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Downward Determination in Semiotic Multi-level Systems

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Peirce's pragmatic notion of semiosis can be described in terms of a multi-level system of constraints involving chance, efficient, formal and final causation. According to the model proposed here, law-like regularities, which work as boundary conditions or *organizational principles*, have a downward effect on the spatiotemporal distribution of lower-level semiotic items. We treat this downward determinative influence as a propensity relation: if some lower-level entities a,b,c,…,n are under the influence of a general organizational principle, W, they will show a tendency to behave in certain specific ways, and, thus, to instantiate a set of specific processes. Our goal in this paper is to examine the role of downward determination in semiotic systems, conceived as multi-level hierarchical systems.

Keywords: semiosis, emergence, downward determination, causation, C. S. Peirce.

Introduction

The Peircean list of categories (Firstness, Secondness, Thirdness) is described as a system of classes of irreducible logical, phenomenological and metaphysical components (see Houser, 1997; Brunning, 1997). In brief, the categories can be defined as follows: (1) Firstness: what is such as it is, without reference to anything else; (2) Secondness: what is such as it is, in relation with something else, but without relation with any third entity; (3) Thirdness: what is such as it is, insofar as it is capable of bringing a second entity into relation with a first one in the same way that it brings itself into relation with the first and the second entities. This system is the foundation of Peirce's philosophy and, also, of his model of semiosis (see Murphey, 1993, pp. 303-306).

Ontologically, the categories are rudiments of the world. Firstness is the mode of being in which something is as it positively is, without regard or relation to anything else (MS 460, pp. 5-21, 1903; MS 575, 1886; CP 5.299). It can be characterized as lacking determination (cf. also MS 277,1908). Therefore, Firstness as a mode of being is related to the modality of possibility. It is the category of vagueness and novelty — "the mode of being which consists in its subject's being positively such as it is regardless of anything else. That can only be a possibility" (CP 1.25). Secondness is the mode of being "which is as it is relatively to a Second but regardless of any Third." It is a kind of *reaction* (see CP 6.200). Like Firstness, Secondness can be related to a

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modality, namely, the modality of actuality (Parker, 1998; CP 6.455). The actuality of a thing is simply its occurrence. Rephrased, actuality is the realization of a possibility, without thereby making reference to something larger, be that a general law or an interpretation. Peirce considered "the idea of any dyadic relation not involving any third as an idea of secondness" (CP 8.330). Thirdness is the category of mediation, habit, generality, and conceptualization (CP 1.340). The example par excellence is Peirce's semiotic process (semiosis) in which a sign is related to an object by mediation through an interpretant.

We are mostly interested here in one particular question: What kind of determinative relations are operating when different levels of description of complex semiotic processes are taken into account? We have preliminarily addressed this topic in another paper (Queiroz & El-Hani, 2006a). Here, we will expand on the issue, considering how semiosis can be described in terms of a hierarchical multi-level system of constraints involving chance, efficient, formal and final causation.

Briefly, causality involves, based on Peirce's theory of categories, three different classes of causal relations. Any act of causation involves an efficient and a final component (general types). Final causes are general types, or general potentialities, determining processes of efficient causation. The efficient aspect lies in the fact that each event is determined by the previous event (by efficient cause) through mechanisms categorically described as secondness. At the same time, each event is part of a chain with a tendency, which is determined by the final cause of the process. This tendency is a habit which develops in the course of natural processes.

Semiosis is, according to several authors (e.g., Short, 2007; Pape, 1993, p. 593), the most general description of the internal structure of final causality. As efficient causation is a dyadic relation between two events, final causation is an irreducible triadic relation that connects, by the mediation of a general possibility, two facts. (Notice that a final state is not conceived in this case as a static final point, but as a general possibility.) Efficient causation is exemplified by blind compulsive relation between two events (Secondness). As an important component of Peirce's evolutionary thought, final causation evolves (developmental teleology, see EP1:313). Peircean kinds are of the nature of habit; and habits changes. Consequently, one of the objections against natural classes, the claim that they are untenable for being related to immutable essences, does not hold for Peirce's position.

