The Metaphysics of Downward Causation: Rediscovering The Formal Cause

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> (…) for the good and the beautiful are the beginning
> both of the knowledge and of the movement of many things.
>
> Aristotle, *Metaphysics*, 1013a 22-3

Introduction

The ongoing battle against the reductionism of science over the last few decades has already brought many important changes in the scientific paradigm. Those changes are probably most transparent in biology, as it is concerned, by definition, with complex structures of living organisms. The rapid development of biochemistry and molecular biology has led some scientists to believe that their reductionist approach will prove to be the only valuable and truly 'scientific' method of biological research. Contrary to these expectations, our ability to enter the molecular level of organisms and biochemical processes has opened us to an incredible complexity of the structures, processes and patterns of living organisms, and thus challenged the reductionist paradigm. The intrinsic interrelatedness of different components of natural processes, such as metabolic or cell signaling networks, and their influence on the behavior of organisms, have led many bio-scientists not only to distinguish between various levels of organization of matter in biology, but also to propose a more holistic account and methodology in the sciences. This is precisely the approach of systems biology, which introduces the concepts of emergent properties and downward causation.

This methodological nonreductionism of contemporary biology opens an interesting discussion on the level of ontology and the philosophy of nature. For it turns out that the theory of emergence (EM), and downward causation (DC) in particular, have some crucial ontological implications. What we face today is a new opening for arguments challenging not only methodological, but also ontological and causal reductionism.

However, the whole discussion is complicated and nuanced, requiring a careful philosophical analysis before formulating any general conclusions.

This article will concentrate mainly on philosophical aspects of emergence and downward causation. At first, we will present a general definition of emergence, with a special emphasis on the role of DC of emergent properties as a crucial aspect for the whole idea of EM (chapter 1). The main part of the article will be devoted to the problem of metaphysics of DC. In the second chapter we will examine the positions of those who seem to understand DC in terms of efficient causality. A question regarding their understanding of a cause, things being caused, and the nature of DC, will be asked. The problems of circularity and incoherence, and their possible solutions, will be addressed. The issues of nonreductive physicalism and the problem of the violation of underlying physical laws will be examined as well. In the third chapter we will refer to those thinkers who perceive DC as an argument against causal monism in sciences. Possible ways of a retrieval of the Aristotelian formal cause and a new understanding of DC will be analyzed. Finally, we will try to name the challenges faced by those who want to follow this new Aristotelian interpretation of DC.

1. Defining Emergence

The history of the development of the concept of emergence goes back to the 19th century. Achim Stephan locates its beginnings in the philosophy of J. S. Mill (1843) and G. Lewes (1875) who analyzed the so-called 'compositions of causes' and introduced the concept of emergent effects. After several decades, at the beginning of the 20th century, emergentism reappeared in the philosophy of biology, in opposition to vitalism and mechanistic reductionism. Its major proponents: Samuel Alexander (1920), C. Lloyd Morgan (1923), and C. D. Broad (1925), were called 'British Emergentists' (Stephan 1992, 25-6). The third phase of the debate on the concept of emergence brought much criticism and skepticism about its relevance, due to the anti-metaphysical agenda of logical positivism and analytical philosophy, in the middle of the 20th century, in both continental and American contexts. The fourth phase and the revival of emergentism coincides with the debate on the mind-brain problem, and contributions to this debate brought by Mario Bunge (1977), Karl Popper (1977), Roger Sperry (1980), and J. J. C. Smart (1981), in particular. To all phases listed by Stephan we should add the fifth, current phase, which – besides the continuing research in brain studies – includes the discovery and description of emergent properties in other parts of molecular and systemic biology. Besides this, the contemporary research in emergent studies has been recently enriched by an important analysis of new philosophical and theological implications of EM.[1]

This pluralism of different realms of science and knowledge referring to the concept of EM brings a pluralism of definitions and classifications of different types of emergent properties. Moreover, philosophical analyses and definitions of EM differ remarkably from the scientific ones. The former examine more speculative, ontological and causal dimensions of the concept of EM, whereas the latter search for practical examples, limiting theoretical discussion to a minimum.[2] Following the first, more theoretical and speculative path, we will now try to list the most important philosophical characteristics of EM, in order to locate the idea of DC in the broader context of the complex definition of EM, and to show its central meaning for the very doctrine of emergentism.

1.1. Emergence of Complex Higher-Level Entities

The first characteristic of EM is thus defined by Jaegwon Kim: "Systems with a higher-level of complexity emerge from the coming together of lower-level entities in new structural configurations (the new 'relatedness' of the entities)" (1999, 20). What is important and emphasized by many authors, is that, thus understood, emergentism strives to follow the rules of physical monism, which assumes that all natural phenomena are explainable in terms of fundamental physical laws and structures. In other words, emergence needs to be physically grounded. This ultimate physicalist ontology underlies

[1] Philosophical aspects of EM will be discussed in present article. Its theological implications are presented and analyzed by Philip Clayton (2006), Michael Dodds OP (2012), Niels Henrik Gregersen (2006a, 2006b, 2007), John F. Haught (2006), Arthur Peacocke (2006, 2007), and William R. Stoeger SJ (2007).

[2] As an example, one can compare the following philosophical fourfold definition of EM presented in this chapter, with the one formulated by a biological anthropologist Terrence Deacon (2006, 122), who simply defines EM as "unprecedented global regularity generated within a composite system by virtue of the higher-order consequences of the interactions of composite parts."

especially the position of nonreductive physicalism, which is strikingly close to the theory of EM, often using the same language and argumentation (Kim 1992, 128-33).

When speaking about EM in terms of new structural configurations and a new relatedness of emergent entities, Kim introduces the concept of levels of complexity. Claus Emmeche, Simo Køppe, and Frederic Stjernfeld offer an important attempt at ontological specification and classification of levels. The physical interdependence of levels is described ontologically as their 'inclusivity'. The higher level being materially related to the lower one, does not violate its laws, but at the same time cannot be simply deduced from it. In this way, emergence avoids both dualism and eliminativism. In terms of ontological priority and posteriority, Emmeche *et al*. thus describe the status of higher and lower levels:

> [A] rational idea of levels must entail that the more basic levels are basic in the sense of the word that they are presupposed by the higher levels - but the word "basic" does not entail any ontological priority. The higher levels are as ontologically pre-eminent as the lower ones, even if being presupposed by them, that is, they are defined by properties by special cases of the lower levels. In this respect, levels are ontologically parallel, but non-parallel in so far as they coexist (1997, 96, 105-13).

