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# DOWNWARD DETERMINATION

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**Abstract**

The problem of downward causation – i.e., the problem of the nature of the influence of a system or whole over its components – is highly debated in the literature on property emergence. Nevertheless, most treatments of downward causation do not really refer to causation at all, but rather to explanation and/or determination, as Menno Hulswit recently argued. In this context, it is quite important to search for an understanding of how the roles usually ascribed to systems relatively to their components, such as those of 'constraining', 'selecting', 'organizing', 'structuring', 'determining', can be connected with the idea of causation. In our view, the important relation here is that in all these cases we are dealing with some kind of 'determination'. But it is required, then, to clarify what we mean by 'determination'. For this purpose, we can take as a starting point a difference between the ideas of 'determining' and 'causing' which seems central to us, and was also highlighted by Hulswit: while 'determining' primarily involves the idea of 'necessitation' (in the sense of 'it could not be otherwise', or, in a somewhat weaker but more broadly applicable manner, 'it does not tend to be otherwise'), 'causing' primarily refers – since the advent of Western modern science – to the idea of 'bringing about' some event. In this work, we propose that discussions about the influence of systems or wholes over their components can benefit from a move from the idea of downward 'causation' to that of downward 'determination'. Downward determination can be understood in terms of constraints that the condition of belonging to a system-token of a given kind imposes on the behavior of the components. Thus, we move from an understanding of the influence of wholes over parts based on a neo-Aristotelian perspective, which introduces other causal modes than just efficient causes, to an understanding in terms of modes of determination other than causal determination. This immediately poses a number of questions, which should be faced in order to make this idea more precise. In this paper, we will only discuss two of them. First, we will strive for explaining in further detail what we mean by 'determination'. We will address this problem here by exploring Peirce's distinction between 'causal' and 'logic' determination. Second, we will establish in a clear manner the nature of the relata in downward determination. In the model we put forward here, the determiner, at the level of the system as a whole, is a general principle of organization, a universal, which is characteristic of the kind of structure observed in a type of system, and the determined, at the level of the parts, are particulars, namely, concrete processes involving the system's components.

## 1. Introduction

In the end of the 1980s, emergentism seemed to be an entirely forgotten philosophical position. Nevertheless, its fortune has changed in the last decade. The debate about emergence has re-emerged. A great number of works dealing with emergence have been published in the philosophical and scientific literature in the last 15 years[1], and the concept

[1] *e.g.,* Klee (1984); Savigny (1985); Blitz (1992); Beckermann et al. (1992); Stephan (1997, 1998, 1999a,b); Kim (1997, 1999); O'Connor (1994); Baas (1996); Newman (1996); Baas & Emmeche (1997); Humphreys (1996, 1997a,b); Emmeche et al. (1997); Emmeche (1997); Bedau (1997,

of emergence has been increasingly used in such diverse fields as artificial life, cognitive sciences, evolutionary biology, theories of self-organization, philosophy of mind, dynamical systems theory, synergetics, etc. The role played by the concept in these fields has been directly responsible for revitalizing emergentism as a philosophical trend, despite the fact that it is often used in vague and imprecise ways.

The term 'emergence' has both an ordinary use, as when the expression 'the emergence of *x*' is employed merely to indicate that '*x* has appeared' or that '*x* has come up', and a technical use. As to the latter use, we draw on a modified version of a definition put forward by Stephan (1998: 639): Emergent properties constitute *a certain class* of higher-level properties related *in a certain way* to the microstructure of *a class of systems*. An emergence theory should, among other things, fill in the open clauses in this definition (shown in italics), providing an account of which systemic properties[2] (of a given class of systems) should be regarded as 'emergent', and offering an explanation of the relationship between these properties and the microstructure of the systems in which they are instantiated. The reason why such a broad definition, with open clauses, seems at first more adequate than a definition with more content and precision has to do with the fact that the concept of emergence and its derivatives are employed in the most diverse fields, and, consequently, a more detailed definition is likely to apply to some fields but not to others.

Nevertheless, for the sake of both accuracy and clarity, it is important to spell out a number of criteria which should be fulfilled in order to a property or process be treated as 'emergent'. Elsewhere, we have presented a careful treatment of the problems faced by an attempt to build an emergence theory in a particular field, addressing both issues related to the open clauses in the above definition and a number of other questions which arise in efforts to interpret a specific phenomenon – in this case, sign processes – within an emergentist framework (Queiroz & El-Hani, 2005). Here, we will introduce some criteria which are derived from one of the classical works on emergence, *Emergent Evolution* (1923), from Lloyd Morgan.

Morgan characterizes 'emergent evolution' as follows:

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2002); Azzone (1998); Schröder (1998); El-Hani & Pereira (1999); Pihlström (1999, 2002); El-Hani & Emmeche (2000); Andersen et al. (2000); El-Hani & Videira (2001); El-Hani & Pihlström (2002a,b); El-Hani (2002a); Symons (2002); Gillett (2002).

[2] A systemic property is a property found only at the level of a system as a whole, not at the level of its parts.

> 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: 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: 5), linking emergent events to the "... expression of some new kind of relatedness among pre-existent events" (Morgan 1923: 6). Finally, Morgan observes:

> 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: 16. Emphasis in the original).

These quotations from Morgan's classical work on emergence contain some basic criteria for treating properties and processes as 'emergent'. First, they should be (genuinely) new under the sun. This obviously leads to the problems of 'novelty' and 'unpredictability', which we will not discuss here, as they fall outside the scope of this paper.[3] Second, they should be closely connected with the appearance of a new kind of relatedness (and, thus, of a new organizational principle) among pre-existent processes and entities, entailing a modification in the way lower-level events run their course, and, consequently, some sort of downward causation. Third, the emergence of properties or processes in a new class of systems (as defined by the above-mentioned new kind of relatedness) should change the mode of systems' evolution. This change, in turn, should be precisely the result of a modification of the behavior of pre-existent entities and processes under the influence of that new kind of relatedness (and, this again leads us to the issue of downward causation).[4]

It is also important to take into account that there is no unified emergence theory. In a systematic analysis of emergence theories, Stephan (1998; 1999a, ch. 4; 1999b) initially

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[3] For discussions of these notions, see, for instance, Emmeche et al. (1997), Stephan (1998, 1999a,b).