According to Peirce, any description of semiosis should necessarily treat it as a relation constituted by three irreducibly connected terms (sign-object-interpretant, S-O-I), which are its minimal constitutive parts (CP 5.484; EP2:171). Peirce also defines a sign as a medium for the communication of a form or habit embodied in the object to the interpretant, so as to constrain (in general) the interpretant as a sign or (in biological systems) the interpreter's behavior (De Tienne, 2003; Hulswit, 2001; Bergman, 2000, 2009). The notion of semiosis as form communicated from the object to the interpreter through the mediation of the sign allows us to conceive meaning in a telic, processual, non-substantive way, as a constraining factor of possible patterns of interpretative behavior through habit and change of habit.

In our description of semiosis, this process is modeled in terms of a multilayered system, with micro-structural functional entities at the bottom and with higher-level processes (such as webs of signs) being mereologically composed of these lower-level entities. But can the large-scale patterns (of semiosis) determine the local interactions that generated them? Is there an influence that downwardly percolates from the web of signs to its parts (as instantiated in the triadic relation S-O-I)? According to our model, law-like regularities, which work as boundary conditions or *organizational principles*, have a downward effect on the spatiotemporal distribution of lower-level items. Then, the following question should be posed: What kind of relation we identify between this downward determination and Peircean categorically oriented forms of causation?

In order to tackle this question, we will first consider how Emmeche and colleagues (2000) address two viable candidates for a scientifically-compatible account of downward causation, and, then, we will move to a formulation of a different account of the determinative influence of wholes over parts, in terms of downward determination.

Downward Determination and Peirce's Categories

Emmeche and colleagues (2000) identified three versions of downward causation (DC), each making use of a particular way of interpreting the causal mode (or modes) at stake: strong, medium, and weak DC. Strong DC interprets the causal influence of a whole over its parts as a case of efficient causation, in such a manner that it implies substance dualism. Consequently, it is an untenable interpretation of DC if we intend to formulate this notion within a scientific framework.

Emmeche and colleagues (2000) emphasize, then, that there are only two viable candidates for a scientifically-compatible account of DC: medium and weak DC. They are both related to an interpretation of DC as a case of synchronic formal causation, as Vieira and El-Hani (2008) discuss.

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" (Emmeche et al., 2000, 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 in terms of 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" (Emmeche et al., 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' (Emmeche et al., 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" (p. 16). 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" and a "constitutive reductionism" (Emmeche et al., 2000, 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*, that is, 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 can 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 at a lower level. (v) The relative stability of an attractor is taken to be identical to the downward *governing* of lower-level entities, that is, the attractor functions as a whole at a higher level affecting the processes that constitute it. (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.

For the sake of our arguments, we will initially work with an interpretation which comes close to medium DC by interpreting boundary conditions as constraints, but, at the same time, departs from it, by 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, and, subsequently, we will move to a reformulation of our arguments in terms of downward determination rather than causation.

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. 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 (supposing a consistent typology of kinds of systems).

The causes in DC can be treated, in these terms, as higher-level general organizational principles which constrain particular lower-level processes (the effect amounts to such constraint), 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 & Emmeche, 2000). 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). The (higher-level) constraining conditions are closely 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*. But can we reconcile this interpretation with Peirce's theory of categories, which entails, as we saw above, three classes of causal relations?

For the purpose of answering this question, we will consider a multilayered model including three levels (a lower, a focal, and a higher level), and we will examine how they can match both Peirce's categories and the above interpretation of causation. In the domain of Firstness, we find a set of potential causal relations at the lower level, which can constitute a particular set of processes at the focal level. It is the emergence of these focal-level processes that we are interested in explaining. In this case, we have a good agreement between Peirce's categories, since Firstness is the category of possibility (CP 1.25), and the account of causation discussed here. The process which will emerge at the focal level is among a set of processes made possible by the micro-structure of a given kind of system. If we consider, for instance, the cell as the focal level, we will speak about the molecular constituents of the cell as establishing a potential space of interactions which can give rise to a particular set of processes at the cell level. The molecular level establishes possibilities to cellular processes, and this is in agreement with Peirce's category of Firstness, when applied to a theory of causation.

It is interesting to notice that the cellular (focal-level) processes are also constrained by the lower-level components, since they cannot realize any imaginable process at the focal level. These constraints entail that lower-level possibilities are part of the explanation of the emergence of focal-level processes. Furthermore, when the focal-level process is actualized and we intend to explain it, we need to consider the

lower level as providing essential elements to build a model of the mechanism that realizes the process at stake.[3] It is at the lower level that we find the componential aspect of the model, namely, the working components involved in the emergence of the process (which amounts to the phenomenal aspect, what the mechanism does, the process into which it is involved). It is at the focal level, however, that we find the (efficient) causal aspect, related to the actions and interactions of the components, when actualized. However, as it will become clearer as we go on with the argument, we cannot really understand the componential and causal aspects by focusing on the lower and focal level alone.