Emmeche *et al.* propose a basic classification of levels. They distinguish four 'primary levels': the physical, the biological, the psychological, and the sociological, suggesting that each one of them can be a base for various sublevels. For instance, the biological level can contain: the cell, the organism, the population, the species, and the community sublevels. They also clarify that the inter-level relations are 'nonhomomorphic'

> in the sense that the emergence of the biological from the physical level does not have the same complex of inter-level relations of dependence as the emergence of the social and psychic levels from the biological one, due to the continuous mutual conditioning and interdependence between emergent psyche and sociality (2000, 15).

Although the ontology of levels proposed by Emmeche *et al.* brings some important clarifications, Jaegwon Kim asks further questions concerning ontological levels that still remain unanswered:

> [H]ow are these levels to be defined and individuated? Is there really a single unique hierarchy of levels that encompasses all of reality or does this need to be contextualized or relativized in certain ways? Does a single ladder-like structure suffice, or is a branching tree-like structure more appropriate? Exactly what ordering relations generate the hierarchical structures? (1999, 20).

1.2. Emergence of Higher-Level Properties

The second characteristic of EM says that "All properties of higher-level entities arise out of the properties and relations that characterize their constituent parts. Some properties of these higher, complex systems are 'emergent', and the rest merely 'resultant'" (Kim 1999, 21) The idea of this central component of emergentism goes back to the philosophy of J. S. Mill and G. H. Lewes, who proposed a distinction between the effect of many causes being an algebraic or vector sum of the effects of each one of them (a homeopathic causal law), and the effect of many causes that cannot be summarized in this way (a heteropathic causal law). The former is the case of a resultant effect, while the latter definition describes an emergent property (Stephan 1992, 27-8).

Jaegwon Kim notices that this characteristic of EM is related to the concept of supervenience (SUP), which simply states that the higher-level properties of a system occur only if appropriate conditions are realized on the lower-level. When describing SUP Kim lists three putative components of supervenient properties: covariance, dependency, and nonreducibility. He shows that covariance (indiscernibility in respect to the base properties entailing indiscernibility in respect to supervenient properties) is metaphysically neutral, whereas dependence suggests an ontological and explanatory directionality. Both are needed in order to describe supervenient relations. In addition, he refers to nonreducibility of the supervenient properties. They cannot be simply educed from their base properties. Because SUP is related to EM, nonreducibility is also an important characteristic of the latter.[3]

1.3. The Unpredictability and Irreducibility of Emergent Properties

"Emergent properties are not predictable from exhaustive information concerning their 'basal conditions'. In contrast, resultant properties are predictable from lower-level information" (Kim 1999, 21). Kim distinguishes here between 'inductive' and 'theoretical' predictability. Knowing from experience (empirically) that the property *E*, emerged from a certain lower-level property *M*, of a system *S*, at the time *t*, we are able to predict and formulate a general emergent law, which says, that whenever the system *S* instantiates the base condition *M*, the emergent property *E* will appear as well. This 'inductive' predictability differs from the 'theoretical' one. No matter how accurate and detailed our knowledge of *S* and *M* is, we cannot theoretically predict *E*. This unpredictability, says Kim, is due to either our not having the concept of *E*, before it actually occurs, or some possible changes in the microstructure of *M,* which, transforming it into *M**, will cause the emergence of *E**, instead of *E* (Kim 1999, 8-9).

The rule of irreducibility can be thus formulated: "Emergent properties, unlike those that are merely resultant, are neither explainable nor reducible in terms of their basal conditions" (kim 1999, 21). Departing from the classic intertheoretical Nagelian reduction, which requires the use of 'bridge laws', Kim proposes a functional model of reduction, which consists of three steps: 1) *E* must be 'functionalized', that is it has to be construed or reconstrued as a property defined by its causal/nomic relations to other properties of *S*; 2) *E* must have its realizers among the properties of *S*, in other words, a property *M*, needs to be found, that instantiates *E*; 3) A theory needs to be found, which explains how realizers of *E*, perform their causal task. Kim shows that functionalization of a property is necessary and sufficient for reduction. As irreducible, an emergent property

[3] Kim says that it is best to separate the covariation element from the dependency in SUP, because it helps to understand that the covariation alone does not entails dependency. For him the question of what must be added to covariation to yield dependence remains an interesting and deep metaphysical question (1990, 5-23).

E, is neither predictable nor explainable on the basis of properties of a given system *S* (1999, 9-18).

1.4. The Causal Efficacy of the Emergents

Any description of a property at any level of organization of matter cannot ignore the question of the causal contribution to ongoing processes of the world. That is why, after describing basic characteristics of emergent properties, Kim asks one more question, namely what they can 'do', after having emerged. For without any causal powers emergent properties would simply turn out to be epiphenomenal, and – as Samuel Alexander says – "undoubtedly would in time be abolished" (1920, 2:8). Addressing this question, Kim defines the last important feature of emergentism: "Emergent properties have causal powers of their own – novel causal powers irreducible to the causal powers of their basal constituents" (Kim 1999, 22). Unlike upward causation (an instantiation of a higher level property by a lower level property), and same-level causation, DC occurs when emergent higher level property causes the instantiation of a lower level property. As an example we may think of symbiosis in biological systems. As an emergent phenomenon it is not merely based on the properties of two different organisms. Its nature changes microstructure and physiology of each one of them, oftentimes making their existence possible in an environment which otherwise will be unfavorable.

DC is of a crucial importance for the whole concept of emergence. Early versions of DC are present in writings of Alexander (1920) and Morgan (1923). In 1974 Roger Sperry and Donald T. Campbell presented a more advanced definition of DC.[4] Recently, the concept has been discussed by many authors among natural scientists, philosophers and theologians. We will refer to some of them in the next part of this article.[5]

[4] See the summary in Nancey Murphy 2007, 28-9.

[5] To list some of the key thinkers addressing the problem of DC recently: David Chalmers (2006), Paul Davies (2006),Terrence Deacon (2006, 2007, 2011), George Ellis (2006a, 2006b, 2007),Claus Emmeche *et al.* (1997, 2000), Charbel N. El-Hani and Antonio M. Pereira (2000), Menno Hulswit (2005), Robert Van Gulick (2007), Allicia Juarrero (1999), Jaegwon Kim (1992, 1999, 2006a, 2006b), Alvaro Moreno and Jon Umerez (2000), N. Murphy (2006, 2007), Arthur Peacocke (1991, 2007), Michael Silberstein (2006), Alwyn Scott (2007a, 2007b).

