

# Sixteen Years Later: Making Sense of Emergence (Again)

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**Abstract** Sixteen years after Kim’s seminal paper offering a welcomed analysis of the emergence concept, I propose in this paper a needed extension of Kim’s work that does more justice to the actual diversity of emergentism. Rather than defining emergence as a monolithic third way between reductive physicalism and substance pluralism, and this through a conjunction of supervenience and (functional) irreducibility, I develop a comprehensive taxonomy of the possible varieties of emergence in which each taxon—theoretical, explanatory and causal emergence—is properly identified and defined. This taxonomy has two advantages. First, it is unificatory in the sense that the taxa it contains derive from a common unity principle, which consequently constitutes the very hallmark of emergentism. Second, it can be shown that the emergence taxa it contains are able to meet the challenges that are commonly considered as being the hot topics on the emergentists’ agenda, namely the positivity, the consistency and the triviality/liberality challenges.

**Keywords** Downward causation · Emergence · Physicalism · Realization · Reduction · Supervenience

[L]ike alcohol, it [the concept of emergence] is a stimulant only in proper doses: many who have used it have gotten drunk in the attempt to apply it to everything. (Ablowitz 1939, 16).

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## 1 Introduction: The Emergence Addiction

In his landmark paper “Making Sense of Emergence” published 16 years ago, Jaegwon Kim somewhat half-heartedly acknowledges that emergence—and more generally, emergentism—has recently made a “strong comeback” that may be rendered explicit by “an increasing, and unapologetic, use of expressions like ‘emergent property’, ‘emergent phenomenon’, and ‘emergent law’ [...], not only in philosophical writings but in primary scientific literature as well” (Kim 1999, 4). Such a comeback, which has now classically come to be called “the reemergence of emergence”,<sup>1</sup> seems to largely mirror—as the opening passage indicates—a situation of “minor philosophic furor” (Ablowitz 1939, 1) that occurred in the 1920s in the wake of the advent—and the subsequent premature decline—of the doctrine of emergent evolutionism.<sup>2</sup> While Ablowitz and Kim’s diagnosis of an increasing use of emergence rhetoric is perfectly well-founded, it is everything except an undue assertion to claim that the enthusiasm for emergence, as well as related holistic ideas, has currently—respectively 76 and 16 years later—become still far more acute. Following respected scientists who openly claim that “science has now moved from an Age of Reductionism to an Age of Emergence” (Laughlin 2005, 208) or that we have moved “beyond reductionism into a scientific worldview that includes “emergence”” (Kauffman 2008, 120), it may indeed be fairly argued that emergence is today an integral and important part of the contemporary science practice.<sup>3</sup>

Nevertheless, borrowing from Ablowitz’ alcohol analogy presented as an opening inscription, it may be said that the still-growing dissemination of emergence in scientific discourse today verges on a dangerous addiction. It becomes indeed more and more difficult to find a scientific field still free of emergence, and it is almost commonplace for every working scientist to claim that the phenomena she is dealing with—from entanglement in quantum mechanics to ecosystem dynamics in ecology—constitute the paradigmatic instantiations of an emergent behavior.

As with any kind of addictive substance, such an excessive use of emergence has some detrimental effects. To begin with, the very high heterogeneity of the putative exemplifications of emergence renders it delicate to identify what would constitute the unity of the concept. If there is no common thread that runs through its possible instantiations, emergence is nothing but a linguistic tool at the service of a flashy rhetorical exercise. In scientific or philosophical debates, then “the only thing participants share is the word “emergence” (Kim 2006, 548) or—according to thinkers less charitable to emergentism— “the buzzword emergence” (Weinberg 1992, 39). Secondly, it is commonplace that the broader a concept’s extension is, the weaker its instructive value is. If one reasonably wants the labeling of a given phenomenon as “emergent” to have some epistemic significance—in the sense that learning that a given phenomenon is emergent teaches us something non-trivial about this phenomenon—, then one should be careful not to be prone

<sup>1</sup> Initially owing to Bryon Cunningham’s eponymous paper (Cunningham 2001).