The missing element in the above explanation concerns the regulatory actions of higher-level entities and processes over the focal and lower levels. Regulation is often described in biology merely at the lower level. Consider, for instance, the typical account of enzyme regulation as the consequence of the interaction between an allosteric molecule and the enzyme. In such an account, regulation seems to take place at the lower level, with no involvement of higher-level processes. However, if we ask why the allosteric molecule involved in the regulation is present when and where it is, we will typically have to consider the influence of the context in which the enzyme is operating, both cellular and supracellular, crucially involving semiotic processes such as those that take a part in cell signaling. Thus, to explain enzyme regulation only at the molecular level is like explaining a subject's indexical (deitic) action by pointing out only to its finger or hand. Obviously, the cognitive system, body, and the context of the action should be also taken into account in the explanation (see Tomasello, 2008). The finger or hand is just the final effector of the act. The same is the case with enzyme regulation. The allosteric molecule is like the finger of the process, but if we want to understand regulation we will have to consider the higher levels which constrain lower-level (in the example, molecular) processes in such a manner that the molecular interaction at stake occurs.

This means that causal processes necessarily involve higher-level constraints, which enslave the components to a given spatiotemporal configuration, which makes it more likely that certain processes emerge at the focal level. These focal-level processes, in turn, show a tendency of progressing toward some final state, realizing some end. There is no necessity of appealing here to problematic or scientifically-incompatible notions, such as that of a designer establishing the means-ends relationship involved in processes, or that of reverse causes, inverting the temporal order of efficient causal relationships. It is enough—and, we think, much more consistent—just to propose, as Peirce did, that nature tends to acquire habits, or, to put it differently, that the evolution of natural systems tends towards the emergence of regularities in the domain of processes. Thus, processes tend to instantiate final states—conceived as general possibilities rather than static final points—as a consequence of their evolution. In the end, this is, indeed, what makes it possible to explain them, through our theories and models. Nothing more is needed – we think –

3. We are using here Craver and Bechtel's (2006) account of models of mechanism.

to capture the meaning of final causality here. After all, in Peirce's thinking, final causation evolves, he speaks of a *developmental teleology* (EP1:313), which is naturalized to the extent that it has the nature of habit, and habits are not designed; rather, they evolve, they change through history.

Notice that we appealed, above, to two concepts that Peirce considers in his account, form (by considering spatiotemporal configuration) and finality. As we argued above, final causes are conceived, in a Peircean account of causation, as general types, or general potentialities which determine processes of efficient causation. Efficient causes, in turn, are modeled as instances of Secondness. This causal mode is located, in our multilayered explanation, at the focal level, in relation to steps embedded in a process realized by lower-level potentialities, which are, also, enslaved by the tendency of the process itself. Each efficient causal event is part of a chain with a tendency, which is determined by the final cause of the process. Final causality is, thus, instantiated at the focal level, but as a result of the history of evolution of the process, involving also the higher level, since evolution entails the relationship between natural systems/processes and their contexts. This entanglement of focal and higher levels in final causality means that this causality shows the nature of Thirdness. It can be seen as an irreducible triadic relation that connects, by the mediation of a general possibility, two or more (efficient) events, even though it is at the development of a focal-level process that a final, end state will be reached, not as a static telos, but as a general possibility (which, sometimes, simply does not happen—the end state can be omitted, the process can fail). Efficient causes are, obviously, about things acting on each other, brute action, but this action never takes place in isolation, but only within processes. In the end, we can see that all categories are interwoven in a single model, with Thirdness playing a central explanatory role, since it is related to habit, generality, and is put into action in all explanations of the emergence of processes, since it concerns what in all probability would be, given a certain set of conditions.

What we need now is to consider how DC interpreted as a formal cause can be introduced in this scheme. It seems to us that the very fact that focal-level processes tend towards certain ends must be explained by their embedment into a higher-level spatiotemporal configuration, considering not only this configuration synchronically, at a given slice of time, but also diachronically, that is, how this configuration evolved through time and how it went on enslaving lower-level components, constraining their possible interactions into a more limited repertoire. It is because this repertoire is more limited than it would be, if we considered only lower-level components, that focal-level processes showing tendencies, habits, regularities can appear. Final states, end states, functions emerge at the level of the components because higher-level constraints make these components have much more ordered configurations in spacetime than they would have by themselves. These formal constraints are, thus, higher-level and show the nature of Thirdness, since they are also habitual and general.