[4] For an application of these criteria for characterizing events in the origins of life as being 'emergent', see El-Hani (2002b).

considers three varieties of emergentism – *weak* emergentism; *synchronic* emergentism; and *diachronic* emergentism – and later expands his typology to include six different emergentist positions.[5] Both synchronic and diachronic emergentism comprise strong emergence theories. They 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 mereological relationship between a system's properties and its microstructure (*i.e.*, the arrangement and properties of the system's parts). 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*. No strong emergence theory can be properly formulated without coming to grips with the problems of irreducibility and/or unpredictability. This paper focuses on the concept of irreducibility, and, particularly, on the problem of downward causation.

## 2. Downward Causation (DC)

The problem of DC is the problem of how a higher-level phenomenon can cause or determine or structure a lower-level phenomenon (El-Hani & Emmeche 2000).[6] To be more precise, what is at stake in this problem is what Jaegwon Kim (1999) calls 'reflexive downward causation', which takes place when some activity or event involving a whole has a causal influence on the events involving its own micro-constituents.

Kim (1993: 350) writes that "... downward causation is much of the point of the emergentist program". But why is the problem of DC so central to emergentism? If we assume, as Kim does (1992, 1993, 1996), that, for something to be real, it should have causal powers, it will follow that to ascribe reality to emergent properties – an ascription that seems at first necessary for avoiding the conclusion that they are merely epiphenomenal properties – we will have to show that these properties instantiate new causal powers of their own. As Kim (1999: 19) puts it, "the claim that emergents have

[5] Stephan's discussion about theories and concepts of emergence that perform different roles in different fields is in accordance with a pluralist attitude towards a diversity of pragmatically-workable notions of emergence, as advocated by El-Hani & Pihlström (2002a,b; 2004). We will not deal with the six positions described by Stephan in this paper. For more details, see the original works.

[6] The expression 'downward causation' was introduced by Campbell (1974) to account for the idea that the higher level is characterized by organizational principles, lawlike regularities, that have a downward effect on the dynamics, distribution, and magnitude of lower level events and processes.

causal powers is entirely natural and plausible if you believe that there are such properties. For what purpose would it serve to insist on the existence of emergent properties if they were mere epiphenomena with no causal or explanatory relevance."

The causal powers of emergent properties should, moreover, be irreducible to the causal powers of their basal conditions. Emergent properties are typically supposed to represent novel additions to the ontology of the world. But it seems that this can only be the case if they bring with them genuinely new causal powers, going beyond the causal powers of the lower-level basal conditions from which they emerge. In particular, it is the case that emergent properties can only show causal powers by causally influencing events and phenomena at lower levels – that is, through reflexive DC.

An argument against Kim's criterion for reality can be derived from C. D. Broad's (1925) distinction between 'existents' and 'abstracta' in connection with the concept of 'properties'. Broad distinguishes between the part of reality which 'exists' and the part which is 'real' but not 'existent' (corresponding to abstracta). But notice that we can plausibly treat emergent properties as immanent universals, and, therefore, include them among abstracta, i.e., 'real' but not 'existent' universals.[7] Kim assumes that emergent properties, to be real, should possess causal powers. He derives from the claim that emergent properties do not possess causal powers, given that their causal roles are preempted by causal relations between their basal conditions, the conclusion that an eliminative reduction of emergent properties obtains, in which they are eliminated as 'properties', being retained only as 'concepts' or 'expressions' (Kim 1999). Nevertheless, we can plausibly claim that the requisite that something to be real should possess causal powers applies to the domain of existents within reality, not to the whole of reality, given the idea that there are abstracta, which are real but not existent. In this sense, causal

[7] This certainly demands that one takes a position as regards the nature of 'properties'. This is not the space for a more careful and detailed treatment of this issue. Nevertheless, a few clarifying words are indeed necessary. Ontological theories about properties have either postulated universals (realism) or denied their existence (nominalism). Realists about universals, in turn, have favored either Platonic transcendental universals, which are supposed to exist independently of the particulars in which they may be instantiated, or Aristotelian immanent universals, which are always instantiated in concrete particulars. Nominalists advocate, generally speaking, that only particulars are real and properties are nothing more than their classifications in terms of language or concepts. A kind of via media has been proposed by trope theorists, who claim that there are indeed properties, but these properties are particulars' individual modes of being ('tropes'), and not universals instantiated in several particulars at the same time. As we stated above, as regards these alternative positions, we are assuming, for the sake of our arguments, that emergent properties are immanent universals.

powers would be necessary to ascribe existence to something, but not reality. Then, Kim's criterion (or, as he calls it, 'Alexander's dictum') could be turned into the idea that something to be existent should possess causal powers. Then, if we consider emergent properties as immanent universals, and, thus, take them to be real but not existent universals, there will be no necessity of ascribing causal powers to emergent properties in themselves in order to argue that they are real. Surely, it would be necessary to ascribe such causal powers if we were to say that emergent properties are existent. Nevertheless, we would be claiming from the start that they are real but not existent parts of reality, so that Kim's requirement would not bother us anymore.

But, even though we may put aside this first reason to worry about DC, a second one is inevitable: DC may provide a way of reconciling the notions of irreducibility and synchronic determination. Briefly, the thesis of synchronic determination, which any physicalist emergentist should assume as a corollary of his commitment to physical monism, can be explained as follows:

> [Synchronic determination] A system's properties and behavioral dispositions depend nomologically 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 (adapted from Stephan 1999a: 26; see also Stephan 1998: 641; 1999b: 50-51).

In turn, two general kinds of irreducibility notions can be discerned: Irreducibility as unanalyzability, and irreducibility as the non-deducibility of the behavior of the system's parts. We will deal here only with the second notion:[8]

> [Irreducibility of the behavior of the system's parts] A systemic property will be irreducible if it depends on the specific behavior that the parts show within a system of a given kind, and this behavior, in turn, does not follow from the components' behavior in isolation or in other (simpler) kinds of system (adapted from Stephan 1998: 644; 1999b: 52).[9]

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[8] For details on both concepts of irreducibility, see Stephan (1998; 1999a,b), El-Hani & Queiroz (2005).

