

Emergence and reduction

Emergencia y reducción

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ABSTRACT

Claims about *reduction* or *emergence* appear in cases in which there are different levels of facts that have between them some kind of ontological connection by which one of them is 'made up' from the other. In the case of reduction, it is supposed that the reduced level of facts is 'nothing over' the reducing level of facts. In the case of emergence, on the other hand, it is supposed that the emergent level is something 'new' with respect to the emergence base. In both reduction and emergence some kind of ontological priority of one level with respect to the other is involved, as well as some kind of explanatory asymmetry between them. In recent years a lot of work has been devoted to different notions of ontological priority, like *grounding* and *dependence*, that might be useful for the clarification of the more traditional questions about the nature of reduction and emergence. This work presents and discusses various attempts to make that clarification.

Keywords: reduction, emergence, grounding, dependence, levels of reality.

RESUMEN

Las alegaciones sobre *reducción* o *emergencia* aparecen en casos en que hay diferentes niveles de hechos que tienen entre sí cierto tipo de conexión ontológica por la que uno de ellos está 'construido' del otro. En el caso de la reducción, se supone que el nivel de hechos reducido es 'nada por sobre' el nivel de hechos reductor. En el caso de la emergencia, por otra parte, se supone que el nivel emergente es algo 'nuevo' respecto de la base de emergencia. Tanto en la reducción como en la emergencia está envuelto un tipo de prioridad ontológica de un nivel respecto del otro, así como cierto tipo de asimetría explicativa entre ellos. En años recientes se ha dedicado mucho trabajo a diferentes nociones de prioridad ontológica, como la *fundación* (*grounding*) y la *dependencia*, que pueden ser útiles para la clarificación de las cuestiones más tradicionales sobre la naturaleza de la reducción y la emergencia. Este trabajo presenta y discute varios intentos de hacer tal clarificación.

Palabras clave: reducción, emergencia, fundación, dependencia, niveles de realidad.

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Questions about whether some facts are or not 'reducible' to or 'emergent' in relation to others appear where there are different 'levels' that seem to have some ontological correlation between them. In general terms, the concepts of 'reduction' and 'emergence' have been considered to be contraries. When one level of facts seems to be 'nothing over and above' the more basic level, philosophers have been inclined to say that one of the levels 'reduces' to the more basic one. When, on the contrary, there is a real ontological difference between the levels, philosophers have been inclined to say that one level is 'emergent' in relation to the more basic one. Claims about reduction and emergence have been frequent not only in philosophy of science, but also in many other areas. For example, it has been contended that mental states reduce to physical or biological facts about the brain and its environment, it has been contended that dispositions reduce to categorical properties, or it has been contended that causal connections reduce to regularities in the occurrence of types of events. The problem here is that it has been notoriously difficult to analyze the concept of 'reduction' (cf. van Riel, 2014) and, also, it has been difficult to analyze the concept of 'emergence'.

There has been a lot of recent work on the clarification of several concepts of ontological priority, like the concepts of *grounding* and *ontological dependence*. These notions of ontological priority precisely have to do with ontological hierarchies in which some facts are basic in relation to others. The same hierarchies that have motivated the claims of 'reduction' or of 'emergence'. The objective of this work is to consider the impact that these recent developments might have for the traditional questions concerning reduction and emergence. Works of Gideon Rosen (2010) and Elizabeth Barnes (2012) have advanced in important ways in the elucidation of both the notions of 'reduction' and 'emergence' from the vantage point of a greater clarity about forms of ontological priority. What will be pointed out, nonetheless, is that the connection between reduction and grounding proposed by Rosen has several shortcomings.

1. Reduction and emergence

The main intuition behind claims of reduction is that reduced entities or theories are *nothing more* than the reducing entities or theories. There have been various ways of making this intuition precise. Reduction has been presented

as a relation between 'theories', 'concepts', 'models', 'properties' or 'events'. Reduction itself has been characterized either as a relation of 'deduction between theories', or as 'mapping functions between models', or as an 'analogy between theories', or as an 'identity of properties'. There is a reason for this variety of formulations, as pointed out below.

Nagel (cf. 1961, chap. 11) proposed that 'reduction' should be taken as a relation between theories. A theory T_1 is reduced to a theory T_2 if and only if T_1 can be deduced from T_2 in conjunction with some coordinating definitions or bridge laws that correlate the terms of T_1 with the terms of T_2 . A 'theory' is conceived as a set of sentences in a language closed with respect to logical deduction. 'Bridge laws' are quantified biconditionals that connect the terms of the reduced theory with the terms of the reducing theory. Bridge principles or coordinating definitions are statements that must be justified empirically as natural laws. This coordination allows the 'explanation' of the reduced theory by the reducing theory plus bridge principles. 'Reduction' of one theory by another is, then, an instance of 'explanation' as understood by the nomological-deductive view. This syntactic characterization was proposed to capture the situation when an old theory is superseded by a new one that can 'retain' the theoretical advantages and the empirical results of the former. It was proposed to capture the situation when a new theory can 'explain' the old one. Cases of this sort are – in principle – the relation of classical mechanics to relativistic mechanics, or the relation of thermodynamics to statistical mechanics. There are many problems with this characterization of reduction that need not be detailed here². It has been notorious that most of the discussions concerning Nagelian reduction have focused on the nature of bridge principles. Nagel made a syntactic characterization of those principles, but it is clear that much more than a formal characterization is required. A quantified biconditional of the form $\forall x (Fx \leftrightarrow Gx)$ can be true in virtue of semantic stipulation or in virtue of a general causal connection by which the satisfaction of F causes the satisfaction of G , and nothing satisfies G except if it is caused by the satisfaction of F . But these are not cases of reduction. It seems that it is further required that what the relevant terms connected by the bridge principles designate should be the 'same'.

