systems, with new structures, instantiating new properties, processes, behaviors, dispositions, etc. It is not our problem here to define where is the threshold beyond which semiotic systems are found in the history of the universe. We assume, for the sake of our arguments, that there was a period in which systems capable of using Signs did not exist. Therefore, even though irreducible triadic relations may have preceded the origins of semiotic systems, we postulate that this class of systems arose in the course of evolution. We consider, then, that before the emergence of semiotic systems, only reactive systems existed, which were not capable of interpreting, and, thus, using Signs. Surely, there were things in the world to which physically embodied natural systems reacted, but these systems were not able to use Signs as media for the transmission of forms, i.e., they were not interpreters. Nothing but a dynamics of systems and things diadically coupled existed, with no interpretative processes taking place. Given this reasonable set of assumptions, we can say that semiotic systems are a new class of systems, with a new kind of structure, capable of producing and interpreting Signs, and, thus, of realizing semiosis, as a new kind of (emergent) process.

The emergence of the competence to handle Signs changed the dynamics of the evolution of natural systems. After all, we can claim that semiotic systems show modes of evolution not found among merely reactive systems. For instance, living systems which possess Signs in the form of DNA can evolve by a process in which past successful interactions between a system and its environment are represented in Signs which are passed over to the next generations, influencing the future evolution of the lineage to which the system pertains. Furthermore, after the competence to handle Signs, and, thus, instantiate semiosis emerged, the evolution of semiotic systems didn't cease, but, rather, new kinds of such systems emerged, operating with different classes of signs (*e.g.*, iconic, indexical, symbolic) and evolving in different manners (see Fetzer 1988, 1997; Queiroz & El-Hani 2004).

At first, the idea that semiotic systems constitute a new class of systems seems to be incompatible with a basic feature of Peirce's metaphysical framework, namely, synechism. After all, the doctrine of emergence is committed to the idea that the evolution of the universe shows discontinuities, and synechism is a "tendency to regard everything as continuous" (CP 7.565). According to Peirce (CP 6.169), synechism is ". . . that tendency of philosophical thought which insists upon the idea of continuity as of prime importance in philosophy and, in particular, upon the necessity of hypotheses involving true continuity."[16]

We claim, however, that this incompatibility is only apparent, since an emergentist philosophy can be seen as providing precisely a way of overcoming the dichotomy between continuity and discontinuity. Such emergentist philosophy can accommodate, in our view, Peirce's synechism. For instance, Morgan's (1923) *Emergent Evolution*, regarded by Blitz (1992) as the founding work in the tradition of emergentism, provides an emergence theory that combines the ideas of continuity and discontinuity.

Among the fundamental theses of Morgan's theory of emergent evolution, we find two which are directly consequential to our present discussion: the theses of the co-occurrence of emergents and resultants, and of quantitative continuity and qualitative novelty.[17] For Morgan, emergent properties were never instantiated at a given level without occurring along with resultant properties, which could be predicted on the grounds of theoretical knowledge about the previous level and conferred continuity to the evolutionary process. Thus, even though emergence concerns the appearance of genuinely new properties that could not be predicted from knowledge about preexistent entities described at a lower level, it does not amount in Morgan's theory to a gap in the evolutionary process. Therefore, it is not in the sense of some sort of leap in evolution, which would be indeed incompatible with synechism, that Morgan put forward the claim of qualitative novelty in evolution. Rather, he conceived qualitative novelty in terms of a qualitative change of direction or a critical turning point in an otherwise continuous evolutionary process. In Morgan's (1923, p. 5) own words, ". . . through resultants there is continuity in progress; through emergence there is progress in continuity." Consider, also, that it is the very process of gradual and quantitative change of natural systems which creates, in Morgan's framework, the conditions for the qualitative change related to the notion of emergence. This qualitative change, in turn, has the character of a critical turning point because it establishes new kinds of relatedness among preexistent entities or events, and, thus, changes the mode of evolution of natural systems. It is clear, then, that emergence is related to punctuations in a continuous process, rather than to a mere jump in the evolutionary process.