[9] This idea was recently expressed as the 'horizontal' condition for emergence by Boogerd et al. (2005). Nevertheless, they don't derive from this condition the requirement of dealing with the notion of downward causation. We think, however, that this is a missing piece in their argument, since DC is an inevitable consequence of the concept of irreducibility as non-deducibility, as we argue here.

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 behavior of those very same parts in isolation or as parts of different kinds of system. Furthermore, DC offers a possible explanation of how an emergent property can be irreducible and yet dependent on, and determined by, the micro-structure from which it emerges, as established by the notion of synchronic determination.

But then we have to face the legion of difficulties besetting the notion of DC. After all, DC has struck a number of thinkers as incoherent and paradoxical. Once more, we can mention Kim, who has repeatedly argued that the combination of upward determination (as in synchronic determination) and reflexive DC may threaten the very coherence of emergentism (*e.g.*, Kim 1992: 137; 1999: 25).

### 3. Synchronic and Diachronic Downward Causation

One of the basic distinctions regarding DC is that between synchronic and diachronic. In synchronic reflexive DC, a whole and its parts are involved in an instantaneous causal relationship:

> [Synchronic reflexive downward causation] At a certain time $t$, a whole, $W$, has emergent property $M$ where $M$ emerges from the following configuration of conditions: $W$ has a complete decomposition into parts $a_1 \ldots a_n$ ; each has Property $P_i$ ; and relation $R$ holds for the sequence $a_1 \ldots a_n$. For some $a_j$, $W$'s having $M$ at $t$ causes $a_j$ to have $P_j$ at $t$ (Kim, 1999: 29).

This kind of downward causation looks like a bizarre metaphysical bootstrapping phenomenon (Symons 2002). For instance, how could an organism by having a given property $M$ at $t$ really causes one of its constituents to have property $P_j$ at the same time $t$? By acting on a part of the very micro-structure by which it is synchronically determined, an emergent property would be changing its own basal conditions. But wouldn't this entail, then, that the identity of the emergent property would itself be changing, in such a way that it becomes, after all, impossible to understand what might be happening in such a case? The whole idea of synchronic downward causation seems, at first, to reduce to absurdity.

This circularity comes from the fact that causation, as typically understood, takes place over time and involves property changes that make 'self-causing' paradoxical – for instance, because of their transitivity. Taking into account that this picture is committed to the usual interpretation of 'causes' in terms of 'efficient causation', a possible way out of the bootstrapping problem might be to understand causation in a way which makes it encompass a wider variety of modes. We shall consider this possibility later. For the moment, let us discuss another way out of the bootstrapping problem.

An emergentist thinker might claim that the synchronic case is nothing but what Peirce (1955) called a 'strawman argument', an argument which is so weak that it is trivial to refute it. We can block this objection by discussing a second case, in which the part-whole relationship takes place over time:

> [Diachronic reflexive downward causation] As before $W$ has emergent property $M$ at $t$, and $a_j$ has $P_j$ at t. We now consider the causal effect of $W$'s having $M$ at $t$ on $a_j$ at a *later time* $t + \Delta t$. Suppose, then, that $W$'s having $M$ at $t$ causes $a_j$ to have $P_j$ at $t + \Delta t$ (Kim 1999: 29).

In the diachronic case, the problematic circularity discussed above is removed, but at the expense of the reflexive aspect of the causal relation at stake. The reason is shown by Kim's argument of causal/explanatory exclusion. Kim (1999: 24) derives a general principle, 'the principle of downward causation', from his arguments about inter- and intra-level causation in the context of a layered model of the world: To cause any property to be instantiated, you must cause the basal conditions from which it arises. When we consider that any higher-level property has, according to the supervenience concept, a supervenience base (or realizer) that is sufficient to bring about its instantiation, the problem of causal/explanatory exclusion enters the scene. Considering that for any single event there can be no more than a single sufficient cause, if both a higher-level property $Q$ and its physical supervenience base $P$ are sufficient causes of another physical property $P^*$ and, hence, of its supervenient property $Q^*$, one of them must be excluded from this causal picture. It is reasonable to claim that the role of $Q$ in the causation of $P^*$ (an instance of DC) should be preempted by $P$, so that we end up with the following picture: $P$ causes $P^*$, and $Q$ supervenes on $P$, and $Q^*$ supervenes on $P^*$. In this picture, causal processes at the micro-level are taken as fundamental and all events of macro-causation (including DC) are regarded as supervenient, or dependent, on micro-causation.

In short, cases of diachronic reflexive DC seem to easily reduce to supervenient causal relations, in which its aspect of reflexivity is lost. This picture poses a serious problem for the emergentist's interpretation of DC as a causal power that could change the behavior of lower-level entities and processes, since the causal powers instantiated at a higher level are taken to be, in the case of both same-level causation and DC, utterly derived from causal powers at the micro-level.

Given the problem of causal/explanatory exclusion, if an emergentist thinker wishes to insist on the idea of irreducible DC, a violation of the physical causal closure will seem to follow. The basic idea in this argument is that irreducible DC would be a causation of physical processes by 'nonphysical properties' (see Kim 1996: 232-233; Kim 1998: 44).[10]

If we intend to propose a coherent and plausible physicalist strong emergence theory, we must (i) either make sense of DC without committing ourselves to a violation of the causal closure of the physical domain, and at the same time avoiding the problem of causal/explanatory exclusion; or (ii) circumvent the incoherence in synchronic reflexive DC. Kim (1993: 356; 1998: 46) claims that the only plausible solution to the problem of DC would be some form of reductionism, allowing us to discard, or at least moderate, the claim that mental properties (on which his argument is focused) are distinct from their underlying physical properties. Then the result is, as shown by Kim's argument itself, the impossibility of postulating any new and irreducible causal powers at the higher level. DC is interpreted in Kim's arguments as a sort of efficient causation (El-Hani & Pereira 1999, 2000; El-Hani & Emmeche 2000), and, furthermore, the causes in DC are understood by him, following Sperry, as concrete, particular events (Hulswit, in press). These two features in Kim's account of DC can be put into question. One may explore, for instance, the possibility of interpreting DC as a type of causation other than the efficient causal mode. This is the move made by neo-Aristotelian accounts of DC. But let us first take a look at a recent argument for a coherent account of synchronic DC.