These discussions have shown that in a claim of reduction there is an explanatory element. In some sense, the reducing theory or entity should *explain* the reduced theory or entity. But, at the same time, in a claim of reduction there is an ontological element, because it is supposed that the entities about which the theories in question talk are 'the same'. This

² For example, in the so-called 'new wave' model (cf. Bickle, 1998, p. 23-55) it is sustained that bridge laws play no role in inter-theoretic reductions. They are the *result* of a successful reduction, and not a premise in it. In the 'new wave' perspective, there is deduction but not between the reducing theory T_2 and the reduced theory T_1 , but between T_2 and a corrected theory T_1^* , that is in an 'analog relation' with T_1 . The fact that the 'analog relation' obtains between T_1 and T_1^* warrants some 'bridge principles' by which the referents of the terms in the reduced theory T_1 are assigned as referents of terms of the reducing theory T_2 . The defenders of the structuralist conception of scientific theories, on the other hand, have pointed out that theories are not sets of sentences but sets of models satisfying certain constraints (Balzer, Moulines & Sneed, 1987). The Nagelian view of reduction presupposes – for them – an incorrect conception of theories and also an inadequate conception of explanation – the deductive-nomological view. Inter-theoretic reduction in the structuralist conception is a matter of mapping the structures of different models. That is, it is a matter of set-theoretic isomorphisms, because 'models' are conceived as set-theoretic entities.

seems in principle incoherent, because nothing can be explanatory of itself. But the point in a reduction claim is to show that there are different ‘descriptive’ ways of presentation of the ‘same’ entity or domain of entities, but with a certain explanatory directionality between those descriptions. One of them explains the other. As van Riel has put it in a recent assessment of all the debate:

[A] sentence of the form ‘F-ness reduces to G-ness’ expresses a truth if and only if (i) for every x , if x is F then (x is F because x is G), and (ii) F-ness = G-ness (van Riel, 2014, p. 4).

That is, there is an explanatory direction between the reduced F and the reducing G – F -ness obtains *because* G -ness obtains – but there is also some kind of ontological ‘sameness’. Of course, this claim of ontological ‘sameness’ should be treated with extreme caution, as discussed below. It seems that there are real cases of identity of the *explanandum* with the *explanans*, but it seems also that there are cases in which there is strict grounding that is incompatible with identity. Because nothing can be an explanation for itself, reduction claims should consider ‘ways’ in which entities are given to us. This is the reason why in the debate sometimes reduction has been presented as a relation between ‘theories’, ‘concepts’ or ‘models’. The explanatory value of a reduction comes not from a supposed relation between entities but from an epistemic relation between different ‘representations’ of entities.

There has been also a variety of proposals concerning the concept of ‘emergence’. The core intuition in a claim of emergence seems to be that some ‘level’ of entities, although ontologically ‘connected’ to another more basic level, is something over or above the entities that constitute the base. If there are two different objects, located in disjointed regions of space, there is no question whether one of those objects is something ‘over or above’ the other. One is inclined to think in a relation like ‘emergence’, nonetheless, when this difference is not obvious. Emergence requires ontological distinctions where there seems to be just one entity. Emergence requires, then, some kind of ontological relation between different ‘levels’ of facts, or states of affairs. One very popular conception of ‘emergence’ understands it as a form of strong nomological supervenience (cf., for example, Kim, 1999, 2006). Under this conception, if x has F , F is an emergent property iff (i) the instantiation of F supervenes with nomological necessity on the properties instantiated by parts of x or the relations between those parts; (ii) the instantiation of F does not supervene with logical necessity on the properties and relations of the parts of x ; and (iii) at least some of the natural laws that determine the supervenience of the instantiation of F on the properties and relations of the parts of x are fundamental. A natural law L is *fundamental* iff the obtaining of L is not entailed by other laws possibly in conjunction with some boundary conditions. In this characterization, emergence is a matter of supervenience determined by brute nomological facts. In this conception of emergence there is an account of the connection between dif-

ferent levels of facts: one of them is ‘covariant’ on the other. There is also something ‘over and above’ the facts of the base, because it is a fundamental – brute – nomological fact that the base gives rise to the emergent facts.

There are well-known criticisms of this conception of emergence. It has been argued that it requires the postulation of epiphenomenal entities (cf. Kim, 1999, p. 25-40; 2006, p. 81-84). Suppose that an emergent event E_1 has as supervenient base the event B_1 . The emergent event E_1 causes another event of the same level E_2 . Insofar as E_2 is also a higher-level event, it should have a supervenient base B_2 . But then, there are two events that compete for the explanation of why E_2 obtains: E_1 and the supervenient base B_2 . If E_1 is going to have any causal efficacy, it must cause the supervenient base B_2 . But the supervenient base B_1 is nomologically sufficient for E_1 – by hypothesis, assuming that ‘emergence’ is nomological strong supervenience – and E_1 is nomologically sufficient for B_2 – by hypothesis, assuming that causation at least entails nomological sufficiency –, then B_1 is nomologically sufficient for B_2 , and the causal contribution of E_1 turns out to be otiose.