A number of quotations from Morgan's seminal work on emergence will suffice to show that property emergence is related to critical turning points in which new patterns of organization (and, thus, constraints) are established in the evolution of systems. Morgan characterizes "emergent evolution" as follows: "Evolution, in the broad sense of the word, is the name we give to the comprehensive plan of sequence in all natural events. But the orderly sequence, historically viewed, appears to present, from time to time, something genuinely new. Under what I here call emergent evolution stress is laid on this incoming of the new" (Morgan 1923, p. 1). He also states that ". . . the emergent step [. . .] is best regarded as a qualitative change of direction, or critical turning point, in the course of events" (Morgan 1923, p. 5). Emergent events are related to the ". . . expression of some new kind of relatedness among pre-existent events" (Morgan 1923, p. 6), and "when some new kind of relatedness is supervenient (say at the level of life), the way in which physical events which are involved run their course is different in virtue of its presence—different from what it would have been if life had been absent. [. . .]. I shall say that this new manner in which lower events happen—this touch of novelty in evolutionary *advance—depends on* the new kind of relatedness which is expressed in that which Mr. Alexander speaks of as an emergent quality" (Morgan 1923, p. 16; Emphasis in the original). An emergent property should, therefore, be genuinely new under the sun; it should be closely connected with the appearance of a new kind of relatedness (a new organizational pattern) among pre-existent events or entities, entailing a modification in the way lower-level events run their course, and, thus, some sort of downward causation; and, finally, it should change the mode of evolution, due to the change in the way pre-existent events or processes run their course in the context of that new kind of relatedness.

Morgan's theory does not postulate jumps in the evolutionary process that, given the central role of synechism in Peirce's thought, might spoil any prospect of a joint emergentist and Peircean account, as we are proposing here. Rather, his theory—and, by extension, any emergentist philosophy that subscribes to a similar rendering of the relationship between continuity and novelty—explicitly claimed that resultant properties provided a quantitative continuity in evolution, upon which qualitative novelties arose from time to time as changes in the direction of evolution, rather than as saltationist leaps.

An example derived from currently accepted theories about the origins of life illustrates the above arguments. These theories claim that, in the prebiotic world, a set of physical and chemical processes, collectively known as "chemical" or "pre-biotic" evolution, gave rise to a soup of chemical and physical resources, including complex molecules formed by the polymerization of simpler molecules, thanks to energy sources such as lightning UV rays, and volcanic eruptions. In that chemical soup, complex organic molecules with a synthesis rate greater than their degradation rate accumulated. Nonetheless, nothing lived in that soup, and, if there was something we could call "evolution" (cf. Sterelny 2001, p. 17), it would not be the same as biological evolution, as those chemical substances changed through time as individual entities, passing through a sequence of transformational stages. In short, the kind of change observed in that chemical soup was a transformational, not a variational process (Lewontin 1983), as in the case of biological evolution. But, in that transformational evolution, a gradual and quantitative change was taking place, in which polymers were becoming more and more complex, by the addition of a growing number of monomers. The continuous transformational evolution of polymers established the conditions for a qualitative change or critical turn in evolution, when it gave rise to a particular kind of molecule, which was something genuinely new under the sun. That molecule was a replicator, which came into existence by chance, through the gradual quantitative increase in the complexity of prebiotic polymers. A replicator, as defined by Dawkins (1976), is a molecule that shows the extraordinary property of making copies of itself, or, in more general terms, it is any structure that in the right environment can act as a template for its own copying (Sterelny 2001). A current influential hypothesis about the nature of the first replicators states that they were molecules analogous to RNA, possessing both a genetic memory and an enzymatic activity related to their own replication.

The origin of the first replicator qualifies as an emergent event, given the conditions drawn from Morgan's seminal work. As Sterelny (2001, pp.17–8) writes, "the formation of the first active replicator is a world-shaking event. It is truly something new under the sun, for it introduces natural selection and hence evolution in the world".[18] The appearance of the first replicator involved the instantiation of a new kind of relatedness among preexistent monomers, and changed all future evolution, introducing a new kind of evolutionary process in the world, variational evolution, based on natural selection. This change in the nature of evolution was related to two emergent properties of replicators, the property of being an enzyme and the property of being a template for its own replication. These properties were as new as the replicators themselves and were related to the way pre-existent processes took place in the context of the new kind of relatedness that characterized those molecules.

In this account, we find no leap which might be incompatible with Peirce's synechism. Rather, the very qualitative change we perceive in the origins of replicators is described as a product of gradual quantitative change. Symptomatically, Morgan (1923, p. 7) argues both for a "resultant continuity between the not-living and the living", the value of which "no evolutionist is likely to under-estimate", and for a qualitative novelty which is not incompatible with such continuity: "But one may still ask whether there is not at some stage of this process a new emergent character of life [. . .]. There does seem to be something genuinely new at some stage of the resultant continuity" (Morgan 1923, p. 7).