<sup>2</sup> One can find early traces of this doctrine in Lloyd Morgan’s *Spencer’s Philosophy of Science* (1913), in which the author introduced the concept of emergence in literature since it had been originally and somewhat anecdotally coined by George Henry Lewes in 1875. Emergent evolutionism has subsequently been mainly championed through Morgan’s *Emergent Evolution* (1923) and, in a closely related way, Roy Wood Sellars’ *Evolutionary Naturalism* (1922).

<sup>3</sup> Beside the evocative fact that entire journals and popular works are now dedicated to emergence, evidence of this may be found in the fact that emergence has now been introduced into textbooks for students. For example, in a popular biology textbook, emergence is presented as one of the big “themes in the study of life”, even before the key notions of cell, heredity and evolution (see Reece et al. 2010, introduction).

to considering anything and everything as paradigmatic exemplifications of emergence. In the limiting case where *everything* emerges—from quantum systems to ecosystems and beyond—emergence becomes empty of content and useless.<sup>4</sup>

Claiming that “too much (frequently thoughtless) emergence is bad for emergence” does not mean that there are not very good reasons to invoke the concept or to be an emergentist. The emergence addiction certainly finds its impetus in the potential fruitfulness of the concept, and it is even plausible that the extent of the addiction is in good proportion with the force of the promises that emergence is often supposed to fulfill. Essentially, such promises may be gathered into three (non exclusive and non independent) categories. First—call this the *ontological* promise—, emergence would be an efficient tool to conciliate some form of scientifically respectable monism with the safeguard of some important bits of reality against reduction and elimination. Typically but not exclusively, this first issue is vivid when it comes to anything that is related to a so-called “human nature” (e.g. free will). In this particular context, emergence would allow to leave untouched the privileged status of “specifically human qualities” in spite of their naturalization (see for instance Jennings 1927; Sellars 1959; or Sperry 1983). Beside resisting what would be an ontological impoverishment of the natural world, emergence is also regularly used to vindicate the autonomy of the special sciences against what is commonly seen as a physics enthusiastic imperialism, which has historically been conveyed through pejorative catch phrases framed on the model of Rutherford’s famous claim that “in science, there is only physics; the rest is stamp collecting” (quoted in Kim 2010, 282; with regard to this *epistemic* promise, see for instance Bunge 1982 [for chemistry]; Mayr 2004 [for biology]; and Sawyer 2002 [for psychology]). Thirdly and lastly, emergentism is supposed to fulfill an ambitious *theoretical* promise, namely to constitute a solution to numerous old philosophical disputes. For example, in the philosophy of chemistry, biology and mind, emergentism has been put forward as a way of dissolving, respectively, the mixture-compound debate, the vitalism-materialism knot as well as the mind-body problem. Given such high ontological, epistemic and theoretical stakes, it is no wonder that so many philosophers and scientists have been—and are still currently—strongly attracted by the emergence idea.

It may actually even be suspected that the balance between the possible fruitfulness and the frequent emptiness of the concept of emergence—emptiness of which the emergence addiction is a symptom and which may be the consequence of an intrinsic contradiction or a trivial characterization (see the “consistency” and the “triviality/liberality challenges” below)—is an explanation of the coexistence of two extreme and opposite trends in past and present literature on the topic: on one hand, an *enthusiastic trend* that risks falling into emptiness by being blinded by fruitfulness; on the other hand, a *suspicious trend* that prefers to sacrifice fruitfulness to avoid emptiness.<sup>5</sup>

<sup>4</sup> Actually, considering that everything emerges is not a fanciful view invoked here only for the sake of the argument. Classical as well as contemporary emergentists have embraced—and continue to embrace—such a view (see for instance Morgan 1923; Morowitz 2002). It may be noted that one should qualify the assertion “everything is emergent” by saying that everything *but the elementary pieces of reality*—supposing these exist and whatever their very nature is—and *maybe some idealized “pure” aggregates of them* is emergent.