The main problem envisaged, then, is that the supervenience account does not seem to allow for authentic new causal powers for the emergent entities. Several later proposals have attempted to correct this defect. O’Connor (2000, p. 108-125) and O’Connor & Wong (2005) proposed a diachronic and dynamic conception of emergence. The idea is that there is no synchronic supervenience between the base event and the emergent event. The base event must be taken as causing the emergent event at a temporal delay. The emergent event, in its turn, can later on interact causally with its base or with other supervenient bases. Another important alternative to the treatment of emergence as strong nomological supervenience is the proposal of Humphreys (1997). On Humphreys’ view the properties of the base – and, correlatively, the events of those properties being instantiated – are connected in a primitive operation of ‘fusion’. Fusion produces a new property with new causal powers that supersede the causal powers of the fused properties of the base. The emergent events, then, are never in competition with their base, because there is no longer any base with definite causal powers. None of these alternative conceptions require the rejection of the idea that emergence is strong nomological supervenience, but they introduce some drastic qualifications in the original scheme.

In all these treatments, the base event is not expected to explain the emergent event. While in the cases of reduction there is an explanatory connection between the reducing and the reduced, in the cases of emergence there is no such connection. The lack of explanatory directionality between the base and the emergent, nonetheless, has to be combined with an ontological connection between the base and the emergent level. In the case of reduction, it is surprising that something that seems to be a complex of different things is really ‘the same’ thing. In the case of emergence, on the other hand, what is surprising is that something that seems to

be ‘the same’ thing is really a complex with different entities connected between them, yet really different and where the higher emergent level is not explained by its lower base. In a case in which one comes to know that there is reduction, there is epistemic gain because one comes to know that there is explanatory ‘sameness’ between seemingly different phenomena. In a case in which one comes to know that there is emergence, there is epistemic gain because one comes to know that there is no explanatory ‘sameness’ in what appears to be just one phenomenon.

2. Grounding and dependence

Philosophers have made claims about ‘grounding’ or ‘dependence’ almost since the beginning of philosophical reflection. More attention to those concepts, nonetheless, has been only a recent development. A milestone in these developments was the contribution of Kit Fine on the concepts of ‘essence’ and ‘dependence’ (cf. Fine, 1994, 1995a, 1995b, 1995c). With the development of quantified modal logic, it was assumed that the notions of ‘essence’ and ‘dependence’ could be easily analyzed in terms of the modal operators \Box and \Diamond , or their semantic correlatives, possible worlds and sets of objects assigned as their inhabitants. The obvious analyses of essence and dependence were:

[Essence] F is essential to $x =_{\text{df}} \Box(\exists y (y = x) \rightarrow Fx)$

[Dependence] x depends on $y =_{\text{df}} \Box(\exists z (z = x) \rightarrow \exists v (v = y))$

But all that is guaranteed by these analyses is some modal covariance between entities. Essential properties just are the properties that something has in all possible worlds in which it exists. Something depends on the entities – whatever those may be – that exist in all the possible worlds in which it exists. Modal covariance, nonetheless, is incapable of capturing explanatory asymmetries and different directions of ontological determination. By the definitions of *Essence* and *Dependence*, it turns out that everything is dependent on necessary entities that exist invariably in all possible worlds. If, for example, mathematical objects are necessary, every single object depends on number 2. But it is clear that my identity

– what I am – has nothing to do with number 2. Even more, all facts about essences – according to the definition of *Essence* above – are necessary. Hence, all facts about essences should be part of any essence. Hence, just by knowing one essence one comes to know all essences. In any possible world in which an object x exists it exists also the singleton set $\{x\}$. It seems preposterous to think, though, that x is dependent on $\{x\}$. So, the treatment in quantified modal logic seems to erase important differences in ontological priorities and in the content of non-trivial essences. Something analogous seems to happen with the concept of ‘supervenience.’ Supervenience is just a kind of modal covariance that cannot discriminate the direction of ontological priority. For example, facts about the existence of objects are supervenient on facts about the existence of singleton sets whose elements are those objects. In effect, if there is any variation in facts about whether certain objects exist or not, there should be a variation about whether certain singleton sets exist. Clearly, though, the relation of ontological priority goes the other way around.

The alternative proposed by Fine is to treat ‘essence’ as a primitive. It is just a primitive fact that some properties are part of the content of the essence of something³. The facts of metaphysical modality do not determine facts about essences; rather, it is the other way around. Facts about essences of the different entities determine metaphysical modal facts. Ontological dependence can be analyzed in term of essence. An object x is dependent on y iff it is part of the essence of x that y exists. In the notation devised by Fine (cf. 1995c) ‘it is part of the essence of x that Fx ’ is expressed as ‘ $\Box_x Fx$ ’. Then:

[Dependence*] x depends on $y =_{\text{df}} \Box_x(\exists z (z = x) \rightarrow \exists v (v = y))$

Facts about essences and ontological dependencies are fundamental. Ontological dependence is a strict order, irreflexive, asymmetric and transitive⁴.