We hope these arguments are enough to show that there is no necessary contradiction between Peirce's doctrine of synechism and an emergentist philosophy. We can speculate that the competence to handle Signs appeared in the evolution of systems as a product of a continuous process. Nevertheless, when semiotic systems appeared, they exhibited a way of behaving which was significantly different from that of reactive systems, as they could go beyond a mere coupling to their circumstances, being able to interpret them. It is reasonable to suppose, then, that that difference in behavior entailed a distinct mode of evolution in the case of semiotic systems, as compared to reactive systems. Thus, we can hold that a qualitative change, a critical turn in evolution, took place with the appearance of semiotic systems. After all, a system which is capable of interpreting the world through the mediation of Signs evolves in a manner which is determined by the fact that they are capable of using Signs to obtain information about the environment in such a way that those Signs perform functions favoring their survival and/or reproduction (Emmeche 1997).

Is Semiosis a Systemic Process?

We should turn now to our fourth question: (4) Can semiosis be regarded as a systemic process? Consider, first, that according to the model developed above the actualization of potential chains of triads depends on boundary conditions established by a macro-semiotic level amounting to networks of chains of triads. It is possible to conceive of the macro-semiotic level as corresponding to the whole semiotic system, based on the idea that the latter can be treated as the embodiment of semiotic processes. Therefore, although semiosis is instantiated at the focal level, it should be understood as a systemic process, given that the macro-semiotic level establishes the boundary conditions required for its actualization. To put it differently, the very instantiation of semiosis at the focal level depends on a constraining influence from the semiotic system as a whole (i.e., the macro-semiotic level).

As to the fifth question—(5) How should we describe the levels in a semiotic system —, section 4 can be seen, as a whole, as an answer to it.

Is Semiosis Synchronically Determined by the Properties and Arrangement of the Parts in a Semiotic System?

Sixthly, we asked: (6) in what sense can we say that semiosis, as an emergent process, is synchronically determined by the properties and arrangement of the parts in a semiotic system? In our hierarchical model, semiosis is located at the focal level, instantiated as chains of triads, while individual triads are situated at the immediately lower level, and networks of chains of triads, at the immediately higher level. Therefore, while considering the idea of synchronic determination, we have to focus our attention on the relationship between chains of triads, at the focal level, and individual triads, at the micro-semiotic level.

Semiosis is described by Peirce as a pattern of determinative relationships between functionally specified correlates. We consider, here, that this description entails the idea that semiosis is synchronically determined by the microstructure of the individual triads composing a chain of triads, i.e., by the relational properties and arrangement of the elements S, O, and I.[19] There cannot be any difference in semiosis without a difference in the properties and/or arrangement of S, O, and I. The arrangement of the elements S-O-I is specified by the triadic relations of determination between them. Otherwise, it would be a mere juxtaposition of three elements (see CP 1.371, 1.363; see Brunning 1997).

The properties of S, O, and I are relational because these elements are engaged in irreducibly triadic ordered relations. As Savan (1987–88, p.43) writes, "the terms interpretant, sign and object are a triad whose definitions are circular. Each of the three is defined in terms of the other two." In fact, the only property of S, O, and I, *as functional roles,* is to be in a specific position in an irreducible triadic relation to one another, namely, to be the first, the second, or the third terms in such a relation (see De Tienne 1992).

One should also consider the modal strength of the relation of synchronic determination between chains of triads and triads. We will consider here four standard possibilities (see Bailey 1999): (i) Weak necessity, in which the determinative relation holds in the actual world, but need not hold in any other possible world; (ii) Natural, or physical, or nomic, or nomological necessity, in which the determinative relation holds in the actual world and in all naturally possible worlds, which can be described, very roughly, as all worlds in which the physical laws sufficiently resemble actual laws; (iii) Metaphysical necessity, in which the determinative relation holds in the actual world and in all metaphysically possible worlds, which comprise all worlds where *a posteriori* necessary truths (such as "water is H_2O") hold; and (iv) Logical necessity, in which the determinative relation holds in the actual world and all logically possible worlds, roughly, those where *a priori* necessary truths hold—this is the set of all possible worlds.