For many proponents of emergence, DC became a criterion of distinction between its weak and strong forms. Weak emergence is understood as a result of limits in our human analytic possibilities. With the development of our knowledge and cognitive skills this epistemic (and thus subjective) emergent properties may simply disappear. Strong emergence, on the other hand, is objective, as it assumes an ontological change and an occurrence of DC of emergent properties (Van Gulick 2007, 59-63). Philip Clayton rightly says that "weak emergence is the starting position for most natural scientists" (2006, 27). It should not be a problem for contemporary science and philosophy of science to accept characteristics of relationships between lower and higher levels of organization of matter and the rule of supervenience, described in points 1.1., 1.2. and 1.3., after they have rejected materialistic and mechanistic reductionism. However, the concept of strong emergence and emergent properties exerting DC on the lower levels, from which they themselves have emerged, can be a challenge and a threat to contemporary science, especially to those who want to both avoid reductionism and keep a physicalist position (nonreductive physicalists). Moreover, the concept of DC raises some critical metaphysical questions which may deeply affect, or even discredit the whole concept of strong emergence. We will now address these issues.

2. Metaphysics of Downward Causation?

Formulating a precise definition of downward causation is problematic. Numerous attempts of various scientists and philosophers writing about EM and DC have failed to find a general and accurate definition so far. In order to find such a definition, one will have answer three fundamental questions: 1) What is the cause in DC?, 2) What is being caused (acted upon)?, and 3) What is the nature of DC? In this part of the article, we will analyze different answers to these questions, given by various authors writing about EM and DC. We will also try to examine the position of those who seem to understand DC in terms of efficient causality.

2.1. What is Causal in DC?

There are several answers to the question of what is a cause in DC. Some of them concentrate on the idea of 'general principles' as having causal powers. When we go back to Donald Campbell, who was the first one to use the concept of DC back in the 1970s in the context of evolutionary biology, we will see that for him 'a cause' in DC means some kind of a law, regularity, or principle, which can be understood as a general disposition of a 'whole' such as "*molecule, cell, tissue, organ, organism, breeding population, species*, in some instances *social system*, and perhaps even *ecosystem*":

> Where natural selection operates through life and death at a higher level of organization, the laws of the higher-level selective system determine in part the distribution of lower-level events and substances (1974, 179-80).

The position of Terrence Deacon is very similar. Defining the second-order EM, he says that "The interaction dynamics at lower levels becomes strongly affected by regularities emerging at higher levels of organization" (2006, 130).

Those who emphasize dynamic aspects of EM and DC find 'patterns of organization', or 'boundary conditions' to be causal. Michael Polanyi (1969) understands them as higher-level principles controlling lower-level processes. Alicia Juarrero (1999, 132-3) introduces the concept of 'context-sensitive constraints' in complex dynamic systems, which connect objects with their environments (systems), strengthening their embeddedness. She redefines the concept of constraints, used formally in Newtonian mechanics and presents them not only as reducing alternatives, but also as producing new possibilities. Arthur Peacocke (1995, 273) uses 'boundary conditions' language as well when defining whole-part constraint (his name for DC). Nancey Murphy (2006, 229), George Ellis (2007, 115) and Paul Davies (2006, 49) hold similar positions. Davies and Ellis additionally introduce some new terms such as 'complexity threshold' or 'higher-level structural relations'. Probably the most detailed description of causal potency of 'patterns of organization' is offered by Robert Van Gulick (2007, 83) who defines their properties as follows:

1. Such patterns are recurrent and stable features of the world.

2. Many such patterns are stable despite variations or exchanges in the underlying physical constituents; the pattern is conserved even though its constituents are not (e.g. in a hurricane or a blade of grass).
3. Many such patterns are self-sustaining or self-reproductive in the face of perturbing physical forces that might degrade or destroy them (e.g. DNA patterns).
4. Such patterns can affect which causal powers of their constituents are activated or likely to be activated. A given physical constituent may have many causal powers, but only some subset of them will be active in a given situation. The larger (i.e. the pattern) of which it is a part may affect which of its causal powers get activated. (…) Thus the whole is not any simple function of its parts, since the whole at least partially determines what contributions are made by its parts.
5. The selective activation of the causal powers of its parts (4) may in many cases contribute to the maintenance and preservation of the pattern itself (2, 3).

Another set of answers given to the question of the causal factor in DC concentrates on concrete events and entities, rather than just ‘patterns of organization’ or ‘boundary conditions’. Nancey Murphy goes back to a philosophical theologian Austin Farrer. Although he does not use the term DC, he talks in his 1957 Gifford Lectures about systems in which “the constituents are caught, and as it were bewitched, by large patterns of action” ([1958] 1966, 57). As we can see, it is a concrete action (event) that has a causal power in Farrer’s description. When formulating a definition of the dynamic third-order EM and its causal factors, Terrence Deacon, follows Farrer’s way of argumentation. Using the event descriptive terminology, he talks about “a higher-order stochastic process extending across time that – like the limited stochastic processes of thermodynamics and morphodynamics – is capable of both cancelling and amplifying biases” (2006, 137). Again, we have here events (stochastic processes) that are regarded as causal factors.

Commenting on Farrer’s thought, Nancey Murphy goes further and talks about “entities that exhibit new causal powers (or, perhaps better, participate in new causal processes or fulfill new causal roles) that cannot be reduced to the combined effects of lower-level causal processes” (2007, 27). Emmeche *et al.* (2000, 18, 24) follow her ideas. Describing a strong and medium DC, they use a concept of an “entity or process”, ascribing to it causal properties. Similar is the position of Sperry and Kim who define certain properties of matter on higher levels of its organization as being causal with respect to properties of entities on lower levels (Stephan 1992). Thus they side indirectly with others who perceive concrete emergent entities as causes in DC. For emergent properties in question have to be embedded in entities.

As we can see, there are many different ways of understanding a causal agent in DC, concentrating either on the concept of laws, general principles and patterns of organization, or referring to events and entities with their properties. This fact has deep metaphysical consequences. But before we analyze them, we will first address the problem of the other end of DC, namely the question of what is being caused (acted upon) in DC.

2.2. What is Being Caused in DC?

Just like the attempt to arrive at a precise definition of the causal factor in DC, an attempt to specify the subject of this process (things being acted upon), brings plurality of answers. Most of the opinions can be classified according to a trifold division presented in table 1.