The more recent treatments about ‘grounding’ follow the same lines. Grounding has been proposed as a primitive ontological relation, not amenable to analysis by other more basic notions (for general presentations, cf. Correia & Schnieder, 2012b; Clark & Liggins, 2012; Raven, 2015). It does not follow from this primitive character that there is nothing intelligible to say about grounding. The notion should satisfy several theoretical restrictions that, although not suffi-

³ Assuming that it is a primitive fact that some properties are part of the essence of x , other senses of ‘essence’ can be defined. The ‘constitutive essence’ of x is just the collection of properties that constitute the ‘identity’ of x , determining what x is. All the properties that follow from the constitutive essence are the ‘consequential essence’. Then, for example, it is not part of the constitutive essence of x that x is an element of $\{x\}$, but it is part of its consequential essence.

⁴ There has been some dispute about whether dependencies are a strict partial order – that is, irreflexive, asymmetric and transitive, although not connected (cf. Jenkins, 2011; Wilson, 2014; Thompson, 2016; Barnes, forthcoming). But it is obvious that dependence is transitive – by the analysis above in *Dependence** – and it should be taken to be irreflexive. Otherwise all the debates concerning substances as ‘independent entities’ could be unmotivated. It is clear that it is an irreflexive relation of dependence that is in question in those debates. If dependence is transitive and irreflexive, then it should be asymmetric. These considerations do not prevent from stipulating another concept of ‘weak dependence’ that can be analyzed as:

[Weak Dependence] x weakly depends on $y =_{\text{df}} \Box_x((\exists z (z = x) \rightarrow \exists v (v = y)) \vee (x = y))$

That is, weak dependence is strong dependence or identity. Weak dependence is trivially reflexive, transitive and antisymmetric.

cient for a full-fledged analysis, help in making it precise. A primitive concept of grounding will prove fruitful if grounding can illuminate other concepts and do theoretical work that cannot be done otherwise (cf. Rosen, 2010, p. 109-114; Fine, 2012a, p. 40-42; Audi, 2012a; Raven, 2012). Normally, ‘grounding’ has been taken as a *relation* between *facts* (cf. Rosen, 2010; Audi, 2012a, 2012b; Raven, 2012). Some treatments conceive grounding instead as a sentential operator (cf. Schnieder, 2011; Fine, 2012a, 2012b), but the normal treatment of grounding as a relation between facts will be followed here. The expression ‘ $[p]$ ’ should be read as ‘the fact that p ’. The relation of grounding – at least full strict grounding – will be expressed as ‘ \Leftarrow ’; *i. e.*, the expression “ $[p] \Leftarrow [q]$ ” should be read as “the fact that q grounds the fact that p ” or “the fact that p is grounded on the fact that q ”. Grounding is a strict partial order; *i. e.*, it is irreflexive, asymmetric, transitive and non-connected. It is multigrade, because any number of facts can be the ground for another. It is non-monotonic, though, because the grounds of a fact are just the facts sufficient for its obtaining. If $[p] \Leftarrow [q]$, there is no further fact $[r]$ that could be incorporated to the ground for $[p]$. As in the cases of ‘essence’ and ‘dependence’ presented above, ‘grounding’ cannot be analyzed in terms of modal quantified logic. Grounding entails modal covariances but is not equivalent to them. In fact, if $[p] \Leftarrow [q]$, then $\Box(q \rightarrow p)$. That is, grounding entails a strict conditional. Of course, the converse doesn’t hold.

There are weaker concepts of grounding that can be defined in terms of the relation of grounding introduced here. Let ‘partial grounding’ (‘ \Leftarrow ’) be the relation that obtains between certain facts in the case where the partial ground with other facts is a full ground for the grounded fact. That is:

$$[\text{Partial ground}] \quad [p] \Leftarrow [q] =_{\text{df}} \exists [r_1] \dots \exists [r_n] ([p] \Leftarrow [q], [r_1], \dots, [r_n])$$

Another important concept is ‘weak grounding’ (‘ \Leftarrow ’). It is the relation that holds between facts when one of them is a strict ground for the other, or both are identical. That is:

$$[\text{Weak ground}] \quad [p] \Leftarrow [q] =_{\text{df}} (([p] \Leftarrow [q]) \vee ([p] = [q]))$$

Weak grounding is trivially reflexive, antisymmetric and transitive⁵. The notion that will be considered here, though, is ‘full strict grounding’.

Both grounding and dependence are concepts that try to do justice to our intuitions of ontological priority in a way that goes beyond what can be expressed in quantified modal logic⁶. While dependence has to do with what is ‘constitutive-

ly’ necessary for something, grounding has to do with what is ‘constitutively’ sufficient for something (cf. Fine, 2015). The concepts of grounding and dependence allow the definition of two different concepts of ‘ontological priority’ and ‘fundamentality’. In effect, something can be called “fundamental” because it is ungrounded or because it is independent. In the same way, $[p]$ can be called “ontologically prior” to $[q]$ because $[p]$ grounds $[q]$, or because the entity or entities involved in $[q]$ are dependent on the entity or entities involved in $[p]$. More precisely:

$$[\text{Fundamental I}] \quad [p] \text{ is fundamental} =_{\text{df}} \neg \exists [q] ([p] \Leftarrow [q])$$

$$[\text{Priority I}] \quad [p] \text{ is prior to } [q] =_{\text{df}} [q] \Leftarrow [p]$$

$$[\text{Fundamental II}] \quad x \text{ is fundamental} =_{\text{df}} \neg \exists y (x \text{ depends on } y)$$

$$[\text{Priority II}] \quad x \text{ is prior to } y =_{\text{df}} y \text{ depends on } x$$

These two different concepts of fundamentality and priority are not equivalent. Then, something can be fundamental in the first sense without being fundamental in the second sense. In principle, something ungrounded can be dependent and something independent can be grounded.