<sup>5</sup> Of course no thinker really is—or will admit she is—a proponent of the first trend so presented, insofar as it has been voluntarily caricatured. Nevertheless, as it will be argued later in this paper, some thinkers conceptualize emergence in a way that may be considered empty of content, insofar as their concept is either unstable—if not thoroughly inconsistent—or trivial. Since they are more prone to show their faces, proponents of the second trend are easier to identify. Either they advocate an abandonment of what they consider to be a spooky or kooky notion (Weinberg 1992), or they adopt a less radical deflationary attitude by construing the concept in a less ambitious way, see for instance the notion of “relative emergence” in

In this paper, I will primarily adopt a neutral attitude that is neither enthusiastic about, nor suspicious of, emergence and emergentism. Supposing that there may be some good and bad things in the notion, I will try to separate the wheat from the chaff in order to render emergence as simultaneously instructive and fruitful as it could be. To this purpose, I will follow the footsteps of philosophers who—on the model of Kim himself—have actively contributed to rendering emergence intelligible or to “making sense of emergence”. In particular, such an objective will be achieved through the building of a comprehensive taxonomy of the possible varieties of emergence, a taxonomy in which each taxon will be (i) constructed and properly identified (Sects. 2, 3), (ii) precisely defined on the basis of positive criteria that refer to the constitutive and causal dynamics of natural systems and (iii) univocally ordered between radical reductionism and outright dualism on the basis of an intuitive metric (Sect. 4).

Even if clarifying emergence by identifying its possible declinations is a conceptual task that has already been carried out on different occasions,<sup>6</sup> the analysis I propose in this paper offers several non-negligible advantages. First, it consists in a *unificatory* clarification of emergence, i.e. rather than providing a mere list of the varieties of emergence that philosophers and scientists have been using in different contexts, it shows how the possible forms of the notion derive from a minimal commitment to a common principle of unity, a principle which may consequently be legitimately considered as the very hallmark of emergence. Secondly, by providing a precise characterization of the varieties of emergence, I will show in Sect. 5 how each of them is able to deal with the different following challenges, which are commonly considered as being the hot topics on the emergentists’ agenda:<sup>7</sup>

- *The positivity challenge* Since its very advent in the doctrine of emergent evolutionism, emergence lacks a *positive*—and hence plausibly instructive—characterization. For example, stating that emergence is a failure of theoretical prediction or simulation, or that it amounts to a conjunction of supervenience and irreducibility, does not say so much about what emergence actually is.<sup>8</sup> Symptomatic of the failure to meet the positivity challenge is the impossibility of knowing precisely if emergence is primarily a matter of epistemology or ontology.
- *The consistency challenge* As it will become clear in the next section, emergence always encounters the risk of being unstable if not self-contradictory. Such a risk manifests itself at the epistemic level—where it is indeed *prima facie* difficult to understand how an emergent phenomenon may be simultaneously determined by, but unexplainable on the basis of, its lower-level basis of emergence—as well as at the

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Footnote 5 continued

Malisoff (1939); or Hempel and Oppenheim (1948); the concept of “weak emergence” in Bedau (1997); or emergence as a “visualization constructed in the mind of the observer” in Ronald et al. (1999, 228).

<sup>6</sup> Beginning as early as Lovejoy (1927). More recently, see for instance Stephan (1999a), Van Gulick (2001), Cunningham (2001), Gillett (2002), Deacon (2007), or Bedau (2010). On the model of all these analyses, I focus on the “synchronic” form of emergence in this paper, and leave aside its “diachronic” declination. More on this distinction can be found in Sartenaer (2015).

<sup>7</sup> For an identification of the first two challenges, see for instance Kim (2006) and more recently Garrett (2013). For the triviality/liberality challenge in the two forms described below, see respectively Berenda (1953), Huneman (2008) or Kim (1998, chapter 3) for discussion; and Smart (1981) or Delehanty 2005.

<sup>8</sup> Another possible and connected trouble for emergentism—call it the *novelty challenge*—is to provide a positive characterization of what assertions like “emergent properties are *new* properties” are supposed to mean, insofar as novelty is usually defined negatively, either as an epistemic limitation or as an antecedent non-existence.

ontological level—where it demands indeed some speculative effort to conceive how an emergent entity may be dependent on its basis and yet somehow autonomous from it.<sup>9</sup> Failing to meet the consistency challenge is often a reason why emergence appears to be mystical or enigmatic.