Author	**Conception of the subject of DC**	
Paul Davies	parts of a whole	entities properties
Austin Farrer	constituents of a system	
Jaegwon Kim	properties of the lower-level basal constituents	
Arthur Peacocke	units of a system	
Roger Sperry	lower-level properties	
Terrence Deacon	component constituent dynamics, lower-order interactions	events
George Ellis	action on the lower-levels	
Robert Van Gulick	micro-events	
Donald Campbell	lower-level events and substances	entities properties events
Emmeche *et al.*	entities or processes on a lower-level	
Alicia Juarrero	molecules in self-organizing processes	
Nancey Murphy	lower-level conditions, structures, or causal processes	

Tab. 1. Various interpretations of the subject of DC grouped in three categories. References to all authors listed here can be found in point 2.1.

As we can see, a careful analysis of theories of DC in terms of both causal factors and things being caused, does not bring us to any clear and precise description and definition of this type of causality. Moreover, the plurality of answers on the level of the metaphysical constituents of DC indicates a deeper problem, that is a difficulty with understanding and defining the very nature of DC. We will now turn to this discussion, which is the core problem of emergentism.

2.3. The Nature of DC

The concept of DC in its contemporary version (beginning with Campbell and Sperry) is intrinsically connected with natural science and its methodology. It is our discoveries in physics, chemistry and system biology in particular that have led us to discover complexities and properties that escape the description of basic-level constituents of any given natural system. However, we cannot forget that the concepts of EM and DC are also philosophical, as they use terms such as: entity, ontology, and causality. And here is the problem. For many proponents of emergent properties and their causal powers support at the same time – according to the first principle of EM described in point 1.1. – the idea of the causal closure of physics and physical laws. It refers especially to those who identify themselves with nonreductive physicalism. But any philosophical reflection on physical causation, if permitted, restricts and constrains causality to efficient cause, based on the physical principle of action and reaction (this position has been predominant in natural sciences since modernity). Those who want to follow this line of argumentation, and to think about EM and DC in terms of causal closure of physics, face the problem of formulating not only a precise definition of a cause and things being caused in DC (see points 2.1. and 2.2.), but also a definition of the nature of this kind of causation.

Our previous considerations show that there is a strong inclination (or at least a danger of such an inclination) among many proponents of EM, to understand DC in terms of efficient causality. It is evident in the case of those who define both sides participating in DC as concrete events or entities with their properties. Those who find laws, general principles, and patterns of organization, as being causal, seem to be alluding to efficient causality as well. For in what way a certain law, a general principle, or a pattern of organization of matter, can have a causal influence on the lower-level constituents? What kind of causation are we dealing with here? These questions remain unanswered in case of many emergentists listed above.

The general problem of EM and DC understood in terms of efficient causality and in accordance with the principle of the causal closure of physics was described by Van Gulick as follows:

> The challenge of those who wish to combine physicalism with a robustly causal version of emergence is to find a way in which higher-order properties can be causally significant without violating the causal laws that operate at lower physical levels. On one hand, if they override the micro-physical laws, they threaten physicalism. On the other hand, if the higher-level laws are merely convenient ways of summarizing complex micro-patterns that arise in special contexts, then whatever practical cognitive value such laws may have, they seem to leave the higher-order properties without any real causal work to do (2007, 64-5).

To avoid this problem, Van Gulick proposes a new model in which higher-order patterns involve the selective activation of lower-order causal powers. But the question of the nature of DC still remains unanswered. If selective activation is a physical efficient cause, the whole argumentation falls into reductionism. If it is not a physical cause, the principle of physicalist ontology is violated.

Nancey Murphy (2006, 228; 2007, 26-7) struggles with the same problem. Thinking of ontological aspects of emergence and trying to define causal factors of emergent properties, she avoids the concept of new causal forces over and above those known to physics. Postulating them would again violate the causal closure of physics. She suggests instead approving the idea of new causal powers that cannot be reduced to the summary of lower-level processes. But what is the nature of these causal powers? If they are not physical, how can they act upon physical constituents of lower-levels? What is the 'causal joint' between high and low levels of organization of matter? The nonphysical aspect of these causal powers seems to be contrary to the principle of the physical causal closure, emphasized in nonreductive physicalism.

Jaegwon Kim points to some other critical issues, faced by those who understand DC as a case of efficient causality (1999, 27). He emphasizes the fact that in DC higher-level properties have to have a causal influence on their micro-constituents. Thus understood, 'reflexive downward causation' (a term coined by Kim) is combined with upward causation. Following Sperry, he gives an example of an eddy, which comes into being if, and only if, each and every molecule constituent to the puddle of water begins to move in an appropriate way. At the same time, it is the eddy that is moving all molecules around "whether they like it or not". But here comes the question:

> [H]ow is it possible for the whole to causally affect its constituent parts on which its very existence and nature depend? If causation or determination is transitive, doesn't this ultimately imply a kind of self-causation, or self-determination – an apparent absurdity? (1999, 28).

Kim adds that his reasoning implies a tacit acceptance of a metaphysical principle, which he calls 'the causal-power actuality principle':

> For an object, *x*, to exercise, at time *t*, the causal/determinative powers it has in virtue of having property *P*, *x* must already possess *P* at *t*. When *x* is caused to acquire *P* at *t*, it does not already possess *P* at t and is not capable of exercising the causal/determinative powers inherent in *P* (1999, 29).

Kim embraces this principle, which is an expression of the transitive character of causation, and says that the circularity and incoherence threatening the plausibility of the whole concept of DC can be avoided only if we understand and define reflexive DC as diachronic. An introduction of a time delay between the cause and effect in DC is indispensable for him if we want to make it metaphysically plausible. He rejects synchronic DC saying that its coherence is doubtful.