## 4. An Argument for Coherent Synchronic DC

The diachronic DC model doesn't fit at all the description of the kinds of phenomena that elicit the idea of 'downward causes' (Hulswit, in press). This is one of the reasons why authors dealing with DC often insist that it should be understood in terms of synchronic DC. Therefore, we will focus here mainly on the second horn of our description of the DC

[10] For a criticism of the interpretation of the term 'physical' in this claim, to the effect that the idea that DC would involve 'nonphysical' causes fails to grasp the thesis that all levels of reality are contained in a global physical level — *i.e.*, the thesis of the inclusivity of levels (Emmeche et al., 1997, 2000), see El-Hani & Pereira (1999, 2000) and El-Hani & Emmeche (2000).

dilemma, that is, we will search for ways of circumventing the incoherence in synchronic reflexive DC.

Symons (2002) developed an argument for a putative case of a non-contradictory synchronic relation between the causal behavior of parts and the emergent properties of the systems (wholes) including those parts. He assumes, first, an interpretation of causality in terms of probability and stresses that probability and structure are related notions. Basically, what he intends in his paper is to show that an interpretation of causes as objective probabilities allows one to see the structure of the whole as playing a role in shaping the causal powers of the constituents. Or, to put it differently, a probabilistic interpretation of causality would make it possible to imagine the structure as having an effect on the system's parts which is distinct from the causal powers of the latter. That is, Kim's causal inheritance principle, according to which the causal powers of a given property are merely a product of the causal powers of its basal conditions (Kim 1998, 1999), would not hold in the probabilistic case.

In order to make it clear the influence of an emergent property, more specifically, the property of a system's having a given structure, on a system's components, Symons (2002) asks us to consider the example of a dean at Harvard Law School telling the students to look to their left, and then to their right, and finally saying: "By the end of the year, one of you will not be here". Surely, this would be just a way of expressing the fact that there was a one-third attrition rate during the first year at that school. But Symons asks us to think about the dean's utterance as a graphic way of pointing out that 1 out of 3 people (33%) on average would have abandoned Harvard Law School by the end of the first year. Symons argues that his statement would have the unintended effect that students sitting at the ends of the rows would be more likely to drop the school than their neighbors. Then, he asks us to suppose that the seating arrangement at that occasion would be important to the outcomes of the dean's statement. A change in this arrangement would change the likelihood that specific students leave the school.

Considering, for the sake of the argument, that the dean's utterance played proxy for a law of nature, we can ask: What is the relationship between a student's chances of graduating and his location in the seating arrangement? Symons argues that, if the students are seated in a row, the students at the end of the row are less likely to graduate, but, on average, students have a 66% chance of making it through school. But suppose the students were seated in a circle. Then, he argues, the average chance of a student graduating would decrease to 50% simply by virtue of the structural or spatial relationship between them.

Symons uses this example in order to show that structural arrangements, as emergent properties, can have a significant effect on the causal powers of systems and their constituents, causally affecting them in a downward synchronic way. He admits, however, that this example is pretty contrived, since it relies on the specification of a hypothetical law of nature that already includes some consideration of structure (Symons 2002: 198). He characterizes the effects of structural arrangements on the causal power of systems and their components as 'constraints', interpreting them as general principles, and not as particular events, as in Kim's account. Finally, he claims that, in the context of a probabilistic interpretation of causality, the behavior of the components can be understood as altered or 'enslaved' by their participation in a given structure. These constraints on the components' behavior amount, on Symons' view, to a downward causal effect resulting from an emergent property, the structural arrangement of the system's components.

According to Symons, this is not a case of diachronic DC, but rather of an instantaneous, synchronic influence of the structure *qua* emergent property on its constituents. He argues that, in a probabilistic interpretation of causality, one can envision a meaningful sense in which a whole can act on its parts without becoming something other than itself. Thus, the incoherence shown by Kim in synchronic reflexive DC would be overcome. The basic argument is that, in the example sketched above, the properties of the parts that are being affected at *t* are not constitutive of the whole at time *t*. The change in the constituents' properties that takes place in the downward causal event is interpreted as a change in the probability that the students graduate or not at Harvard Law School. As Symons (2002: 200) summarizes: "… the structural property exerts a change on the causal power of the parts, but a funny kind of change, namely a change in their potential for behavior in the moment immediately following their entry into the whole."

It is not clear whether and how the alteration or 'enslavement' of the components due to the influence of a structural arrangement can be conceptualized as the effect of an efficient cause. Alternatively, we might understand such an influence in terms of another causal mode. But, then, we should ask which causal mode might be adequate to understand the sort of structural effect at stake in Symons' arguments.[11] Symptomatically, he

[11] We may ask, in a similar way, what do other authors which discuss DC, such as Stephan (see, for instance, his 1998: 644) and O'Connor (1994: 103, note 18), exactly mean by appealing to other

acknowledges that his arguments raise far more questions than they answer. Nevertheless, we consider that they do offer an interesting starting point for developing an argument for a kind of synchronic DC that does not fall prey to the bootstrapping problem.

**5. Neo-Aristotelian Approaches to DC**

Symons seems to be on the right track in his arguments about DC. Nevertheless, several issues remain to be clarified in his account, and, indeed, a number of authors before him tried to elucidate some of these issues. We will discuss some of them when we address Hulswit's critique of recent attempts to solve the problem of DC. In this section, we will address the following problem: what does it mean, precisely, to claim that the structure of a system, as an emergent property, changes the causal powers of the components by 'enslaving' them?

To answer this question, a good starting point lies in Emmeche, Køppe, and Stjernfelt's (2000) systematic analysis of different notions of DC, in which they advance an Aristotelian understanding of causality as a way of grasping the nature of the influence of wholes over their parts.[12] They identified three versions of DC, each of them making use of a particular way of interpreting the causal mode (or modes) involved in this sort of causation: 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, to claim that a higher level exerts an efficient causal influence over a lower one, we need to postulate a sharp distinction between these two levels, regarding them ultimately as being constituted by different kinds of substances (Emmeche et al. 2000; El-Hani & Videira 2001; Hulswit, in press). In other words, strong DC demands an acceptance of substance dualism, and, thus, it is blatantly incompatible with a scientific understanding of emergence. Moreover, this notion faces other important difficulties, such as the bootstrapping problem discussed above. Therefore, Emmeche and colleagues (2000) rightly emphasize that there are only

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'types of causality' in their arguments? On our view, this is precisely the sort of clarification that neo-Aristotelian approaches to DC intend to offer.