- *The triviality/liberality challenge* In order to make emergence at least minimally instructive, it is necessary to avoid defining the notion in a too liberally way. Two typical examples may be mentioned in this respect. First, claiming that “an emergent property of a whole is a property that none of the whole’s constituents has” is certainly true, but also quite trivial.<sup>10</sup> It indeed merely amounts to a recognition of the fact that combinations of properties give rise to *different* properties, either in the qualitative sense (e.g. synthesizing gaseous dihydrogen and dioxygen yields liquid water) or even in the quantitative sense (e.g. piling up thousand bricks weighting one kilogram yields a one ton wall), a fact that no proponent of reductionism, even the most radical, will be prone to deny. Things are similar with respect to accounts according to which an emergent phenomenon is not reducible to its underlying parts *in isolation*.<sup>11</sup> It is actually a far too strong requirement for reductionism—and consequently a too liberal condition for emergence—to merely exclude the possibility of invoking relations between the system constituents as well as their relations with the environment. Without further qualification, both of these liberal accounts render emergence ubiquitous, and hence empty of any significative content.

## 2 The Unity of Emergentism

As far back as one can trace the history of the doctrine—up to British Emergentism and beyond<sup>12</sup>—emergentism has always been put forward as a middle course between radical monism and dualism (or more generally pluralism). A conciliatory and intermediate view between such classical antagonistic stances has indeed been, and is still currently, a repository of hopes to fulfill the promises of emergence—a denial of pluralism (or “a little bit of monism”) being the ingredient to ensure a minimal compatibility with the scientific image, and a denial of monism (or “a little bit of pluralism”) being the ingredient to avoid full-blooded reductionism.

In this respect, emergentism has always been somehow committed to the following theses that together capture the unity of the doctrine:<sup>13</sup>

<sup>9</sup> In this particular ontological context, the consistency challenge often takes the form of what may be called Kim’s *causal challenge*, which consists in giving a coherent account of the causal autonomy of emergent entities (e.g. through downward causation), essentially in the face of causal overdetermination.

<sup>10</sup> Such liberal account has been endorsed in Bunge (1977). It is now more often endorsed by scientists in popular works (see for instance Reisse 2006; or Lestienne 2012).

<sup>11</sup> For example, such account of irreducibility is endorsed in Williams (1998). For a short discussion of Williams’ view, see Melnyk (2003, 219).

<sup>12</sup> For historical analyses of British Emergentism, see Blitz (1992), McLaughlin (1992), Stephan (1992), and Stephan (1999b). For identifications of earlier versions of what may be called “proto-emergentisms”, see for instance Fagot-Largeault (2002) (proto-emergentism in French spiritualism), Malaterre (2007) (proto-emergentism in neo-vitalism), Clayton (2004) (proto-emergentism in Plotinian emanationism), Heinaman (1990), and Caston (1997) (proto-emergentism in Aristotelianism), or Ganeri (2011) (proto-emergentism in Indian philosophy).

<sup>13</sup> For the sake of generality, I speak here of emergent *entities* in place of properties, laws, processes, or whatever other relata of emergence one would want to consider.

- *The continuity (or homogeneity) thesis* An emergent entity is *continuous* with its emergence basis (or an emergent entity and its emergence basis are *homogeneous*).
- *The discontinuity (or heterogeneity) thesis* An emergent entity is *discontinuous* with its emergence basis (or an emergent entity and its emergence basis are *heterogeneous*).

While the continuity thesis captures a *monistic* demand, in the sense that it states that emergents are not purely disconnected from their basis, the discontinuity thesis constitutes a *pluralistic* commitment, insofar as it specifies that emergents are not merely identical to their basis.