In the case of semiosis, we propose that the determinative relations between the elements of individual triads, as well as between triads, in a chain of triads, hold with logical necessity.[20] Initially, consider that the demonstration that S-O-I constitute an indecomposable relation should be first carried out logically (see Houser 1997, p. 16). The reason for the precedence of a formal treatment of relations over the empirical and metaphysical treatments lies in the fact that only formally can one perform an analysis of the properties of completeness and sufficiency of Peirce's categories (Parker 1998, pp. 3, 43). It is only subsequently that the property of logical irreducibility should be checked in the empirical and metaphysical domains. The precedence of the logical treatment has methodological consequences. An analysis of the formal properties, in contrast with the material properties,[21] should precede any empirical or metaphysical investigation of the categories. In other words, a logical-mathematical analysis of the categories should be previous to any formulation in the domains of phenomenology, normative sciences, and metaphysics,[22] which employ mathematical techniques and results to validate the categories established by the logical treatment of relations (see Hookway 1985, p. 182; Parker 1998).

Therefore, in our discussion about the modal strength of the relation of synchronic determination between chains of triads and triads, we will begin with a logical treatment of the relations between the elements of semiosis. We will focus our attention, first, on the functional roles of S, O and I, as established in a logical analysis of their relations. The functional roles of S, O and I are logically determined in each triad, as regards both the relationships within a triad and the constitution of chains of triads. Therefore, these determinative relations hold with *logical necessity*: in a world substantially different from the actual world in its physical laws, i.e., a world nomologically distinct from the actual world, the logical relationships between S, O and I would still be the same.

If we are right in our arguments, then these relations hold in the set of all possible worlds, provided that the conceived world allows the existence of physical entities or processes. After all, there is an important constraint for something to be a semiotic system, namely, that it should be physically embodied (see above). This does not mean that the determinative relations between S, O, and I in a semiotic process might be only nomologically valid, but rather that any logically conceivable world in which semiosis can take place is a world in which natural laws allow the existence of physical entities or processes, which are a necessary condition for semiosis. In any such world, then, the determinative relations between S, O, and I hold with logical necessity. If we suppose, for the sake of our argument, that there are logically conceivable worlds where no physical entities or processes are present, it will be simply the case that such worlds will not show any semiotic process or system, and, thus, no determinative relation at all between the elements involved in semiosis will take place there.

In the empirical domain, in turn, we should focus our attention not only on the functional roles of S, O, and I but also on how these functional roles *may be* embodied, and how the relations between them *may be* instantiated in the actual world. In this case, notice that while the functional roles are logically determined, the occupants of the functional roles of S, O, and I are contingent. For instance, that the word "elephant" is a Sign for that big animal in the world can be treated as a contingent fact; that is, it is not logically necessary that the word "elephant", as an occupant of the functional role of a Sign (S), stand through the Interpretant (I) for that big animal, the occupant of the functional role of the Object (O) in the example at stake. But the determinative relationships between these elements are logically determined, and, consequently, are also the functional roles of S, O, and I. Thus, in a world sufficiently distinct from the actual world in its physical laws, entirely different entities or processes might be playing the functional roles of S, O, and I in distinct semiotic systems. We can conclude that the fact that a given class of entities or processes plays a functional role in a semiotic process holds with *nomological rather than logical necessity*, even though the functional role itself holds with logical necessity.

In what Sense is Semiosis Irreducible?

Among the several properties related to semiosis (processuality, CP 5.484; irreversibility, CP 5.253, 5.421; continuity, MS 875, see also Parker 1998, p.147; tendency to the *infinitum*, CP 2.92, 2.303; vagueness, CP 5.447; generality, CP 6.172, see Potter 1997, p.89; regularity; growth; lawfulness), we can say that the relational irreducibility of the triad is one of the most, if not the most, important. Thus, the next question (7) is particularly important, as it concerns the interpretation of the principle of the irreducibility of semiosis. The semiotic triadic relation is regarded by Peirce as *irreducible*, in the sense that it is not decomposable into any simpler relation:[23]

> . . . by 'semiosis' I mean [. . .] an action, or influence, which is, or involves, a cooperation of three subjects, such as a sign, its object, and its interpre-

tant, this tri-relative influence not being in any way resolvable into actions between pairs. (CP 5.484)

As Peirce carefully discusses the irreducibility of triads, we will consider in the following arguments what we defined above as the micro-semiotic level. We will argue, first, that the semiotic relation is *not* irreducible because the condition of analyzability is violated. Peirce would accept, in our view, that from the behavior of the elements of a triad it must follow the properties the triad possesses, including the very property of being semiotic. If we know the relations in which any three elements are involved, then we will be able to know also whether the process in which they are engaged is semiotic, since we will know whether or not the elements play the logical-functional roles of S, O, and I. To put it differently, non-analyzability or what Boogerd et al. (in press) call the vertical condition for emergence is not the reason why we should consider, in a Peircean framework, semiosis as an irreducibly triadic relation.