[12] Other authors also take Aristotelian causal notions as an inspiration to think of causal processes in biological and other complex systems, as, for instance, Salthe (1985, 1993), Rosen (1991), Riedl (1997), Van de Vijver et al. (1998), Ulanowicz ([1999]2000), El-Hani & Pereira (1999, 2000), El-Hani & Emmeche (2000), El-Hani & Videira (2001). In this connection, we can also refer to Putnam's (1994, 2000) claim that a return to Aristotle can be a fruitful approach in the philosophy of mind.

two viable candidates for a scientifically acceptable account of DC, both committed 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 "factors of selection" 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" – lawlike 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", 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, or, else, a higher-level entity should be regarded as a "real substantial phenomenon" in its own right. (vii) This interpretation of DC may assume either a thesis Emmeche and colleagues call "formal realism of levels", 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 they designate as "substantial realism of levels", claiming that a higher-level entity is defined by a "substantial difference" from lower-level entities. The difference from strong DC is said to lie in the necessary commitment, in this position, to the thesis of a "substantial realism of levels".

In turn, Emmeche and colleagues' 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", 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) By employing phase-space terminology, Emmeche and colleagues 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, i.e., the attractor functions as a "whole" at a higher level affecting the processes that constitute it. (vii) 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 basis are tokens.

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 some advance in organizing the variety of such accounts. As Hulswit (in press) sums up, Emmeche and colleagues made "… a valiant attempt at creating some order in the conceptual chaos that characterizes the discussion regarding downward causation".[13] Nevertheless, their typology faces a number of problems. It is not really something surprising. After all, many attempts to explain DC available in the literature are confronted with important difficulties. In the case of Emmeche and colleagues' arguments, in particular, the distinctions between strong, medium, and weak DC should be further clarified. For instance, it seems necessary to describe 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. But we will not try here to classify our account in terms of Emmeche and colleagues' typology. We will rather concentrate on explaining how we conceive the relationship between DC and constraints.

To explain the relationship between DC and constraints, we can begin by considering that, when lower-level entities compose a higher-level system, the set of possible relations among them is constrained, as the system causes its components to have a much more

[13] One of the authors of the present paper (C. N. El-Hani) was greatly influenced by Emmeche and colleagues' treatment of DC, discussing it in several papers (El-Hani & Pereira 1999, 2000; El-Hani & Emmeche 2000; El-Hani & Videira 2001; El-Hani, 2002a).

ordered distribution in spacetime than they would have in its absence. This is true both in the case of entities or processes, since processes also make the elements involved in it 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 basis for a concept of irreducibility based on the non-deducibility of the components' behavior. As we saw above, while discussing Symons' arguments, we can plausibly argue that lower-level entities are 'enslaved' by a particular pattern of constraints established by the higher-level structure in which they are embedded, so that their relations to each other are modified, and, consequently, their causal powers. We are dealing, then, with higher-level constraints on the components' relations which results from the fact that the components are part of the space-time form, or pattern, of the system's structures and processes. We can conceptualize, then, the *modification* suffered by the system's parts as a *constraint resulting from being part of a (spatio-temporal) pattern*. This modification is not the same as an effect in an efficient causal event. It should be rather thought of as the consequence of a multinested series of constraints on the possible interactions of the components (Emmeche et al. 2000).

Then, we can arguably interpret DC as a formal cause by basically recasting the notion of higher-level 'constraints' (or 'constraining conditions') 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).[14] A given set of constraining conditions acting on the parts of a given whole can be interpreted, in a neo-Aristotelian approach to causality, as an instance of formal causality.[15] Moreover, we can interpret the specific functions that many components come to perform while their relations are constrained within a given higher-

[14] Notice that a case can be made for sticking to the vocabulary of constraints without introducing a potential source of contention such as the Aristotelian formal causal mode. We will come back to this possibility later. For the moment, consider that it is quite natural that, since the problem we are dealing with concerns causation, it seemed worth exploring, for a number of authors, the consequences of recasting the treatment of constraining conditions in terms of formal causal influences of wholes over parts. Nevertheless, we should not lose from sight that the very difficulties faced by the concept of DC, which are indeed the main motivation for emergentist thinkers to seek new ways of understanding causality, can be seen as an evidence that causality is the wrong issue when it comes to emergence (at least in some domains. See Pihlström 2002) and, generally speaking, complex systems (see Van de Vijver et al. 2003).

[15] Emmeche and colleagues (2000: 7) characterize formal causality as corresponding to the form or pattern into which the component parts of a given entity or process are arranged. This is entirely compatible with Aristotle's definition of the formal causal mode: "A second way in which the word [cause] is used is for the form or pattern (i.e. the formula for what a thing is, both specifically and generically, and the terms which play a part in the formula" (*Physics* II.3, 194b26-28. Aristotle 1996: 39).

level structure (contributing to the dynamical stability of the system itself) in terms of a 'functional causality'.[16]

The notion of 'boundary conditions', introduced by Polanyi (1968), is useful for characterizing these higher-level constraints (see also van Gulick 1993). Polanyi 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 is consisted by 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.