3. Emergence as ungrounded dependence

As has been pointed out above, something ‘emergent’ is, in principle, something ‘over and above’ its base, or something ‘new’ with respect to its base. What makes things complicated is that the emergent should also have some sort of ontological connection with its base. Elizabeth Barnes (2012) has proposed how to clarify this ‘connectedness’ and ‘novelty’ between what is emergent and its base.

Barnes sustains that something emergent with respect to a certain base should be taken as ‘fundamental’. In the senses of fundamentality described above it is fundamental in the sense I, that is, it is an ungrounded entity. As indicated above, it is perfectly compatible to be fundamental in the sense I with not being fundamental in the sense II. This is precisely what Barnes proposes for emergent entities. They are *fundamental dependent entities*. The emergent turns out to be something ‘new’ with respect to its base because it is not grounded on it, but at the same time there is an ontological connection with that base, because the emergent depends

⁵ It has been pointed out that there are several advantages in using ‘weak grounding’ as primitive instead of ‘strict grounding’. Cf. Fine, 2012a, p. 63-71.

⁶ There have appeared, also, several works offering important reasons for resisting the idea of a general notion of ‘grounding’ and a general notion of ‘dependence’. For example, cf. Wilson, 2014. This is not the place for detailed answers to all those reasons. Wilson argues that all the supposed work that is attributed to the notion of ‘grounding’ is already done by more specific concepts. In part, all the theoretical work that the notions of ‘grounding’ and ‘dependence’ are doing for the elucidation of reduction and emergence – as will be pointed out here – is a response to doubts such as those put forward by Wilson and others.

on it (cf. Barnes, 2012, p. 882-886). Barnes maintains that the typical cases of emergence traditionally discussed can be handled by this new treatment: minds with respect to brains, living beings with respect to their molecular bases, tropes with respect to the other tropes with which they constitute a bundle, or entangled states in quantum mechanics with respect to the particles that compose the state. Barnes also adds the case of 'gunk', not very familiar in the literature on emergence. 'Gunk' is something that has mereological proper parts but none of those parts are mereological atoms. That is, it is a fusion of parts that also have parts, that also have parts, and so on *ad infinitum*. In an ontology of gunk there is no fundamental basic level of objects that might be taken to ground all the others. One may suppose that some 'higher-level' objects can be taken as fundamental. Those objects, nevertheless, are dependent on their proper parts. They are 'emergent' in the sense defended by Barnes. In all these cases, there are properties on the 'higher-level' that seem not determined from the complete state of the base. The higher-level, though, cannot exist without its base. There is no mind without a functioning brain; there is no living being without some or other organic molecules of the right kind; there is no quantum entangled state of two electrons without such electrons; there is no mereological fusion without its parts.

The main objections against the intelligibility of emergence are related to the issue of emergent causation (cf. Kim, 1999, 2006), as indicated above. Barnes thinks that she has an answer for these concerns. For philosophers of physicalist inclinations, causation should be a relation between the 'most basic' physical entities. But emergent facts are not one of the physical building blocks of reality. For physicalists, then, emergent entities should not have new causal powers. But Barnes replies:

Emergent causation is a problem if you situate it within a levels ontology. Once we have levels in place, the physicalist then claims warrant to explain all causation solely in terms of what is absolutely fundamental (the very basic things), which will never include emergent entities. But the analogous claim for the ontological structure assumed here looks to be this: all causation can be explained solely in terms of what is fundamental. In that case, of course, there is no causation problem for emergence, since

emergent entities are fundamental (just not independent) (Barnes, 2012, p. 895-896).

That is, the worry for physicalists is that only fundamental entities should have causal relevance. But in Barnes' conception emergent entities *are* fundamental. So, the problem seems solved. One may point out that in Barnes' conception, although emergent entities are fundamental in sense I, they are not fundamental in sense II, because they are dependent. Isn't this also a problem? Barnes thinks it is not:

You might think that the analogous claim should instead be: all causation can be explained solely with reference to independent entities. But this seems to be too strong. Surely we think that there could still be causation in a gunky world, or that a mass trope can have causal powers, etc. Restricting to independent entities in this way looks unmotivated (Barnes, 2012, p. 896).

The charge against emergent entities is that they are epiphenomenal. Any causal role that an emergent event may fulfill is also a causal role that its base event can fulfill. It seems crucial for the appearance of this problem that the emergent should be supervenient on its base. Anything for which the emergent event might be causally sufficient is also something for which the supervenient base of that same emergent event is causally sufficient. When one considers the situation from the perspective of grounding and dependence instead of supervenience between the entities in question, important differences appear. The main point is that the base event is now not sufficient for the emergent event. As indicated above, the ground of a fact⁷ is something constitutively sufficient for that fact. In Barnes' conception of emergence, emergent entities are fundamental, so there is nothing on which they are grounded. There is nothing, then, on which they might be supervenient on, in the relevant sense⁸.