We can understand why a semiotic relation is irreducible, in a Peircean framework, on the grounds of the second notion of irreducibility discussed above, based on the non-deducibility of the behavior of the system's parts. In this case, we should show that the specific behavior of the elements of a triad does not follow from the elements' behavior in simpler relations. We think that semiosis can even be regarded as the best example of a class of relations in which the second condition for reducibility discussed above is violated, since the behavior of the elements of a semiotic relation does not follow from the behavior they show in isolation or in dyadic relations.

The functional roles of the elements in a semiotic relation cannot be identified in structures simpler than a triadic relation. The functional role of S can be identified only in the mediative relation that it establishes between O and I. Similarly, the functional role of O is identified in the relation by which it determines I through the mediation of S. And, finally, the functional role of I is identified by the fact that it is determined by O through S. Therefore, if we consider only dyadic relations, S-I, S-O, or I-O, or the elements of a triad in isolation, we cannot deduce how they would behave in a triadic relation, S-O-I (EP 2:391). Therefore, the irreducibility of semiosis should be understood in terms of the non-deducibility of the behavior of the logical-functional elements of a triad on the grounds of their behavior in simpler relations. Or, to put it differently, rather than the vertical, the horizontal condition for emergence (Boogerd *et al.,* in press) holds in the case of semiosis.

Is Downward Determination Involved in Semiosis?

We will turn, now, to another question about the understanding of semiosis as an emergent process: (9) can we describe any sort of downward determinative relation in semiosis?

It is very interesting to discuss the problem of downward determination in the context of Peirce's philosophy, since, as Hulswit (in press) remembers, Peirce himself may have been the first to suggest that downward causation may be regarded as a sort of formal causation (see EP 2:115–32). Even if we move here from downward causation to downward determination, Peirce's contribution to the current debates on this issue is still very relevant, since the problem of the influence of wholes over parts is addressed in a more consistent way in terms of dynamical interactions between processes at different levels. In Hulswit's words, it ". . . requires an ontological framework that breaks through the constraints imposed by the Western 'substance addiction'. Indeed, it should do full justice to the primacy of processes and events, along the lines of suggestions made by C. S. Peirce and A. N. Whitehead" (Hulswit, in press).

If we consider, first, the relationship between the macro-semiotic level and semiosis at the focal level, we can argue that it involves a determinative downward relation. More specifically, as the model presented in section 4 shows, downward determination in semiotic phenomena can be conceptualized as boundary conditions which select, among the potentialities established by the micro-semiotic level, those semiotic processes which will be actualized at a given time *t*.

If we focus, rather, on the relations between elements within a triad, then we will be able to see that, in a precise sense, Signs, Objects, and Interpretants constrain each other's behaviors. Moreover, a Sign can be defined as a medium for transmitting the form of an Object to an Interpretant. It seems, thus, that an interpretation of downward determination in terms of formal constraints applies smoothly to the determinative relations in triadic-dependent processes. Surely, a proper interpretation of downward determination in semiotic phenomena demands more elaboration. We shall leave, however, this issue for future works.

Is the Structure of Semiotic Systems or Processes Unpredictable?

The last question we should discuss is the following: (8) is the structure of semiotic systems or processes in principle theoretically unpredictable?

The structure of triads and chains of triads can be indeed regarded as unpredictable, since Peirce advocated that indeterminism, spontaneity, and absolute chance are fundamental factors in the universe. Thus, the behavior of the elements in a semiotic process is also unpredictable from the behaviors they may exhibit in simpler systems. In a Peircean framework, we can claim, thus, that semiosis is a process the structure of which is in principle unpredictable due to the indeterministic nature of the evolutionary process. This argument is grounded on the Peircean thesis of tychism, the metaphysical defense of "absolute chance" as a real factor in the universe (see Murphey 1993, Potter 1997). Tychism plays an essential role in Peirce's account of cosmological evolution, to the extent that he regards it as the only explanation of the multiplicity and irregularity found in the universe.

The most important point for our arguments here is that, according to a Peircean evolutionary cosmology, *everything* should be explained as a product of an evolutionary process which has states of indetermination and chance as its starting points. In a paper about tychism and mental processes, Pape (2002, p. 226) comments that "matter, time, space, and the laws of nature themselves—they all have to be explained as emergent regularities of interaction arising from a state of indeterminateness". This suggests, once again, the compatibility of emergentist thought with central doctrines in Peirce's metaphysics, as synechism and tychism.