To explain further the ideas of constraint and boundary conditions, we can argue that, as the parts of a system are 'enslaved' by a particular pattern of constraints which is characteristic of that kind of system (assuming, for the sake of the argument, that a clear scheme for classifying systems is available), they partly lose, so to speak, their 'freedom' to behave, while the system, conversely, acquire more freedom to behave precisely by coordinating the behaviors of its components. Consider, first, a set $W$ of all possible behaviors the constituents of a system may show. The boundary conditions established by the system's organization select, among all the possible behaviors the constituents might show, a more limited set ($W - x$) of behaviors they will effectively show, as parts of that kind of system.[17] In turn, by constraining the behaviors of its parts, the system shows

[16] Emmeche and colleagues (2000: 17) substitute a new notion of causality, 'functional causality', for the original meaning of the Aristotelian 'final causality', describing it as amounting to the role played by a part in an integrated processual whole, or the purpose of a behavior as seen from the perspective of a system's chance of remaining stable over time. Aristotle characterized the final causal mode as a way of specifying the cause "in the sense of end or that for the sake of which a thing is done [...]. The same is true also of all the intermediate steps which are brought about through the action of something else as means towards the end [...]" (*Physics* II.3, 194b32-35. Aristotle 1995: 332-333). Given the ongoing debates concerning the relations between the concepts of 'function', 'teleology', and 'finality', and their explicit intention of reinterpreting Aristotle's causal modes in the light of contemporary theoretical frameworks, it is understandable that Emmeche and colleagues preferred to avoid either identifying 'function' with the Aristotelian 'final cause' or using the notion of finality at all.

[17] In fact, a model for explaining emergence needs to consider not only boundary conditions established by a higher level – in relation to the level in which a given emergent property or process is instantiated ( we can call it, following Salthe (1985), 'focal' level) –, but also initiating conditions described at a lower level. As Salthe (1985: 101) argues, 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", but "what actually will emerge will be guided by combinations of boundary conditions imposed by the next higher level". This entails the necessity of explaining emergence in the context of a model comprising three, and not only two levels. The

enhanced capacities, in the sense that it becomes capable of displaying behaviors we would not observe if the system didn't constrain them, and, thus, coordinate (orchestrate) the processes which take place within it. Constraints increase the likelihood that the parts of a system be engaged in relations which, in turn, are embedded in a certain set of particular processes which is smaller than the set of processes they could be part of in the absence of the system. And, in turn, the instantiation of these processes in a coordinated manner allows the system to show novel higher-level behaviors, increasing its 'freedom' to behave.

The interpretation of DC as a formal cause, in terms of higher-level constraining conditions influencing the behavior of a system's components, has an additional bearing on current debates about emergence. A downward causal influence is usually ascribed to emergent properties in a rather general way, i.e., each and every emergent property is supposed to exert such an influence on the microstructure. Emergentist thinkers usually claim that emergent properties, in such a general sense, bring into the world new causal powers of their own and that those properties have powers to influence and control the direction of the lower-level processes from which they emerge (cf. Kim 1998: 100; 1999: 6/22). But, in the interpretation of DC presented above, a specific kind of emergent property is supposed to exert a formal influence over a system's parts, namely, the property of a class of systems $\{Z\}$ having a given kind of structure $S$. This is an important outcome of Emmeche and colleagues' treatment of DC: downward macrodetermination should be thought of as stemming from the structure of systems, as a particularly important emergent property.[18] It is worth stressing the primary role of structures in downward causation for several reasons, most importantly, because the downward influence of systems' structures

reason why our arguments throughout this paper will consider only two levels lies in the fact that our problem here is that of explaining DC. A development of a model in three levels to explain the emergence of a particular kind of process – namely, sign processes – can be found in Queiroz & El-Hani (2005).

[18] It is possible that the characterization of the structure of a system as an emergent property gives room for confusion, since we mentioned above the relationship between emergent properties and the microstructure of systems. It is important to avoid losing from sight, however, that the structure (even though referred to as 'microstructure', to stress its role as a realizer of a given emergent property) is itself a systemic property (see Kim 1998). Maybe a good way of avoiding this confusion is to dispense with the term 'microstructure', notwithstanding its currency in contemporary philosophy of mind. We can think of the situation as follows: the structure of a system is a macroproperty, which is realized by a set of relations among the components of the system, at the lower level. This macroproperty, in turn, has a downward formal influence over the components, creating a condition in which they can produce other emergent properties, at the systemic level.

on their components plays a crucial role in the explanation of other emergent systemic properties.

This explanation of DC can arguably provide appropriate grounds for understanding in what sense parts and wholes can be involved in mutually determinative relations. Synchronic determination, as a determinative upward relation, is combined in this account with a determinative downward relation. In these terms, the codetermination of parts and wholes would be grounded in the conjunction of two distinct asymmetric determinative relations, synchronic determination and DC. The putative incoherence of combining upward and downward determinative relations, rightly pointed out by Kim in a causal structure admitting only efficient causal relations, would be avoided, in the present case, by the use of a richer array of causal concepts.[19]

## 6. A Critique of Neo-Aristotelian Approaches to DC

Nevertheless, we can put into question, as Menno Hulswit did in a recent paper, whether neo-Aristotelian accounts of downward causation satisfy basic requirements for a theory of causation. Hulswit (in press) focuses his critique on two questions: (i) What sort of things are said to be causing and caused in the case of DC? (ii) What is the meaning of 'causing' in DC?

He concludes that the concept of DC is 'fuzzy' with respect to the nature of causes and effects and 'muddled' as regards the meaning of causation. Regarding the first problem, we should take into account a distinction found in the literature about DC between two types of 'downward causes': general principles and particular events or substances. In his original formulation, Donald T. Campbell (1974) interpreted 'downward causes' as general principles, in the sense that, say, the behavior of a molecule inside a cell is not only determined by physical-chemical laws, but it is also constrained by the 'laws' (in the very broad sense of 'general disposition') of the higher levels. Thus, in Campbell's account, the

[19] A fully developed argument about the prospects of assuming both synchronic and downward determination in a coherent emergentist account also demands a claim about the mode of irreducibility one should ascribe to emergent properties. We will not develop this argument here, but we refer the reader to another paper in which we argue that synchronic determination creates problems for a specific mode of irreducibility, particularly popular in the philosophy of mind, namely, irreducibility as unanalyzability, but not for the mode of irreducibility indeed related to DC and more relevant to the natural sciences, irreducibility as non-deducibility of the behavior of a system's parts (see El-Hani & Queiroz 2005).

causal relata in DC are concrete *processes* (effects) at the lower level and *laws* or *lawlike general principles* (causes) at the higher level.

As explained above, it is in that sense that the higher-level organizational principles constrain lower-level processes.[20] This is consistent with Polanyi's (1968) interpretation of boundary conditions as higher-level general principles that control lower-level processes. As Hulswit (in press) summarizes, Campbell, Polanyi, and, also, Van Gulick (1993) understand DC as "… a selective activation of lower-level causal processes by higher-level boundary conditions, which basically are general principles." Moreover, he takes this position to mean that "downward causes' are not *causes in the strict sense* but general principles". This has important bearings on a claim we will advance below, namely, that the influence of a system over its components is better understood in terms of other kinds of determination, rather than in terms of a causal determination.