But diachronic self-reflective DC does not solve all problems for Jaegwon Kim. When applying emergence to the mind-body causation, he still finds it problematic, and claims that it eventually collapses into physicalism. He tries to show this by analyzing a theoretical example of an emergent mental property. We will try to summarize and illustrate his argumentation using a concrete example of a mental state of pain and escape reaction to it. See fig. 1.[6]

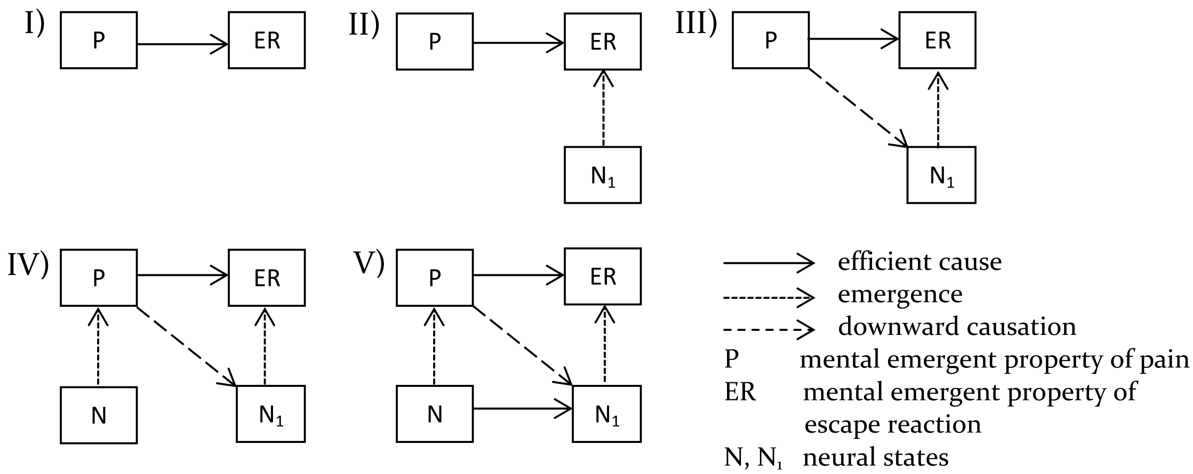

Fig. 1. The collapse of emergent properties into physical causation, according to Jaegwon Kim (1999, 31-3; 2006, 557-8). (**I**) An instance of emergent property of pain (P), causes another emergent property of escape reaction (ER) to instantiate, as an effect of the same-level causation. (**II**) ER, being an emergent property, must have a basal (physical) property, a neural state N_1 from which it emerges. Moreover, as long as N_1 occurs, ER will be instantiated, whether or not ER's purported cause, P, occurs at all. (**III**) The only way to save the claim that P caused ER appears to be to say that P caused ER by causing N_1. In this case, the same-level causation from P to ER, entails downward causation from P to N_1. (**IV**) Now, P, as an emergent, must itself have an emergence base property, that is a neural state N. (**V**) Here Kim asks a critical question: if an emergent property of pain (P), emerges from basal neural state N, why cannot N displace P as a cause of neural state N_1? If causation is understood as nomological (law-based) sufficiency, N as P's emergent base is nomologically sufficient for P, and because P is nomologically sufficient for N_1, it follows that N is nomologically sufficient for N_1, and can be regarded its cause. Moreover – adds Kim – a causal chain from N to N_1 with P as an intermediate causal link is not possible because the emergence relation from N to P is not properly causal. If P is to be retained as a cause, we are faced with the highly implausible consequence that the case of DC (from P to N_1) involves causal over-determination (since N remains a cause of N_1 as well). But if DC goes – Kim concludes – emergentism goes with it.

[6] We are presenting an original argumentation by Kim but we have changed his literal symbols in order to apply them to the concrete example of pain and escape reaction. See Kim, 1999, 31-3; 2006, 557-8.

Kim tries to salvage DC and suggests giving it a 'conceptual' interpretation. We can interpret higher levels as levels of concepts and descriptions, or levels characteristic for our representative apparatus, but not as levels of real phenomena and properties in the world. DC would then mean a cause described in terms of higher-level concepts or higher-level language, although it could be representable in lower-level concepts and language as well. This approach will not save real DC – Kim admits – but it will save downward causal explanation, and maybe we should not expect anything more (1999, 33).

However, Kim's argumentation is vulnerable to critique. Alwyn Scott rejects his concept of diachronic DC, showing that from the nonlinear point of view the problem of circular causal loops and time in DC does not exist at all. According to Scott, an emergent structure does not pop into existence at time t. It "begins from an infinitesimal seed (noise) that appears at a lower level of description and developes through a process of exponential growth (instability). Eventually, this growth is limited by nonlinear effects, and a stable entity is established" (Scott 2007, 287). Using Kim's notation applied in his 'causal-power actuality principle', Scott depicts DC using nonlinear differential equations:

$$\frac{\mathrm{d}x}{\mathrm{d}t} = F(x, P), \qquad \frac{\mathrm{d}P}{\mathrm{d}t} = G(x, P),$$

where x is an object, P is an emergent property, F and G are nonlinear functions of both x and P. The emergent structure is not represented by $x(t)$ and $P(t)$, but by x_0 and P_0, according to the following equations:

$$0 = F(x_0, P_0), \qquad 0 = G(x_0, P_0).$$

If x_0 and P_0 are asymptotically stable solution of the given system, we may assume that:

$$x(t) \rightarrow x_{0,} \qquad P(t) \rightarrow P_0.$$

Because $t \rightarrow \infty$, what we are dealing here with is a dynamic balance between upward and downward causation. "Thus, Kim's causal-power actuality principle – says Scott – is a theoretical artifact stemming from his static analysis of a dynamic situation" (2007, 287). He then gives two examples of a simple and complex causal loops in the feedback mechanisms, to explain the relation between upward and downward causation (see fig. 2).

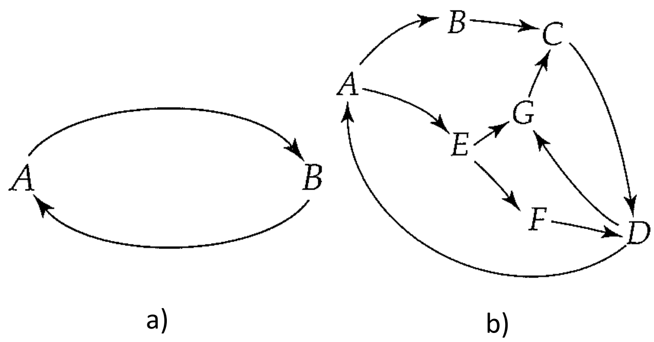

Fig. 2. Examples of feedback causal loops (Scott 2007, 288-90). (a) A simple loop. (b) A graphic representation of the organization of a complex network. "In this diagram, the node **A** might represent the production of energy within an organism, which induces a muscular contraction **B**, leading the organism to a source of food **C**, which is ingested **D**, helping to restore the original energy expended by **A**. Additionally, **A** might energize a thought process **E**, which recalls a positive memory of taste **F**, further encouraging ingestion **D**. The thought **E** might also induce the generation of a digestive enzyme **G** which also makes the source of food seem more attractive. Finally, ingestion **D** might further induce generation of the enzyme **G**. In this simple example – which is intended only as a cartoon – the network comprises the following closed loops of causation: **ABCD**, **CDG**, **AEFD**, and **AEGCD**, where the letters correspond to entities at various levels of both the biological and the cognitive hierarchies."