Consider, moreover, that Peirce's categories constitute a system of necessary presupposition (see Hausman 1993, p. 97), and, thus, it is impossible to conceive thirdness without secondness, and secondness without firstness. Therefore, as firstness entails indetermination, novelty, independence, and, consequently, unpredictability, the latter becomes a necessary component also in thirdness, and, thus, in semiosis.

The arguments developed in this section lead to the conclusion that a strong emergence theory can be supported in the case of semiotic phenomena. In conformity to Peirce's theory of Signs, this theory should include (i) a concept of irreducibility based on the non-deducibility of the behavior of Signs, Objects, and Interpretants in semiotic relations from their possible behaviors in simpler relations, and (ii) a concept of in principle theoretical unpredictability of the structure of semiotic processes, based on the doctrine of tychism.

6. Conclusion

According to Rosenthal (1994, p. 27), "meanings" should be understood as relational structures that emerge from patterns of behavior. A precise interpretation of this statement—with which we basically agree—demands a clear understanding about the characterization of "structures" as emergent systemic properties. Furthermore, it also depends on a good grasp of the relationship between emergent properties and processes, observed at the level of a system, and patterns of behavior of its parts. This is a typical case in which it is not adequate to employ the idea of emergence in an ordinary, colloquial sense. Rather, we should use it in a technical way, as in the other cases we mentioned in the introduction of this paper. We do think it is a relevant problem in semiotic investigations how to connect properly discussions about emergence and the analysis of semiosis, meaning, information, and so on. Nevertheless, we did not find a treatment of this problem in journals and books devoted to semiotics, at least to the extent of our knowledge. This was the main motivation for the research reported in this paper, in which we discussed the conditions that should be fulfilled in order to adequately characterize semiosis as an emergent process.

Methodologically speaking, we addressed this problem by raising a series of questions to be answered in order to describe semiosis as being "emergent", based on an analysis of central characteristics and varieties of emergentism. Here are the questions we raised, and to which we offered tentative answers:

(1) What is a semiotic system?
(2) Are the systems showing semiosis exclusively physically constituted?
(3) Do semiotic systems constitute a new class of systems, instantiating new structures, processes, properties, dispositions, etc.?
(4) Can semiosis be described as a systemic process?
(5) How should we describe levels in semiotic systems and how do these levels relate to the emergence of semiosis?
(6) In what sense can we say (and explain) that semiosis is synchronically determined by the properties and arrangement of its parts?
(7) Which interpretation of irreducibility is more adequate to understand Peirce's claims about the irreducibility of semiosis?
(8) Is the structure of semiotic systems or processes in principle theoretically unpredictable?
(9) Can we describe any sort of downward determinative relation in semiosis?

We concluded that a strong emergence theory can be advocated in the case of semiotic phenomena, including a concept of irreducibility based on the non-deducibility of the behavior of Signs, Objects, and Interpretants in semiotic relations from their possible behaviors in simpler relations, and a concept of in principle theoretical unpredictability of the structure of semiotic processes.

We drew on Salthe's hierarchical structuralism to propose a model for explaining the emergence of semiosis in semiotic systems. According to this model, semiosis is conceived as a systemic process at a focal level, in which chains of triads are instantiated as a result of the interaction between potentialities established at a micro-semiotic level (initiating conditions)—containing potential Signs, Objects, and Interpretants—and the regulatory, selective influence of a macro-semiotic level (boundary conditions)—corresponding to networks of chains of triads.

Our aspiration here is that the questions we raised in order to characterize semiosis as an emergent process in a precise manner, the tentative answers we proposed, and the modeling of this process based on Salthe's hierarchical structuralism, contribute to a consistent treatment of the emergence of semiosis in the context of Peirce's metaphysics and evolutionary cosmology. An understanding of how semiosis emerges in evolution has to offer, in our view, proper answers to the set of questions we systematized in this paper, and, furthermore, has to work with adequate tools for modeling such an emergent event, such as those advanced by Salthe in his basic triadic system.