In the traditional argument against emergence an emergent event or fact E_1 causes another event or fact of the same ontological level E_2 . If E_1 is an emergent event, then it has a base B_1 . It is supposed that E_2 also has a base B_2 – leaving open if it is an emergent event or not. The first problem appears because there are two competitors for explaining the obtaining of event E_2 : event E_1 and its base B_2 . So, under the traditional

⁷ 'Event' and 'fact' are used here interchangeably. There are various theories about the conditions of identity of events. One of the most appealed to is the conception in which the conditions of identity of an event are the property or relation, the objects or objects that instantiate that property or relation, and the time when that object or objects instantiate that property or relation. These are the same conditions of identity postulated for facts.

⁸ Supervenience is simply a concept of modal covariance, so there are possible cases in which, although there is no grounding between two facts, there is supervenience. For example, supervenience is compatible with identity. If facts of type A, for example, reduce to facts of type B, then trivially facts of type A supervene on facts of type B. But grounding is incompatible with identity. Supervenience, also, is compatible with necessary causal connections between different entities, but causation is incompatible with grounding (however, cf. Schaffer, 2016, for a different view about causation and grounding). Nevertheless, in the cases in which philosophers talk about the supervenience of one fact on another they have in mind an asymmetric explanatory relation of ontological non-causal determination, i. e., grounding.

scheme the only way in which event E_1 can be causally efficacious for the production of E_2 is by the downward causation of the base B_2 . But now, under the new conception of emergence, clearly there is no competition for the explanation of the obtaining of E_2 . The base B_2 is not sufficient for that explanation. Event E_2 is dependent on B_2 , but it is not grounded on B_2 . If event E_1 is going to be causally efficacious for the production of E_2 it should cause the base B_2 , but that base is not sufficient for E_2 , so that it is not by causing B_2 that E_1 causes E_2 . On the other hand, the base B_1 is not sufficient for E_1 , because E_1 is not grounded on it. One cannot say, then, that the way in which E_1 causes E_2 is by the fact that B_1 causes B_2 . Neither the base B_1 is sufficient for causing B_2 , nor the base B_2 is sufficient for the obtaining of E_2 .

A brief comparison shows the advantages of this treatment with respect to the previous proposals by Humphreys (1997), O'Connor (2000, p. 108-125) and O'Connor & Wong (2005). With respect to Humphreys' proposal, it is not necessary here to introduce a primitive *sui generis* operation of 'fusion' between properties. The general ontological relations of grounding and dependence are enough. With respect to O'Connor's and O'Connor & Wong's view in which emergence is a diachronic and dynamic, it is not necessary to introduce temporal differences between the obtaining of the base and the obtaining of the emergent level.

4. Reduction as grounding?

There seem to be two main contentions in a claim of reduction, as indicated above: (i) that the reduced and the reducing entities are – in some sense – the 'same', and (ii) that the reducing entities have explanatory priority over the reduced ones. These two contentions seem to be – in a way – captured in a claim of grounding. In the first place, claims of grounding seem to be claims of non-causal explanation, following a direction of explanation from the ground to the grounded (cf. Fine, 2012a, p. 37-40; Audi, 2012a, p. 102-108; 2012b; Correia & Schnieder, 2012b, p. 22-24). In the second place, the ground of something is 'constitutively sufficient' for it, that is, sufficient for the obtaining of the grounded fact due to what this grounded fact is, *i. e.*, its essence (cf. Fine, 2012a, p. 74-80; 2015). So, in some sense, the grounded fact seems to be 'nothing over or above' its ground. Fine says, commenting on some cases of grounding:

It is for this reason that it is natural in such cases to say that the explanans or explanantia are constitutive of the explanandum, or that the explanandum's holding consists in nothing more than the obtaining of the explanans or explanantia (Fine, 2012a, p. 39).

It is notorious that here Fine uses the typical expressions by which reduction is characterized. Even more, the cases of grounding often cited coincide with cases in which

some kind of reduction has been in view: normative and non-normative facts, dispositional and categorical facts, or semantic and socio-psychological facts (cf., for example, Rosen, 2010, p. 110-111; Audi, 2012a, p. 106). Rosen has also proposed that the best way of formulating a general naturalistic metaphysics is by appealing to 'grounding'. A naturalist is a philosopher that sustains that everything is grounded on 'natural' fundamental facts (cf. Rosen, 2010, p. 111-112; they are fundamental in the sense I presented above). This sounds very close to saying that everything 'reduces' to natural facts.

The most precise and explicit treatment of the link between reduction and grounding has been made by Gideon Rosen (cf. 2010, p. 122-126). The link he proposes is straightforward: reduction entails grounding. Any claim of reduction should be correlated, then, by a connected claim of grounding. There are several aspects of the way in which Rosen presents the question that seem peculiar. 'Reduction' is taken as a relation between propositions in which an 'account' is given of the entities constituting the reduced propositions:

As I understand the notion, reduction is a metaphysical matter. To say that p reduces to q is not to say that p and q are synonymous, or that q gives the meaning of p . It is to give an account of what it is for p to obtain (Rosen, 2010, p. 122).