The critique of Kim presented by Scott is justified and offers an answer to the problem of circular causal loops in DC. It also gives an argument against Kim's idea of diachronic reflexive DC. In terms of nonlinear causality, the problem of time simply disappears, and the whole concept of diachronic DC is needless.

However, we think that Scott's criticism of Kim does not address the key problem, which is the nature of DC. In his explanation of fig. 2b, Scott talks about entities which belong to different levels of both the biological and the cognitive hierarchies. They are entangled in a complex causal network. But what is the nature of causation between mental and biological entities? What is the causal joint between cognitive and physical structures? It seems to us that Scott is thinking in terms of efficient causality when presenting an example of a complex causal loop, in which various biological and cognitive properties are entangled. If this is the case, his explanation is insufficient.

The same criticism applies to Kim's argumentation reducing emergent properties and causality to the physical (fig. 1). The downward causative feature of a mental property of pain (P) 'standing' between two neural states (N and N_1), and included in a regular efficient causal chain, would be truly superfluous, causing a problem of overdetermination. But the whole argumentation collapses once we acclaim that DC is not an efficient cause and cannot be understood in terms of this type of causality. But this would require a breakdown of causal monism in natural sciences, a departure from the position that science embraced and has protected ever since the scientific revolution in the modern era. Although for many it may not be an easy step to take, it seems that there is no other way to make the concept of DC plausible.

3. DC as Formal Cause

Those who manage to escape the narrow worldview of the scientific interpretation of the efficient causality are ready to begin their journey back to the notion of four distinctive modes of causality described by Aristotle. By no means is it an easy journey. The rejection of final and formal causality and the redefinition of the material cause became a heritage of modern science, and one of its most fundamental principles, affecting profoundly the mindset of many generations of scientists and philosophers. However, paradoxically, this same – natural science – becomes today more and more aware of many shortcomings of causal monism, thus opening anew the way for other types of causality.

Although this ongoing change in the relationship between natural science and philosophy of nature brings optimism and encouragement, we find ourselves witnessing its preliminary phase, knowing that much work remains to be done. Nonetheless, we believe that the whole discussion about DC is an important part of this process. In what follows we shall analyze the position of those who perceive DC as a formal cause, and address difficulties faced by those who would like to use Aristotle's division of causes in EM and DC.

3.1. Beyond Efficient Causality

We shall begin this part of the article with the trifold division of DC formulated by Emmeche *et al*. In their article published in 2000, Emmeche, Køppe, and Stjernfeltd present an original classification of different types of DC, based on a distinction between efficient and formal causality. The first type of DC in their classification is a strong downward causation (SDC). Its definition assumes an efficient causal influence of higher-level entities on lower-level entities. Moreover, it understands the former ones as being substantially different from the latter, and thus entails a substance dualism allowing for a violation of the assumption of the inclusivity of levels (see point 1.1.). According to Emmeche *et al.*, SDC is erroneous because, while assuming a real, existent chain of efficient causes, it locates this process in time, accepting the idea of exchange of energy between higher and lower levels as well. Their argumentation follows our critique of DC understood as efficient cause presented above (point 2.3.). Pointing out the problem of the causal joint between higher and lower levels, they show that it is not only SDC, but also strong upward causation that raises questions. For just as it is difficult to think of the biological level inflicting purely physical effects, the idea of physical cause having nonphysical efficient influence on higher level is also problematic. Thus, Emmeche *et al.* reject SDC and suggest that we should look for an understanding of DC beyond the idea of efficient causality.[7]

At this point of their considerations, they introduce the idea of medium downward causation (MDC). In order to describe it they refer to the mathematical and physical language of differential equations describing the dynamics of systems. Using terms such

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[7] Emmeche *et al.* 2000, 18-23. As an example of an erroneous understanding of DC as SDC, they refer to a living cell understood as an emergent entity. In literature a cell is described as causing changes in the molecules constitutive to it, making them specifically 'biological', substantially different from other molecules of the nonliving matter. "But if we imagine a microscopic view of this alleged causal process, - say Emmeche *et al.* – we will be unable to find any effective causality in the scenario. First, the process does not take place in time; second, the two events in question do not even possess the ability of causing each other. Of course, it is evident that the biological cell 'governs' or 'influences' the biochemical processes taking place in it – but at the same time the cell remains in itself a biochemical construct. (...) The cell consists of biochemical processes, we could say, but this is a non-temporal (mereological) relation and therefore non-causal in the efficient-causality use of the word. So even the idea of an upward efficient cause (or 'strong' upward causation) from biochemistry to cell is wrong because of this; what we could say instead is that the molecules and the biochemical reactions in questions *constitute* the cell, that is, they are the material and formal causes of the cell." (*Ibid*, 20)

as boundary (or constraining) conditions, they define MDC in terms of higher level entities as constraining conditions for the emergent activity of lower levels. In other words "the higher level is characterized by *organizational principles* – lawlike regularities – that have an effect ('downward', as it were) on the distribution of lower level events and substances" (2000, 25).

This definition reminds us of the whole group of authors to whom we referred in the second part of this article, who use the same language of boundary conditions and law-like regularities in their description of the causal factor in DC (Juarrero, Peacocke, Murphy, Ellis, Davies, and others). But there is a substantial difference between them and Emmeche *et al.* who emphasize that

> [M]edium DC does not involve the idea of a strict 'efficient' temporal causality from an independent higher level to a lower one, rather, the entities at various levels may enter part-whole relations (e.g., mental phenomena control their component neural and biophysical sub-elements), in which the control of the part by the whole can be seen as a kind of functional (teleological) causation, which is based on efficient, material as well as formal causation in a multinested system of constraints (2000, 25).

What we find here is a retrieval of the Aristotelian fourfold division into material, formal, efficient, and final causality. An attempt to present Aristotle's position in details exceeds the scope of this article. Nevertheless, we should emphasize that he defined material cause not only in terms of particles understood as building blocks of entities, but also as a dynamic source of potentiality (primary matter). Formal cause for Aristotle is in turn something more than just a geometric shape of an entity. It is a principle of its actuality, that, by which a thing is what it is. His notion of efficient and formal cause is somewhat easier to grasp. The former one refers to the activity of an agent bringing a change, whereas the latter is understood by Aristotle as 'that for the sake of which' a thing is done, a good proper for a being that can be attained (Aristotle, *Physics*, *Metaphysics*).