Acknowledgements:
João Queiroz thanks The State of São Paulo Research Foundation (FAPESP) for the support for his post-doctoral studies. Charbel Niño El-Hani thanks the Brazilian National Research Council for the general support given to his research and, in particular, for his post-doctoral studies and

research grants. He also thanks Claus Emmeche for all the support in his post-doctoral studies at the Center for Philosophy of Nature and Science Studies, Faculty of Sciences, University of Copenhagen. We are indebted to Floyd Merrell for his insightful comments about a preliminary version of the paper. Finally, we'd like to thank the anonymous reviewers and Randall Dipert for his helpful comments for the elaboration of the final version of the paper.

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NOTES

1. It is true that one may treat a process as a property exhibited by a given system, but, in order to emphasize the dynamic nature of semiosis, we will systematically describe it as an emergent "process", rather than as a "property". We follow here Rescher in his definition of a process as ". . . a coordinated group of changes in the complexion of reality, an organized family of occurrences that are systematically linked to one another either causally or functionally" (Rescher 1996, p.38).

2. Previously, this idea has been typically stated in a weaker version, as the thesis of "mereological supervenience". The reason why this latter thesis is to be regarded as weaker than synchronic determination lies in the issue that it does not entail, as it is usually thought, the determination and dependence of the system's properties on its microstructure. Supervenience simply states a pattern of covariance between two sets of properties, and we cannot directly derive a metaphysical relation of dependence/determination from property covariance (for treatments of this issue, see, e.g., Kim 1993, 1998; Heil 1998; Bailey 1999). In this respect, it seems better to rely on a stronger statement, directly addressing determination, instead of relying upon the notion of supervenience.

3. On British emergentism, see Blitz (1992), McLaughlin (1992), Stephan (1999).

4. Stephan begins his systematic analysis of varieties of emergentism by discussing these three basic forms, but later expands his typology to include six different emergentist positions. We will not deal with these six positions in the scope of this paper. For more details, see the original works.

5. Boogerd et al. (in press) are obviously aware that complexity does not depend only on the number of components, but also on the system's structure and mutual interactions of the parts. They only indicate differences of complexity by the number of parts for the sake of the argument.

6. Indeed, the previous contributions to the emergence debate by one of the authors (C. N. El-Hani) face many problems identified by Hulswit (in press). See, for instance, El-Hani & Pereira (2000), El-Hani & Emmeche (2000), El-Hani & Videira (2001).

7. As we argued above, this is the basis for irreducibility as the non-deducibility of the behavior of a system's parts.

8. Notice that theoretically-unpredictable structures or properties can be inductively-predictable (Kim 1999), given that, once a structure or property appears for the first time, it is possible that further occurrences of that structure or property are adequately predicted, given the thesis of synchronic determination. Moreover, "in principle" unpredictability is introduced in opposition to "practical" unpredictability, which is dependent on our cognitive limitations and state of knowledge.

9. The regulation of a focal-level process by higher-level boundary conditions is interpreted here as a kind of selective process. Suppose that the causal relation between a given element of a system, *A*, and another element of the same system, *B*, is regulated. This is understood, in this framework, as the selection of *B* as the most probable effect of *A*, among other possible effects, by boundary conditions established by a level higher to the level where the causal relation at stake is taking place. This is connected with ideas found in Polanyi (1968) and Campbell (1974), and is also related to the problem of downward causation, but we will not pursue this issue further here.

10. The choice of a focal level depends in fact on the purpose of a given researcher. Therefore, a researcher can choose as a focal level in his investigation a level in which another researcher, guided by another purpose, locates the boundary conditions in the triadic system she is studying.

11. The term "*x*" indicates a set of potential chains of triads which *cannot* be actualized at *t*, given the set of potential Signs, Objects, and Interpretants at stake.

12. Even though we will not pursue this issue in this paper, we should emphasize that there is a clear correspondence between the hierarchical structure proposed by Salthe and Peirce's distribution of categories. The micro-semiotic level—at which processes relating S, O, and I are initiated—gives Sign processes an inevitable character of indeterminacy. It is straightforward, then, to associate the micro-semiotic level with firstness. Salthe himself stresses that this level exhibits a fundamentally stochastic behavior. At the focal level, specific, particular processes are spatiotemporally instantiated, as *tokens*, which are cases of secondness. The macro-semiotic level, in turn, gives Sign processes their *generality* and *temporality*, making them historical and context-dependent. We can say, thus, that the macro-semiotic level shows the nature of thirdness. The stochastic behavior at the micro-semiotic level establishes *potentialities* for the particular Sign processes that are instantiated at the focal level. These potentialities are not the same as mere *possibilities*. For the sake of our arguments, consider Peirce's treatment of Quality as a "mere abstract