The main difference between reduction and grounding is that, while grounding is a relation between facts, reduction is a relation between propositions. In the way in which Rosen envisages propositions and facts, both are structured entities constituted by objects and properties. For every proposition, there is a corresponding fact, and vice-versa. The 'proposition that p ' is expressed as " $\langle p \rangle$ ". Then, the link reduction/grounding can be expressed thus:

[Reduction-Grounding Link] If $\langle p \rangle$ is true and $\langle p \rangle$ reduces to $\langle q \rangle$, then $[p] \Leftarrow [q]$.

Reduction claims show what it is for the reduced proposition to obtain. Rosen considers as cases of reduction, for example (cf. Rosen, 2010, p. 123-125), that to be equal to 2 reduces to be equal to the successor of 1; that for the number of F s to be equal to the number of G s reduces to there being a one-to-one and onto function between the F s and the G s; that to be a bachelor reduces to be an unmarried male; or that to be a square reduces to be an equilateral rectangle. There is an obvious problem with this proposal, though. The property of being a bachelor just seems to be identical to the property of being an unmarried male. It seems to be numerically the same property. But grounding is an irreflexive relation. Then, it seems impossible for the property of being an unmarried male to ground the property of being a bachelor, because nothing grounds itself. The solution Rosen offers for this problem gives us pause:

We can resist this line of thought by insisting that the operation of replacing a worldly item in a fact with its real definition never yields the same fact again. It yields a new fact that 'unpacks' or 'analyzes' the original. To see that this is plausible, consider an example involving the real definition of an individual. Suppose for the sake of argument that to be the number two just is to be the successor of 1. In our notation, for all x , $\langle x = 2 \rangle$ reduces to $\langle x = s(1) \rangle$. One might accept this while rejecting the exotic view that the number 2 somehow contains the number 1 as part or constituent (Rosen, 2010, p. 124-125).

According to Rosen, all cases of reduction are cases of grounding – that is, full strict grounding – because all the cases in which it appears that there are different representations of the same property, fact, or phenomenon are cases in which there are really *different* properties, facts or phenomena.

More clarity about the issues involved here requires more clarity about the *relata* of grounding and, eventually, about the *relata* of reduction. As indicated above, usually philosophers have postulated 'facts' as *relata* for grounding. In general, a 'fact' is conceived as a structured entity with properties and objects as constituents. Of course, different metaphysical positions concerning the nature of a particular object or the nature of a property induce also differences in this general scheme. If one, for example, maintains that objects are bundles of properties, then there will be no need to posit objects besides properties as constituents of facts. If one maintains that there are no properties, because – for example – classes of resembling objects are sufficient for all the functions attributed to properties, then there will be no need to posit properties besides objects as constituents of facts. The distinction that is of relevance here, nevertheless, is that between 'sparse' and 'abundant' properties. It is not important to detail here what fulfills the functions usually attributed to a property – universals, tropes, resemblance classes of objects, etc. There are two broad sets of functions that properties are expected to fulfill and these sets of functions determine either a conception in which properties are 'abundant' or a conception in which properties are 'sparse' (cf. Lewis, 1983, p. 10-19). Among the philosophers that have proposed theories of grounding some have preferred facts with 'coarse-grain' conditions of identity and others have preferred facts with 'fine-grain' conditions of identity (cf. Correia & Schnieder, 2012b, p. 14-16). Facts with 'coarse-grain' conditions of identity are correlated with 'sparse' properties as constituents. Facts with 'fine-grain' conditions of identity are correlated with 'abundant' properties as constituents.

'Sparse' properties are those that must appear in a complete description of reality. They determine what causal powers have their bearers. Laws of nature should include those properties. Possession of those properties determines objective resemblances between objects. We come to know what 'sparse'

properties exist normally by empirical research and not only by a priori reflection. It usually is natural science who decides what properties really exist and not the philosopher. When it comes to 'abundant' properties, on the other hand, there are as many as sets. For any collection of objects there is a property that those objects and only those objects instantiate. There is a property instantiated by anything that is 'grue', for example. There are negative properties, like the property instantiated by all and only objects that are not quarks. There are enough abundant properties to assign semantic values to any possible predicate of our languages or for a language of angels.

'Facts' are essentially the instantiation of a property in an object at a time – or the instantiation of a relation in some objects at a time. Its conditions of identity are those property, object – or objects – and time. If two facts are constituted by the same property, the same object – or objects – and the same time, then they are the same fact. The problem here is that there is a big difference if properties are taken to be 'sparse' or 'abundant'. For a defender of sparse properties there are facts only for real properties for which it makes sense to be – or not – instantiated in something. It might be true, for example, that ' x is not a quark' but there is no 'fact' of x being a non-quark. There is no negative property of being a non-quark. If there is no such property, then there is no such fact. Of course, also, there may be different expressions for referring to the same property. If heat is identical to mean molecular kinetic energy, then the fact of there being a lot of heat here is the same fact of there being a lot of mean molecular kinetic energy here. Not any sentence in our languages is correlated with a corresponding 'fact'. Although it seems easy to put square brackets around a sentence p , there is no guarantee that the expression $[p]$ is successful in referring to a fact if properties are taken as 'sparse'. This situation is completely different if facts are constituted by 'abundant' properties. It doesn't matter if the predicate of a sentence is satisfied by extremely heterogeneous objects. A predicate can be as gerrymandered as "grue" or "bleen". There is certainly a unique property that all and only the objects that satisfy that predicate will instantiate. There are, then, negative and disjunctive facts. And, what is more relevant for the discussion here, facts that under a 'sparse' conception of properties may be identified, are kept distinct and separate under an 'abundant' conception of properties.