Even this short reference to classical Aristotelian fourfold notion of causality shows that the position presented by Emmeche *et al*. needs further clarification and poses many questions (e.g., the question of the nature of the teleological and formal causation, and the question of the metaphysical status of a substance as a whole and the status of its components), nevertheless, the very fact of breaking the causal monism is significant, and that is why we strongly support Emmeche *et al.* when they say that

> [T]here is a place for a rational concept of downward causation (in some version) in science and philosophy, but only with a broader framework of causal explanation. Very often 'causality' is implicitly equated with the usual notion of efficient causality, but if downward causation is regarded as an instance of efficient causality it will form a 'strong version' of the concept, which (…) is not a plausible one. The notion of causality should therefore be enlarged to make sense of downward causation (2000, 17).

Finally, Emmeche *et al.*, using the phase-space terminology, define weak downward causation (WDC), in which the higher-level is the form into which the constituents of a lower-level are arranged (2000, 26-31). In other words, the higher-level is not a concrete substance, but an organizational level. The formal cause in WDC can be understood by analogy to the concept of 'attractor' in a dynamical system, that is a steady state towards which the system may evolve. The application of the formal causation in WDC is another example of a wider understanding of causality by Emmeche *et al*. Their position is recalled by C. N. El-Hani and A. M. Pereira (2000, 127, 134-5), who emphasize the importance of the entanglement of matter and form, the role of higher-order structures constraining lower ones, and the role of functional causation, in search for a middle road between reductionism and radical dualism.

3.2. Retrieval of Aristotle's Notion of Causality

The example of Emmeche *et al.* suggesting a return to the Aristotelian notion of causality is not an isolated one. There are several authors among 'emergentists', taking similar position, although most of them do not develop this idea more broadly. Michael Silberstain, for instance, mentions at one point (with no further explanation) that

> Systemic causation means admitting types of causation that goes beyond efficient causation to include causation as global constraints, teleological causation akin to Aristotle's final and formal causes, and the like (Silberstein 2006, 218).

A. Moreno and J. Umerez (2000, 107) also go back to Aristotle, arguing for an acceptance of a new type of causation in biological systems, which "is 'formal' in a sense that it infuses forms, i.e., it *materially restructures matter according to a form.*" But at the same time they claim that their position differs from the classical Aristotelian understanding of material and formal cause:

> In Aristotle, both formal and material causes are intrinsic, whereas efficient and final ones are extrinsic. In our view of formal cause being efficient and being intrinsic do not exclude each other. In a sense, formal cause is intrinsic inasmuch as it is inherently generated in the very system which becomes an autonomous complex system. Anyway, formal cause can also be extrinsic with respect to some levels or subsystems (or even systems) which allow for relatively autonomous kinds of description (2000, 107).

Alwyn Scott, in his introduction to *The Nonlinear Universe* (2007, 5-7), presents a description of all four of Aristotle's causes. He also adds that, in modern terms, Aristotle's material and formal causes are put together and classified as 'distal causes', his efficient cause is called a 'proximal cause', while the final cause is given the name 'teleological cause'. One can see the differences between his position and that of Moreno and Umerez.

Philip Clayton and Terrence Deacon go back to Aristotle as well. The former does it while explaining the historical trajectory of the conceptual foundations of emergence theory (Clayton 2006, 4-5). Deacon's approach is similar. He lists four Aristotelian causes and describes the process of a slow erosion of the plural notion of causality in the history of philosophy and science. This enhanced reductionism in which "only 'pushes' seem allowable as determinants of the efficacy and direction of physical changes" (2006, 113-4). But Deacon does not confine himself to historical references to Aristotle only. In fact, just as Emmeche *et al.* propose an application of Aristotelian causality in metaphysics of EM and DC, Deacon offers some interesting applications of formal and final causes in philosophy of biology (2006, 2011). When explaining the third-order emergent dynamics, he introduces the concept of specific 'absences', thus describing certain processes at higher levels of organization of matter:

> This physical disposition to develop toward some target state of order merely by persisting and replicating better than neighbouring alternatives is what justifies calling this class of physical processes *teleodynamic,* even if it is not directly and literally a 'pull' from the future.
>
> [T]he 'constitutive absences' characteristic of both life and mind are the sources of this apparent 'pull of yet unrealized possibility' that constitutes function in biology and purposive action in psychology. The point is that absent form can indeed be efficacious, in the very real sense that it can serve as an organizer of thermodynamic processes (2006, 143-4).

We find in Deacon's ideas of 'constitutive absences', 'efficacious absent forms' and 'teleodynamics' proposals for a new and original understanding of formal and final causation in biology. Clearly, the whole matter requires a careful analysis and study beyond the scope of this article. Nonetheless, a reference to Aristotle is apparent, and we think that Deacon's work opens a new possibility for a retrieval of all four of Aristotle's causes in philosophy of biology. Deacon himself thus concludes his description of the three orders of EM:

> In many ways, I see this analysis of causal topologies as a modern reaffirmation of the original Aristotelian insight about categories of causality. Whereas Aristotle simply treated his four modes of causality as categorically independent, however, I have tried to demonstrate how at least three of them – efficient (thermodynamic), formal (morphodynamic), and final (teleodynamic) causality – are hierarchically and internally related to one another by virtue of their nested topological forms. Of course there is so much else to distinguish this analysis from that of Aristotle (including ignoring his material causes) that the reader would be justified in seeing this as little more than a loose analogy. The similarities are nonetheless striking, especially considering that it was not the intention to revive Aristotelian physics (2006, 148).[8]

Deacon's account of EM is somehow related to the idea of causally effective goals, proposed by George Ellis (2007, 118-22). He sees them as central factors in feedback

[8] Deacon's remark about independency of causal modes in Aristotle is somehow mistaken. In Aristotle's biology, for instance, final causality is intimately related with formal (as in generation of offspring).

control systems, and ascribes to them causal properties which are the result of the information about the system's desired behavior or responses that they embody. For him, living systems are 'teleonomic', that is goal-seeking. Moreover, these goals are not the same as material states, although they are expressed and become effective in a material way. Ellis says that goals can be either: in-built, as homeostasis; learned; or consciously chosen. Although he does not refer to Aristotle, his notion of causally effective goals resembles the Aristotelian final cause.