potentiality" (CP 1.422). Quality has the nature of firstness, being essentially indeterminate and vague. But we can also talk about a generality of Quality. In this case, we are beyond the realm of pure firstness, as generality refers to some law-like tendency, and thus shows the nature of thirdness. Peirce works, in this case, with a merging of firstness and thirdness. It is in this latter sense that we understand potentialities at the micro-semiotic level here, as a particular set of potential Signs, Objects, and Interpretants which have been established due to the fact that the micro-semiotic level is embedded in a hierarchical system which includes levels showing the nature of secondness and thirdness (focal and macro-semiotic levels, respectively). These potentialities show, thus, the nature of a generality, being closer to a merging of firstness and thirdness, than to pure firstness. Such a treatment seems to be compatible with Peirce's categoreal scheme, since, as Potter (1997, p. 94) stresses, "the categoreal structure which Peirce uses is [. . .] highly subtle and complex, admitting of various combinations".

13. Notice that by characterizing a semiotic system as an embodiment of semiotic processes, we are blurring the distinction between entities and processes. This can be justified on the grounds of an understanding of entities as relatively stable bunches of processes. It is not the case that a process philosophy should necessarily claim that the idea of entities or things has to be abandoned. Western substance addiction can be overcome by claiming that processes should be treated, in a dynamic world, as more fundamental than things, since ". . . substantial things emerge in and from the world's course of changes . . ." (Rescher 1996, p. 28). This is the basis for process philosophy as a tendency to address philosophical issues which is committed to the idea that reality is best understood in terms of processes. In this framework, it is true that substances are conceptually and ontologically subordinated to processes. The fact that we give privilege to processes does not mean, however, that we cannot or should not talk about things; it is rather that, when we refer to them, we should bear in mind all the time that they emerge from processes, change all the time through processes, and subsequently vanish in processes.

14. At first, it may seem that qualisigns refute this idea, since they consist in qualities which are Signs, but may not be physically instantiated. But a qualisign only functions as a Sign if physically instantiated in a sinsign (see CP 2.244). It is important to take in due account that we assumed above that physical instantiation is necessary for the *active* mode of being of a Sign. It is the case, then, that a qualisign can only be active when it is physically instantiated in a sinsign. The idea of a "potential Sign", i.e., that an entity or a process is a Sign if it is potentially capable of producing Interpretants, does not create difficulties for this view too, since a system should be physically embodied even to potentially show semiosis. According to the model developed above, if a semiotic system has the potentiality of showing a given semiotic process, it can only have this potentiality if it is a physically realized system which can establish boundary conditions for the actualization of that potential semiotic process. If we claim that a Sign can exist as a potential entity or process, we should be committed to the idea that, given a set of conditions a, b, c, . . . , n, that Sign would be capable of engaging in semiosis, producing Interpretants. It remains potential while those conditions are not fulfilled. Whenever those conditions are fulfilled, that Sign will turn from potentiality to actuality. As this can only happen, according to the model presented here, when boundary conditions guide the actualization of the Sign, and boundary conditions, in turn, are established in physically embodied systems, then, even as potentiality, the action of Signs presupposes physically extended systems.

15. Notice that, even if one assumes that there can be semiosis before the emergence of semiotic systems, the Sign processes at stake would still have to be physically

instantiated or realized in one way or another, since Sign processes are relationally extended within the spatiotemporal dimension no matter if they involve semiotic systems or not.

16. For further discussions about synechism, see Parker (1998), Potter (1997), Murphey (1993).

17. See Morgan (1923), Blitz (1992). The theses were named by Blitz.

18. We would rather say 'variational evolution'.

19. To understand our argument in a clear way, it is very important to avoid conflating synchronic with diachronic determination. We claim here that a Peircean framework accommodates a thesis of synchronic determination, while denying any claim of diachronic determination.

20. Notice that while discussing the logical relations between elements and triads, we are working in the domain of Speculative Grammar, the study of the "general conditions of signs being signs" (CP 1.444). For Houser (1997: 9), "the logician who concentrates on speculative grammar investigates representation relations (signs), seeks to work out the necessary and sufficient conditions for representing, and classifies the different possible kinds of representation."

21. The distinction between material and formal properties was clearly established by Peirce after 1885 (see Kent 1997, p. 448).

22. For an introduction on phenomenology, normative sciences and metaphysics, see De Waal (2001), Parker (1998).

23. About the demonstration of the irreducibility of a triadic relation, see Ketner (1986); Brunning (1997); Burch (1991, 1997).