Hulswit (2006) 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). We explored in previous works 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*, and so forth, 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 (see El-Hani & Queiroz, 2005; Vieira & El-Hani, 2008).

It seems to us that the important relationship here lies in the fact that in considering either DC or ordinary, efficient causation, we are dealing with some kind of determination. As Hulswit (2006) 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 suggested, then, that we should move from a notion of downward causation to one of downward (formal) determination (El-Hani & Queiroz, 2005; Vieira & El-Hani, 2008). 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 really about determination or explanation rather than causation. Second, that efficient causes are typically regarded as individuals (usually events, facts, or substances), and downward causes are more properly interpreted as general, law-like organizational principles. Third, causes are not the only sort of determining factors in the world and it is largely accepted in other current philosophical debates the introduction of non-causal determinative relations. For instance, a similar move has been made in the case of another determinative but mereological relation, namely, physical realization (and, consequently, supervenience), which cannot be properly accounted for as causal (see, e.g., Kim, 1993).

However, the idea of downward determination (DD) should be formulated in a consistent manner. If we intend to develop a theory about DD, we should answer the following two questions: (i) What sorts of things are said to be determining and determined in a case of DD? (ii) What is the meaning of *determining* in DD?

In our account, a higher-level organizational pattern, interpreted as a general principle, is the determiner, while lower-level particular processes are determined. DD does not have a causal nature in the sense that it does not concern productive events, which bring about an effect. Rather, the relation at stake is not productive, but constraining, it does not bring about effects, but regulates cause-and-effect, lower-level relations so that some are realized, some are not, at any given time and space.

As we saw above, a key idea in our account is that the relations between the components at the lower level of a given system, which instantiates a token of a given type of structure, are constrained by the organizational, regulatory influence of this structure. From this idea, we argue that a determinative relation holds between higher-level organizational principles and particular processes at the lower level, which can be treated, in order to allow for statistical relationships between organizational principles and processes, as a propensity relation:

> If some lower-level entities a,b,c,…,n are under the influence of a general organizational principle, W, they will show a tendency to behave in certain specific ways, and, thus, to instantiate a set of specific processes. The determining influence in this case is from a higher-level general organizational principle on particular lower-level processes, and can be framed as follows: if a,b,c,…,n are under the influence of W, then they will show a tendency, a disposition, to instantiate process p or a set of processes {P}. (Vieira & El-Hani, 2008, p. 129)

DD is treated, thus, as a *would be tendency*, a relation leading to a higher likelihood that a given process or set of processes will happen, and it can be clearly taken, in terms of Peirce's categories, as an instance of Thirdness, that is, of what in all probability would be, given a certain set of conditions.

We can see in a clearer way, then, that DD involves both final and formal modes of explanation (each showing the nature of Thirdness). If we now recast our argument above speaking about modes of determination (ontologically) and modes of explanation (epistemologically), and avoiding the framing of the argument in terms of causal modes, we will have: efficient causes as events embedded in focal-level processes (Secondness); potentialities of emergence of efficient causal events at the lower level (Firstness); and formal and final determination at the higher-level (with final determination being instantiated at the focal level, when the process tends towards an end state) (Thirdness).

If we now briefly come back to Craver and Bechtel's (2006) account of mechanisms, formal and final determination are involved in the organizational aspect of a model of mechanism. The organizational aspect concerns the spatiotemporal organization of the components and their causal relations, in such a manner that the phenomenon at stake (as grasped by the phenomenal aspect) is produced. This spatiotemporal organization includes the relative locations and times, shapes, sizes, orientations, connections, and boundaries of the mechanism's components. It is clear, then, that we cannot understand the componential aspect of the model, the components involved in the emergence of the process, and the (efficient) causal aspect, the actions and interactions of the components, without a higher-level account of the spatiotemporal organization of the system at stake and the tendencies instantiated in their processes, as a consequence of its evolution. Final and formal modes of explanation are necessary to any model of mechanism. Thus, models of mechanisms cannot be framed only in lower-level terms; rather, they need multilayered models, as the one proposed here. This can be seen as an outcome of DD, as explained here: the focal-level processes that account for the emergence of the

phenomenon produced by the mechanism are realized due to a disposition of lower-level entities a,b,c,…,n of instantiating a process p or a set of processes {P} when they are under the influence of a general organizational principle, W, grasped by the organizational aspect of the mechanism model.