Then, if the suggestion of Rosen that there are different facts of being a bachelor and being an unmarried male is going to work, it is clear that a 'fine-grained' conception of the conditions of identity of facts is required. Somehow, it should be justified that the property – if there is any – of being a bachelor is different from the property of being an unmarried male; or that the property of being a square is different from the property of being an equilateral rectangle. It is characteristic of theories of 'abundant' properties that the conditions of identity of properties are determined by their compositional structure (cf. Jubien, 1989; Swoyer, 1998). Even if it is necessary that everything instantiates P_1 if and only if it instantiates P_2 , properties P_1 and P_2 may be different. Suppose that property P_1 is 'atomic' or 'basic', while P_2 results from the

conjunction of properties P_3 and P_4 . The compositional structure of P_2 differentiates it from P_1 , even if the causal powers given by both properties were the same. Then, for example, the property of being a square is different from the property of being an equilateral rectangle. The latter includes as constituents two properties while the former has no constituents.

But how wise is it to endorse a fine-grained conception of facts and the *Reduction-Grounding Link*? Any decision between fine-grained and coarse-grained facts requires a decision as to whether properties are really 'sparse' or 'abundant'. Obviously, that cannot be done in this work⁹. There are, nevertheless, additional reasons to reject outright the *Reduction-Grounding Link*. Such a link could have unacceptable consequences. If Rosen is right, then heat, for example, should be something different from mean molecular kinetic energy; genes should be different from DNA molecules; and light should be different from beams of photons. Whatever the problems involved in these particular examples as examples of reduction, there seems to be something wrong in the contention that – in virtue of the nature of the relation of reduction – if we come to have justification enough to endorse a claim of reduction in any of these cases, then we will be obliged to postulate the ontological difference between the reducing and the reduced. There is never a case in which we gain epistemic understanding by coming to know that what seem to be different entities, properties or phenomena are just the same. He rejects the cases of explanatory identity in which learning that, for example, two properties are identical has explanatory value. The identification of reduction with grounding, far from being an elucidation of the former, turns out to be its denial. Even granting to Rosen that many cases of purported reduction of some facts to others are really cases of full strict grounding, he should allow at least for the *possibility* of cases in which two properties, facts or phenomena are identical, and in which learning this has explanatory value. It may be wise to reserve the expression "reduction" precisely for those situations. In any case, if one prefers to use the expression "reduction" not so strictly, one must admit that there can be situations of explanatory identity that are *not* cases of grounding.

5. Conclusions

Recent developments concerning the concepts of 'grounding' and 'dependence' have brought important advantages. Those concepts seem more precise and ontologically more suited for the treatment of ontological relations of

priority. It is clear that some kind of ontological relations of priority is involved in the many cases traditionally treated as cases of reduction or cases of emergence. What the examination of the proposals of Rosen and Barnes shows is that these connections look promising, but with mixed success.

With respect to the connection of reduction with grounding proposed by Rosen, the *Reduction-Grounding Link* seems not advisable. The most typical cases of reduction appear to be cases of identification of properties, facts or entities, but identity precludes grounding. Maybe many traditional cases of reduction are really cases of grounding, but certainly there is a conceptual distinction that should be respected between grounding and identities with explanatory value. In the case of emergence, though, the treatment proposed by Barnes seems correct, simple and better suited than its previous alternatives to handle some traditional difficulties.

Then, the introduction of the concepts of grounding and dependence allows us to fix certain important ontological relations that determine what is usually characterized as 'ontological levels.' There is *grounding* of one fact by other or others – which presupposes the numerical differences between the grounded fact and the grounding fact. There is *dependence* of one entity on another. An ungrounded dependent entity is *emergent*. There is the case, also, in which facts or entities that seem to be numerically different are really identical. When there is explanatory gain in learning about this identity, it is a case of *reduction*. Of course, there is the case in which a supposed fact simply does not exist, and all the theoretical work attributed to the putative entity is done by another. This is a case of *elimination* – that is incompatible both with grounding and dependence. There is, finally, the case of an independent grounded entity. A case like this is the contrary of emergence and corresponds to what has been called *realization*. More precision in the treatment of these different concepts, and in the different kinds of ontological 'priority' and 'fundamentality' that result, is very welcome¹⁰.

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⁹ Of course, there are reasons to prefer one or the other conception of properties. 'Abundant' properties seem to be too close to the way in which we represent things, or in which things appear to us. Why should we distinguish, for example, between the properties of being an equilateral rectangle and of being a square? Because someone can *believe* that x is a square while at the same time not believing that x is an equilateral rectangle. But that seems a conflation of epistemic and ontological issues not advisable for an ontological theory of grounding.

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