It is noteworthy that there is an implicit reference in these theses to an important emergentist tenet, namely the fact that there exists some form of hierarchical order in nature, by virtue of which a minimal sense may be given to the idea that emergent entities are “higher-level” entities with regard to their “underlying” bases of emergence.<sup>14</sup> It may also be noted that the traditional emergentist maxim—“The whole is more than the sum of its parts”—constitutes a sufficient criterion for being committed to the continuity and discontinuity theses. While acknowledging a part-whole relationship is indeed a minimal recognition of continuity in emergence, claiming that an emergent whole “is more than” the mere aggregation of its underlying parts also constitutes an acknowledgment of some form of discontinuity in emergence. Claiming that “the whole is more than the sum of its parts” is nevertheless not a necessary criterion for emergence, for the continuity and discontinuity theses allow considering emergence in non-mereological cases—e.g. in cases that involve “causal roles” and their “role fillers” that are located at the same compositional level, that is, in cases of “flat realization” (Gillett 2003).

The emergentist unity principle so construed renders explicit the consistency challenge I have described above. How is it possible to *simultaneously* maintain the theses of continuity and discontinuity? In other words, how is it possible to deny both monism *and* pluralism? In the particular mereological cases, how is it possible for a whole to be composed of its parts *and* at the same time to be “something more” than its parts? To borrow from Ablowitz’s own terminology, is this not an “appealing paradox” (Ablowitz 1939, 2)? Even if it is true that some varieties of emergence may fall short of answering these questions in a satisfactory manner, I will show in Sect. 5 how one may secure the consistency of emergence for the different kinds of concept that I will identify. At this point, I can confine myself to giving an outline of the (often implicit) emergentist strategy of avoiding outright inconsistency: creating a discrepancy between the scopes of continuity and discontinuity, in the sense of considering an emergent to be continuous *in some  $R_1$  respect*, and discontinuous *in some  $R_2$  respect*, with its emergence basis (with  $R_1 \neq R_2$ ). As a consequence, emergentism of this sort is committed to some form  $F_1$  of monism and to some *other* form  $F_2$  of pluralism. For example, claiming that water liquidity is a property E that emerges from a set of basal properties  $\{B_i\}$  in which figure the properties of oxygen and hydrogen, in the sense that (i) E is univocally determined by  $\{B_i\}$  and (ii) E cannot be adequately explained on the basis of a full knowledge of  $\{B_i\}$ , is arguably a consistent move, insofar as it does not construe continuity and discontinuity in the very same respect. Actually, the continuity involved in this illustration is *compositional* continuity whereas the discontinuity involved is *explanatory* discontinuity. Such an emergentist claim may then be considered as a *prima facie* consistent commitment to some form of *ontological* monism and *epistemological* pluralism.

<sup>14</sup> Since it would lead me too far away from my initial purpose, I will not discuss this “layered” view of nature in this paper. For useful discussions, see Emmeche et al. (1997), or Kim (2002).

Beside capturing the traditional emergentist maxim, the unity principle identified here is faithful to the common uses of emergence, both in past and present emergentisms. As far as old-style emergentism—e.g. British emergentism and its foreign declinations—is concerned, one may highlight the common commitment to the two theses of continuity and discontinuity with the help of the following sample of quotations:<sup>15</sup>

Mind is thus *at once new and old*. No physiological constellation explains for us why it should be mind. But at the same time, being thus new, mind is through its physiological character continuous with the neural processes which are not mental. It is not something distinct and broken off from them, but it has its roots or foundations in all the rest of the nervous system. It is in this sense that mind and mental process *are vital but not merely vital*. (Alexander 1920, 8. Emphasis mine)

We shall argue that there are levels of causality in nature and that new properties and capacities arise with novel integrations. We shall aim to show that *genetic continuity does not conflict with logical discontinuity*. (Sellars 1922, 322. Emphasis mine)

The theory that organic responses have mental quality in the degree to which they deal with the uncertain recognizes *both continuity and difference* [...]. There is *neither a sudden jump* from the merely organic to the intellectual, *nor is there complete assimilation* of the latter to primitive modes of the former. (Dewey 1929, 220. Emphasis mine)

While being often quite different from classical emergentism, today's forms of emergentism may also be viewed as particular ways of construing the continuity and discontinuity theses, with an emergent entity being “dependent” on, but “distinct” from its underlying parts (Crane 2001), “constituted” by its parts, but “autonomous” from them (Bedau 1997), or finally “supervenient” on, but “irreducible” to them (Kim 1999, 2006).