Can We Describe Any Sort of Downward Determination in Semiosis?

S. Salthe's (1985) *hierarchical structuralism* provides one of the fundamental grounds for the account presented in the previous section in order to examine how Peirce's categories might be introduced in our interpretation of downward determination. We previously Salthe's approach to explain the emergence of semiosis in semiotic systems (Queiroz & El-Hani, 2006a, 2006b; El-Hani et al., 2009). According to our model (figure 1), semiosis is conceived as a systemic process at a focal level, in which chains of triads (S-O-I) are instantiated as a result of the interaction between potentialities established by a micro-semiotic level (initiating conditions) and the regulatory, selective influence of a macro-semiotic level (boundary conditions). 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 at the focal level. At the lower level, the constraining conditions amount to the potentialities or initiating conditions (Firstness) for the emergent process (as composed by efficient causal events at the focal level [Secondness]), while constraints at the higher level are related to the role of a (selective/regulatory) environment played by the entities at this level, establishing the boundary conditions that coordinate or regulate the dynamics at the focal level. The regulation of a focal-level process by higher-level boundary conditions is interpreted here as a kind of selective process, which operates by downwardly determining (in the sense described above) processes at the focal level. As explained above, the higher level has a formal and final determinative influence over processes at the focal level, so that they tend towards some (evolving) end state (Thirdness).

The micro-semiotic level concerns relations of determination that may take place within each triad S-O-I. These relations 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, p. 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). At the macro-semiotic level, we should consider networks of chains of triads which embed the semiotic process at the focal level. Focal-level semiosis will emerge (as a process) through the interaction between micro- and macro-semiotic

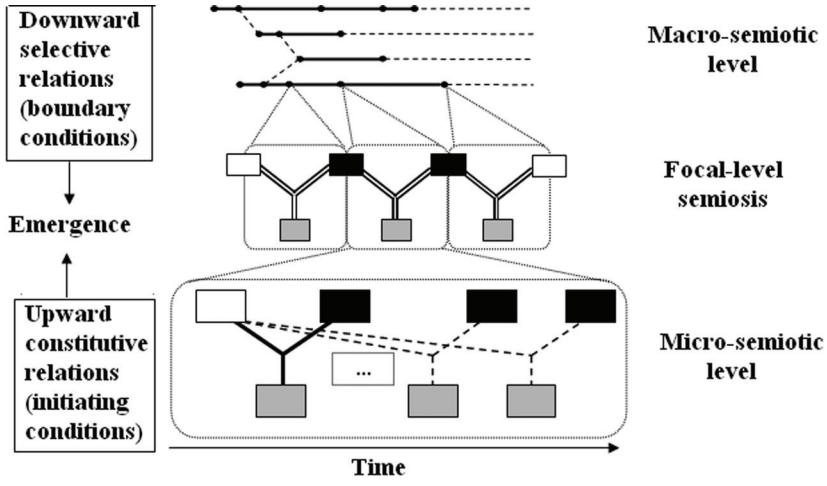
processes, that is, between the relations of determination within each triad and the embedment of each individual chain in a whole network of sign processes.

We consider a whole set W of potential determinative relations between these three elements (S, O, I), which can generate a set of potential triads. These triads cannot be determined, however, by the micro-semiotic level, which 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/ regulatory role, which is required for the actualization of potential chains of triads. After all, according to this model, chains of triads are actualized at the focal level by a selection of those triads that will be effectively actualized amongst those potentially engendered at the micro-semiotic level. 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 $T = \{..., t_{i-1}, t_i, t_{i+1},...\}$ and networks of chains of triads $ST = \{T_1, T_2, T_3,..., T_n\}$.[4]

Considering the dynamics of semiotic processes at the focal level, we can say that their temporal evolution 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 possible 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 – x of potential chains of triads that might be actualized at *t*. Then, a second kind of constraint acts on the set W, namely, 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 $T_i = \{..., t_{i-1}, t_i, t_{i+1},...\}$ to be actualized at *t*.

4. It is useful to consider, also, Tomasello's (2008) discussion about how temporally-dependent higher-level structures and processes regulate deitic semiotic events. On the role of context in Peirce's model of semiosis, see Queiroz and Merrell (2006).