It is particularly important to avoid – as we explicitly do in this paper – an interpretation of 'downward causes' as particular events, as we find, for instance, in Roger Sperry's (1969, 1980, 1983, 1986, 1991) and Kim's accounts.[21] Even though the bootstrapping problem does not disappear if 'downward causes' are interpreted as general principles, we can say that it certainly becomes worse when the causal relata in DC are taken to be particulars at different levels of organization.

Hulswit (in press) also argues that the meaning ascribed to the term 'causation' in debates about DC usually refers to ideas closer to 'explanation' and 'determination' than to 'causation', provided we understand causation in the intuitive sense of 'bringing about', *i.e.*, in the current sense of efficient causation. Not surprisingly, he considers the expression 'downward causation' badly chosen. Even though one of the authors of the present paper has argued in previous works for a neo-Aristotelian interpretation of DC, we should stress we basically agree with Hulswit's conclusions. In fact, his paper reinforced our conclusion that the idea of downward determination was better than that of DC and added to our motivation to make the move summarized in the present paper.

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[20] Despite some ambiguities one finds in papers advocating neo-Aristotelian approaches to DC, a basic idea in interpreting DC as a kind of formal cause is to understand it in terms of general principles.

[21] We should not neglect the fact that Sperry provides most of the standard examples of downward causation considered in Kim's works. Thus, Kim's understanding of DC as involving concrete events as causes is certainly strongly influenced by Sperry's view. Thus, we can even say that at least some of the flaws Kim finds in the concept of DC can be traced back to problems which are specific of Sperry's position.

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’ (in the sense of ‘bringing about’), they are certainly not equivalent to ‘causing’ (Hulswit, in press). 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, came to be included in the meaning ascribed to the term ‘cause’ in most modern languages. Symptomatically, the Greek word translated as ‘cause’ (*archai*) in Aristotle’s works does not mean ‘cause’ in the modern sense (Ross [1923]1995: 75; Lear 1988: 15).[22] 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. In other terms, to refer to Aristotle’s *archai* as ‘causes’ is very misleading; they should be rather treated as ‘principles’. It is in this sense that Aristotle can conceive matter and form as also having the nature of ‘causal’ modes – in terms of his material and formal causal modes. It is not surprising, then, that, if we stick to our currently intuitive ideas about causation, Aristotle’s causal modes are more similar to modes of explanation than to modes of causation. Aristotle seemed to be thinking mainly about the grounds for our understanding, while pondering about causal modes.

It would be possible to use the above claims as a ground for counteracting Hulswit’s arguments. But we do think he pointed out important limitations in recent accounts of DC, and we will rather employ these claims as a basis for combining Hulswit’s ideas with some tenets advanced by those accounts. Indeed, DC, as explained by neo-Aristotelian approaches, is closer to ‘determination’ than to ‘causation’. But how should we understand the relationship between the higher-level ‘activities’ usually related to DC and the meaning of ‘causing’? It seems to us that the important relation between the ideas usually connected to DC in neo-Aristotelian accounts and the basic ideas involved in causation concerns the fact that, in both cases, 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

[22] Translated into Latin, *archai* turned into *causae*, which in turn was translated into English as ‘cause’ (and, equivalently, in the case of other languages).

otherwise' or, to put it in terms more consistent with probabilistic events, 'it would not tend to be otherwise') while the latter primarily involves the idea of 'bringing about'. We would like to invite our readers, then, to consider three issues: 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 individual entities (usually events, facts, or substances), and 'downward causes' are more properly interpreted (in our view) as general, lawlike organizational principles[23]; and, third, that a similar move has been made in the case of another determinative but mereological relation, namely, physical realization (and, consequently, supervenience), that cannot be properly accounted for as 'causal' (see Kim 1993, 1996).

We will be able to see, then, how proper it may be to advance the claim that it would be better to refer to downward (formal) determination, rather that downward causation: "… so-called 'downward formal causation' is neither a species of downward *causation*, nor of downward *explanation*, but […] it is first and foremost a species of *downward determination*" (Hulswit, in press. Emphasis in the original). Instead of proposing that an understanding of the influence of wholes over parts demands causal categories other than efficient causation, we can rather claim that such understanding requires kinds of determination other than just causation. In fact, causes are not the only sort of determining factors in the world and, in fact, it is largely accepted in other current philosophical debates, such as those about supervenience, the introduction of non-causal determinative relations.

## 7. From Downward Causation to Downward Determination

The Aristotelian formal cause intended to explain the stability of the world in terms of the structure of things. Accordingly, it is strongly committed to an ontology of substances. One may say, however, that the current revision of the theoretical framework employed to understand complex systems and phenomena which stems from ideas such as those of self-organization, emergence, complex networks, fractal patterns, etc., can be more fruitfully pursued inside a framework in which the stability of the world is rather explained in terms of dynamic relationships between events (*e.g.*, Hulswit, in press). This explanation, in turn, should be embedded into a process philosophy, i.e., a philosophical

[23] For this reason, Campbell (1974) himself remarked that the expression 'downward causation', which he was the first to explicitly use, is 'awkward'.

tendency of treating processes as being more fundamental than entities as ontological categories. A process can be defined 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: 38). To give ontological primacy to coordinated, organized family of occurrences clearly contradicts the priority historically given to entities in most of the Western thinking, substantially influenced by Aristotelian philosophy. But such a disagreement can be seen as part of a criticism of the 'substance paradigm' or 'myth of the substance' (Seibt, 1996) which has been put forward by a number of thinkers, such as Alfred N. Whitehead, Charles S. Peirce, Charles Hartshorne, Paul Weiss, Samuel Alexander, Conway Lloyd Morgan, and Andrew Paul Ushenko (see Rescher 1996, 2002).