We could probably find some more examples of authors going back – directly or indirectly – to the classic Aristotelian understanding of causation. We find this tendency very promising from the perspective of philosophy of nature and metaphysics. It can serve as another powerful argument opposing the reductionist approach, still prevalent in science and philosophy of nature. However, this line of research is at its preliminary stage, and those who want to continue it will have to face some difficulties. What is more, the very idea of using Aristotle's notion of causality in the contemporary discussion of DC has already been criticized. We will close this article with a short analysis of this criticism, trying to show that it opens in fact some new perspectives for EM and DC theory understood in the light of the Aristotelian pluralistic notion of causality.

3.3. Perspectives for the Future

An attempt to bring the Aristotelian notion of causality back into discussion, made by Emmeche *et al.*, has been criticized by Menno Hulswit. In fact, his comments seem to apply to other authors who are in favor of explaining DC as a type of formal causality as well. Hulswit begins his criticism by saying that Emmeche *et al.* show a strong bias towards thinking in terms of substances and substantial forms without presenting any arguments to explain and support this position. (2005, 276).[9] To that we answer that it is

[9] Later on (p. 283) Hulswit talks about "Western 'substance addiction'", and refers to Bickhard and Campbell (2000, 277-8), who argue that the Aristotelian substance ontology is "an inadequate metaphysics for relationships and process, most especially open process," and claim that we should substitute it with a process metaphysics. As an example of process metaphysics applied in explaining emergent phenomenon of mind we can refer to David Griffin's *Unsnarling the World-Knot: Consciousness, Freedom, and the Mind-Body Problem*. However, process metaphysics has its problems as well. According to Deacon who is addressing the same problems as Griffin, panpsychic assumptions of process metaphysics do not explain "why the

not possible to embrace Aristotle's view of causation without accepting his understanding of substance. However, we agree that this turn to substance metaphysics needs to be clarified and explained in more detail, in the context of the entire system of Aristotle's philosophy and contemporary science.

Hulswit continues his critical evaluation of DC by saying that Emmeche *et al.* are not consistent in their description of MDC. When formulating its definition they identify higher and lower-level entities as substances or substantial form, while later on, when giving some concrete examples of MDC, they refer to thoughts constraining neurological states and mental phenomena controlling their component neural and biophysical sub-elements. Neither of these can be treated as substances, according to Hulswit. What is more, the same criticism refers to processes and interactions (2005, 276-7). We find all these questions important and relevant. Answering them requires a detailed study of Aristotle's substantial metaphysics, his ideas of substance and its categories, substantial and accidental form, and substantial and accidental changes. However, we agree that the ontological status of the causal relata in DC needs to be clarified.

Hulswit is also skeptical about the summary of Emmeche's *et al.* exposition of medium and weak DC, in which they use the language of supervenience:

> The point of departure in both cases is the assumption of formal causality. As higher level entities (e.g., a cell) supervene on lower order entities (molecules), formal causality on the higher level supervenes on the efficient causality of the lower level. This can be interpreted as the selection – from a very large set of possible (efficient) interactions – of a small set of realizable (efficient) interactions on the lower level, on which the higher level then (formally) supervenes. In any case, in our view this is the only non-contradictory version of downward causation possible (2000, 31-2).

We agree that this explanation of the nature of DC, based on the theory of supervenience, is somehow unfortunate. As we have seen in the first part of this article, DC is more than just a relation of dependency between supervenient and subvenient properties (see points 1.2. and 1.4.). The whole discussion shows that it is not only causal

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character of physical process associated with life and mind differs so radically from those associated with the rest of physics and chemistry – even the weird physics of the quantum" (2011, 79).

relata, but also the nature of DC understood as formal causation, that need to be explained in more details. Otherwise, we may find ourselves helpless in the face of sharp criticism on the part of Menno Hulswit, who says that "the concept of 'downward causation' is muddled with regard to meaning of causation and fuzzy with regard to what it is that respectively causes and is caused in downward causation" (2005, 284).

In his article Hulswit presents one more critical argument, which is of a great importance for the whole debate. He contrasts the classical Aristotelian concept of formal cause with the modern concept of natural law. He claims that – although they have the same function, that is to explain the apparent stability of the world – they differ significantly, for

> the formal cause was meant to explain the stability of the world in terms of the structure of things, whereas natural laws explain the stability of the world in terms of the dynamic relations between events (2005, 278).

At this point we strongly disagree with Hulswit. His differentiation between the formal cause and natural laws presupposes a static interpretation of the Aristotelian metaphysic of substance, which is irrelevant. We should not forget that Aristotle's "Physics" and "Metaphysics" have their origin in the philosopher's reflection on both stability and the dynamic change of entities (substances) observed in the natural world. His philosophy of nature is by no means static. Thus we can see that an attempt to formulate a plausible account of DC explained in terms of formal cause will require a reconsideration of Aristotle's basic metaphysical assumptions and rediscovering the dynamic aspect of his thought.

To sum up, our analysis of Menno Hulswit's criticism of the work of Emmeche *et al.* appears to be very insightful. Although many of his questions and doubts are justified, they do not force a rejection of the whole idea. Quite the contrary, we find them setting a new stage for the future research and conversation about the metaphysics of DC interpreted in terms of formal causation. We hope to participate actively in this conversation, and search for answers to these and other questions concerning DC.

Conclusion

Witnessing scientists discovering complex structures ("wholes") is really fascinating for a philosopher of nature in his encounter with contemporary science. The reductionist paradigm has been called into question, and seems to be losing its power. Our fascination with complexity of nature and multilayered irreducible structures of its organization requires from us a new and more holistic approach to the reality described in sciences. Philosophy of nature seems to be of a great help for all scientists who do not constrain themselves to the narrow perspective and terminology of their own field.

The theory of emergence and downward causation appears to be a promising tool, opening a fruitful conversation between scientists, philosophers of nature and philosophers of science. We hope that it will also bring us closer to a more holistic and integral understanding of the world, its structures and processes. However, we are aware of the fact that as interdisciplinary theories, both EM and DC raise many questions and require further study and clarification. This article shows that both sides of the dialogue (science and philosophy) are struggling in search for a proper and adequate language, which would help to explain EM and DC. We tried to prove that the language of efficient causality, which has been predominant in natural science since modernity, is not sufficient anymore. In opposition to causal monism, we suggested a return to Aristotle's language of plurality of causes. We believe this return is possible and rational, although our study shows that the way back may be long and challenging. But we should not be surprised. It is never easy to retrieve a language that has not been used for a long time.

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