Figure 1: A Multi-level Model of the Emergence of Semiosis



Note: The upward arrow shows the constitutive relation from individual triads to chains of triads, corresponding to Salthe's initiating conditions, or potentialities (Firstness). The downward arrow shows selective relations from networks of chains of triads to chains of triads, corresponding to Salthe's boundary conditions (formal and final determination, Thirdness). At the focal level, a semiotic process is actualized by efficient events embedded in it, enslaved by its tendency toward some (evolving) final state, under the influence of the spatiotemporal configuration of structures and/or processes which is characteristic of a given kind of system. To understand a semiotic process, we need a mechanistic model that considers all these types of determination, alongside with a functional and a semiotic model (see El-Hani, Arnellos, & Queiroz, 2007).

Final Comments

We mentioned above the example of a subject's indexical (deitic) action in order to argue that we cannot account for it by pointing out only to his or her finger or hand, without considering his or her cognitive system, body, as well as the context of the action. In this example, a pointing gesture is interpreted as a sign (index) of an object because it determines (constrain) an oriented effect on an interpreting mind. The irreducibly triadic relation S-O-I is dependent on the fact that any pointing gesture of similar nature has been interpreted as an equivalent index of an object or event to an interpreter who has experienced a similar effect (interpretant) successfully. What is important here is that the functional and semiotic nature of the terms S, O, and I is governed by semiotic specific situations. Therefore, there is a pragmatic irreducible dimension to the phenomena described, according to this model, which supposedly ensures that no explanation of it can be confined only to lower levels of description. Additionally, the role of the context is explicitly associated (according to this model) to Peirce's typology of causality. But, in relation to the nature of the relata S-O-I, there is another relevant dimension to consider. Can anything potentially act as a sign of anything else to any kind of interpretant? Probably not. Peirce was aware of the fact

that certain qualities allow specific semiotic operations. Diagrams, for instance, are the best candidates to represent spatial relations (see Stjernfelt, 2007); discrete signs accurately represent properties of compositionality and recursiveness; events that co-vary in spacetime are good candidates to act as indexical signs (see Queiroz & Ribeiro, 2002). This dimension is related to the characteristics that the sign has qua sign, which form the bases of its capacity, as a sign, to represent an object. The established conditions in the micro-semiotic level are coupled with specific properties that some materials have that make them likely to act as signs of certain types of objects. These specific properties are potentialities (Firstness) that can be engaged in semiotic processes, which both depend on efficient events (Secondness) and higher-level regularities or habits, which have a downward formal and final determination over semiosis (Thirdness).

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References

Bergman, M. (2000). Reflections on the role of the communicative sign in semeiotic. *Transactions of the Charles S. Peirce Society, XXXVI* (2), 225-254.

Bergman, M. (2009). *Peirce's philosophy of communication*. London: The Continuum International Publishing Group.

Brunning, J. (1997). Genuine triads and teridentity. In N. Houser, D. Roberts, & J. Van Evra (Eds.), *Studies in the logic of Charles Sanders Peirce* (pp. 252-270). Bloomington, IN: Indiana University Press.

Craver, C. F., & Bechtel, W. (2006). Mechanism. In S. Sarkar & J. Pfeifer (Eds.), *Philosophy of science: An encyclopedia* (pp. 469-478). New York: Routledge.

El-Hani, C. N., & Emmeche, C. (2000). On some theoretical grounds for an organism-centered biology: Property emergence, supervenience, and downward causation. *Theory in Biosciences, 119*, 234-275.

El-Hani, C. N., & Queiroz, J. (2005). Downward determination. *Abstracta, 1* (2), 162-192.

El-Hani, C. N., Queiroz, J., & Emmeche, C. (2009). *Genes, information, semiosis*. Tartu: Tartu University Press.

Emmeche, C., Køppe, S., & Stjernfelt, F. (2000). Levels, emergence and three versions of downward causation. P. B. Andersen, C. Emmeche, N. O. Finnemann & P. V. Christiansen (Eds.), *Downward causation: Minds, bodies and matter* (pp. 13-34). Aarhus: Aarhus University Press.

Houser, N. (1997). Introduction: Peirce as a logician. In N. Houser, D. Roberts, J. Van Evra (Eds.), *Studies in the Logic of Charles Sanders Peirce* (pp. 1-22). Bloomington, IN: Indiana University Press.