Before turning to the next section, it is worth drawing attention to the fact that, while being extremely general and therefore liberal, the unity principle proposed here for emergence has a normative connotation, by virtue of which some particular conceptualizations of emergence existing in literature are *ipso facto* ruled out as “genuine” forms of emergence.<sup>16</sup> Such a restriction should nevertheless not be taken too seriously, in the sense that ruled out concepts, i.e. concepts that fail to meet the continuity and discontinuity theses, may be consistent, useful or fruitful. There are just good reasons to consider that they differ too drastically from usual emergence to be qualified as forms of emergence without further confusing the debates.

### 3 The Plural Unity of Emergentism: Building a Taxonomy of Emergence

While the aforementioned continuity and discontinuity theses capture the prime unity of emergentism, their very equivocality also makes this unity *plural*. There exist indeed numerous different ways of construing and conciliating both theses, and each of these ways may be associated with a particular form of emergence. With this idea in mind, it is

<sup>15</sup> As an attempt to cover different emergentist trends, this sample is voluntarily heteroclitic. It includes quotes from a “classical” British emergentist (Alexander), an American proponent of emergent evolutionism (Sellars) and a co-founder of pragmatism who developed an emergentist theory of mind (Dewey).

<sup>16</sup> For example, Van Gulick’s “radical emergence” falls short of meeting the continuity thesis, insofar as it implies a lack of bottom-up determination (Van Gulick 2001).

possible to develop a twofold analysis at the term of which different taxa of emergence may be identified. Since the successive steps of such an analysis have already been extensively described elsewhere (see Sartenaer 2011; Sartenaer 2013), I provide only a summary of it in this section. Section 4 will then be devoted to providing precise definitions of the emergence taxa and to showing how these taxa deal with the challenges described in the introduction.

### 3.1 Representational and Causal Emergence

Presuming it is necessary to conciliate a certain form  $F_1$  of monism with another form  $F_2$  of pluralism in order to consistently meet the emergentist unity principle—and hence to be an emergentist—, identifying the available emergentist strategies requires one to distinguish between different kinds of monism and pluralism and to assess their mutual compatibility. The following three kinds of monism will be discussed here—the corresponding kinds of pluralism being merely their negation:<sup>17</sup>

- *Substance monism* All natural entities are ultimately and exclusively composed of physical elementary particles.
- *Property monism* All properties are ultimately and exclusively realized by (combinations of) physical elementary properties.
- *Predicate (and proposition) monism* All scientific predicates are ultimately and exclusively definable as (combinations of) physical elementary predicates (and consequently all scientific propositions are deducible from physical elementary propositions).

Taking for granted some relations of entailment between these varieties of monism, namely that predicate monism entails property monism which entails substance monism, it is only possible to identify the following four non-contradictory views:<sup>18</sup>

- *Reductive physicalism* as being predicate monism (and hence property and substance monism).
- *Non-reductive<sup>R</sup> physicalism* as being the conjunction of property monism (and hence substance monism) with predicate pluralism.
- *Non-reductive<sup>C</sup> materialism* as being the conjunction of substance monism with property pluralism (and hence predicate pluralism).
- *Substance pluralism* (and hence property and predicate pluralism).

<sup>17</sup> I am not construing here the notion of substance as necessarily referring to something that has an independent existence or that persists through time. Rather I simply consider substances to be property carriers. I also adopt the causal theory of properties and the metaphysical presupposition that, contrary to the thesis of the “infinite descent”, there exists in nature something like a fundamental level populated by elementary objects. I also only consider each form of monism in its materialistic or physicalistic declination, leaving out other options like idealism, mentalism, etc. Finally, I take here “realization” in the broad sense of constitution that can either be compositional or non-compositional, a difference that can be captured by Gillett’s (2003) distinction between “dimensioned” and “flat” realization.