It is not that process philosophy should necessarily claim that the idea of entities has to be abandoned. It is only that, when considering entities, we should always bear in mind that processes should be treated, in a dynamical world, as more fundamental than entities, since "… substantial things emerge in and from the world's course of changes" (Rescher 1996: 28). Or, to put it differently, entities are just relatively stable bunches of processes, which emerge from processes and subsequently vanish into processes.

As Hulswit (2001) argues, a Peircean process and semiotic approach to causation can play an important role in the construction of a process philosophical approach that aims at explaining the stability of the world in terms of dynamic relationships between events, since it includes an idea of forms as having a relational nature, and not as something embodied in a substance. This is one of the motivations behind our appeal to Peirce's philosophy in order to advance in the treatment of downward determination.[24]

Here, when we consider a system *A* and a set of *B*-elements that constitute *A*, we will say that the behavior of the *B*-elements is *partly determined* by *A*. This is a stronger claim than the assertion that the behavior of the *B*-elements cannot be adequately *explained* without a reference to *A*. Our ideas about determination certainly have consequences for explanatory endeavors, but it is necessary to formulate the basic ideas in a stronger sense, related to the idea of determination itself, and then subsequently derive epistemic consequences, such as those regarding efforts to explain part-whole relationship in complex systems.

[24] For a defense of a process approach to emergence, see, for instance, Bickhard & Campbell (2000).

The claim that the behavior of the *B*-elements is *partly determined* by *A* is, in turn, weaker than the assertion that the behavior of those elements is partly *brought about* by *A*, since this would commit us to an idea of 'cause' in the sense of efficient causation.

If we intend to develop a theory about downward determination, we should answer the following two questions: (i) What sorts of 'things' are said to be determining and determined in a case of downward determination? (ii) What is the meaning of 'determining' in downward determination? We intend to develop a coherent account about how principles of organization constrain, and, thus, *partially determine* the behavior of a system's lower-level constituents. In this account of downward determination, a higher-level organizational pattern, interpreted as a general principle or disposition, is the determiner, while lower-level particular processes are determined.

Finally, we should ascribe a clear meaning to the notion of 'determination', distinguishing between causal and other kinds of determination, particularly, that one we take to be involved in downward determination. We will take Peirce's philosophy as a starting point to deal with this task.

It is very interesting to discuss the problem of downward determination in the context of Peirce's philosophy, since, as Hulswit (in press) stresses, 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 will still be 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. And, as we argued above, this approach demands an ontological framework that breaks through the constraints imposed by the Western 'substance addiction', doing full justice to the primacy of processes and events, along the lines suggested by process philosophers, such as Peirce.

According to Ransdell (1983: 23), the notion of determination, in the context of Peirce's philosophy, carries a logical and a causal sense. If we regard it dynamically, it will be associated to the idea of production of an effect. In this sense, we are dealing with causal determination, in the intuitive sense of 'bringing about', elaborated in the modern theory of causality in terms of efficient causation. If we consider the logical sense of determination, it will be related to material implication: if *p*, then *q*. In this sense, 'determination' should be understood as a constraining rather than a causally deterministic process.

At first, this seems to lead us from ontological to logical and/or epistemological discourse. But we should not forget that, in the light of Peircean pragmatism, the logical structure of thought, rules, and generals is the same (Hulswit, 2001). Peirce wrote, for instance, that "nature only appears intelligible so far as it appears rational, that is, so far as its processes are seen to be like processes of thought" (Peirce, CP 3: 422). Moreover, for Peirce, generals were not abstractions of the thinking mind, but real features of the world. Peirce was not a nominalist, but a realist. We can say, thus, that Peirce was likely to agree with a hypothesis similar to Emmeche and colleagues' (2000) 'formal realism of levels', 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.

As we argued above, downward determination does not have a causal nature, it does not concern productive events, which bring about an effect. To expand on this issue, we can take as a point of departure the idea 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 will argue that a logical determinative relation holds between higher-level organizational principles and particular processes at the lower level. Nevertheless, in order to allow for statistical relationships between organizational principles and particular processes, we will treat this determinative influence as a propensity relation: if some lower-level entities $a,b,c,\ldots,n$ are under the influence of a general organization 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 organization principle on particular lower-level processes, and can be framed as follows: if $a,b,c,\ldots,n$ are under the influence of $W$, then they will show a *tendency*, a *disposition*, to instantiate process $p$. In other terms, we treat here the relation of implication, $p \rightarrow q$, as a 'would be tendency', as a relation leading to a higher likelihood that a given process happens.

We understand downward determination, thus, in terms of a probabilistic approach. Or, to put it differently, we consider that a general organizational principle, $W$, makes the occurrence of a given process, $p$, more likely than if the components of this process were not under the influence of $W$. A general organizational principle, $W$, can be said to be a logical determinant of a given process, *p*, if, given the instantiation of *W*, the probability of the occurrence of *p* is higher than the probability of its occurrence would have been if *W* had not been instantiated.

The difference between causal and logical determination is striking: while causal determination is a *productive* event, which brings about effects, logical determination is rather a *subtractive* event, which, as explained above, constrains the possibilities of behaviors of the components of a system. It rather eliminates possible effects than produces new effects, and, by doing so, makes it possible that a system as a whole show an enhanced set of capabilities, due to the coordination of the behavior of its parts. Moreover, it is consequential that the constraints imposed by a system's organizational principles on its parts don't have only a negative effect on the latter, but also a positive one, since they enable the parts to efficiently take part in a set of processes, by channeling their behavior, so to speak, towards a particular collection of activities.

Certainly, this can be framed as a sort of formal or structural determination, making this approach relatively close to the neo-Aristotelian perspective on downward causation, with the caveat that we shall rather refer to downward determination and embed this notion within a process-oriented approach – which is at odds with an Aristotelian view, which shows a clear bias in favor of entities and substances.

## 8. Concluding Remarks

It is quite clear to us – as it certainly is for our readers – that the idea of downward determination sketched above demands further work in order to be formulated in a clear and fruitful way. Our current research goes in this direction, and our next steps will be: (i) to develop this explanation of downward determination by means of a biological example, the initiation of signaling processes in a particular class of micro-domains in the cell membrane, called 'lipid rafts'; (ii) to elaborate a full-blown argument for a coherent emergence account combining synchronic determination, downward determination, and a notion of irreducibility as the non-deducibility of the behavior of a system's parts.

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