Hulswit, M. (2001). Semeiotic and the cement of the universe: A Peircean process approach to causation. *Transactions of the Charles S. Peirce Society,* XXXVII (3), 339-363.

Hulswit, M. (2006). How causal is downward causation? *Journal for General Philosophy of Science, 36* (2), 261-287.

Murphey, M. G. (1993). *The development of Peirce's philosophy.* Indianapolis, IN: Hackett.

Kim, J. (1993). Supervenience and mind. New York: Cambridge University Press.

Pape, H. (1993). Final causality in Peirce's semiotic and his classification of the sciences. *Transactions of the Charles S. Peirce Society, XXIX* (4), 581-608.

Pape, H. (2002). What thought is for: The problematic identity of mental processes with chance events in Peirce's idealistic metaphysics. *Transactions of the Charles S. Peirce Society, XXXVIII* (1/2), 215-251.

Parker, K. (1998). The continuity of Peirce's thought. Nashville, TN: Vanderbilt University Press.

Peirce, C. S. (1992). *The essential Peirce. Selected philosophical writings*, Vol. 1 (N. Houser & C. Kloesel, Eds.) Vol 2 (Peirce Edition Project, Eds.). Bloomington and Indianapolis, IN: Indiana University Press. (cited as EP1: followed by page).

Peirce, C. S. (1998). *The essential Peirce. Selected philosophical writings,* Vol. 2 (The Peirce Edition Project, Eds.). Bloomington, IN: Indiana University Press. (cited as EP2: followed by page).

Peirce, C. S. (1931–1935, 1958). The collected papers of Charles Sanders Peirce. Electronic edition reproducing Vols. I–VI [C. Hartshorne & P. Weiss (Eds.), Cambridge: Harvard University Press, 1931–1935]; Vols. VII–VIII [A. W. Burks (Ed.), same publisher, 1958]. Charlottesville, VA: Intelex Corporation. (cited as CP followed by volume.paragraph.)

Peirce, C. S. (1967). Annotated catalogue the papers of Charles S. Peirce. (R. S. Robin, Ed.). Amherst, MA: University of Massachusetts. [cited as MS, followed by the number of the manuscript].

Peirce, C. S. (1982-2000). *Writings of Charles S. Peirce: A chronological edition, Vol. 2*. (Peirce Edition Project, Eds.). Bloomington, IN: Indiana University.

Polanyi, M. (1968). Life's irreducible structure. *Science, 160*, 1308-1312.

Potter, V. (1997). *Charles S. Peirce: On norms & ideals*. New York: Fordham University Press.

Queiroz, J., & El-Hani, C. (2006a). Towards a multi-level approach to the emergence of meaning in living systems. *Acta Biotheoretica, 54*, 179-206.

Queiroz, J., & El-Hani, C. (2006b). Semiosis as an emergent process. *Transactions of the Charles S. Peirce Society, 42* (1), 78-116.

Queiroz, J. & Merrell, F. (2006). Semiosis and pragmatism: Toward a dynamic concept of meaning. *Sign System Studies, 34* (1), 37-66.

Queiroz, J., Emmeche, C., & El-Hani, C. (2005). Information and semiosis in living systems: A semiotic approach. *S.E.E.D. Journal – Semiotics, Evolution, Energy, and Development, 5* (1), 60-90.

Queiroz, J., & Ribeiro, S. (2002). The biological substrate of icons, indexes, and symbols in animal communication. In M. Shapiro (Ed.), *The Peirce seminar papers – The state of the art* (Vol. V., pp. 69-78). Oxford: Berghahn Books.

Salthe, S. N. (1985). *Evolving hierarchical systems: Their structure and representation*. New York: Columbia University Press.

Short, T. (2007). *Peirce's theory of signs*. Cambridge: Cambridge University Press.

Stjernfelt, F. (2007). *Diagrammatology: An investigation on the borderlines of phenomenology, ontology and semiotics*. Dordrecht: Springer.

Tomasello, M. (2008). *Origins of human communication*. Cambridge, MA: The MIT Press.

Van Gulick, R. (1993). Who is in charge here? And who's doing all the work? In J. Heil & A. Mele (Eds.), *Mental Causation* (pp. 233-256). Oxford: Oxford University Press.

Vieira, F. S., & El-Hani, C. N. (2008). Emergence and downward determination in the natural sciences. *Cybernetics & Human Knowing, 15* (3-4), 101-134.