<sup>18</sup> One can vindicate the idea that substance pluralism entails property pluralism through the contrapositive of the identity of indiscernibles—or McTaggart’s principle of the dissimilarity of the diverse—stating that two distinct entities must differ from one another by at least one property. Justifying the idea that property pluralism entails predicate pluralism requires the commitment to a minimal form of realism. In a realistic context, it is indeed arguable that heterogenous properties are referred to by distinct predicates or, by contraposition, that co-extensional predicates refer to one and the same property.



As far as they respectively consist of radical monism and pluralism, reductive physicalism and substance pluralism do not meet the emergentist unity principle. Both views fail to meet either the discontinuity or the continuity thesis. In this respect, they are not proper stances for conceptualizing emergence; rather, they are the extreme positions *between which* various forms of emergentism may be developed as middle courses.

The first step of this analysis already reveals that, between radical reductionism and outright pluralism, there exist two distinct (families of) such middle courses, viz. non-reductive<sup>R</sup> physicalism and non-reductive<sup>C</sup> materialism. Being a conjunction of property monism (and hence substance monism) with predicate pluralism, the former meets the emergentist unity principle insofar as it is committed to a form of *causal* (and hence substantial) *continuity* and a form of *representational discontinuity*. I call this view “representational emergentism”, capturing the idea of the representational irreducibility—therefore the “R” written as a superscript—of emergents in a physicalistic ontology. Being a conjunction of substance monism with property pluralism (and hence predicate pluralism), non-reductive<sup>C</sup> materialism meets the emergentist unity principle in a different way, namely by construing continuity as *substantial continuity* and discontinuity as *causal* (and hence representational) *discontinuity*. This view may then be called “causal emergentism” in the sense that it captures the causal irreducibility—therefore the “C” written as a superscript—of emergents in a materialistic ontology.

At this point, two terminological clarifications should be brought to light. First, although materialism and physicalism are usually taken to be synonymous or, more precisely, the latter is conceived as an historical extension of the former (see for instance Loewer 2001), it is clear that I construe these notions differently here. Whereas materialism is defined as a particular declination of substance monism, physicalism is identified with property monism (and hence substance monism).<sup>19</sup> As a consequence, it is possible in this context to argue for a non-physicalist version of materialism—the converse being nevertheless forbidden—, i.e. a view according to which every natural entity is ultimately made of elementary physical particles but may exhibit non-physically realized properties. Secondly, the reader may be surprised to read about *representational* and *causal* emergence in place of the more usual couples of notions that are “epistemological/ontological” or “weak/strong” emergences (see for instance, respectively, Silberstein and McGeever 1999; Chalmers 2006). As far as the second distinction is concerned, here I am simply following the footsteps of philosophers who prefer to use adjectives like “weak”, “strong”, “modest”, “robust”, etc., to qualify the *strength* of the emergence involved, for instance be it absolute or relative to scientific theories at a certain time, its *type* being stipulated by expressions like “representational” or “causal” that indicate the nature of the emergence relata (respectively our representations of the world and causal properties; see Van Gulick 2001). As far as the first distinction is concerned, the reader may use as he pleases the couple “representational/causal” and “epistemological/ontological” interchangeably. I nevertheless try to avoid the latter terminology as it may be somewhat confusing. Whereas the terminology I prefer explicitly indicates the type of emergence involved, the alternative is highly dependent on the way one conceives the complex relationship between ontology and epistemology.

<sup>19</sup> Materialism thus defined in its “atomistic” sense, namely as the thesis according to which everything is made of elementary bits of matter, whatever these are. Physicalism is here identified with “realization physicalism” in a materialistic context, i.e. the thesis that every property is realized by combinations of physical properties of material objects.

### 3.2 Theoretical and Explanatory Emergence

It is now possible to expand this first taxonomy by distinguishing—within the scope of non-reductive<sup>R</sup> physicalism—between sub-types of representational emergence. The further distinction I propose to draw is based on the difference between derivational and functional models of representational reduction. Whereas the first model can be traced back to Ernst Nagel’s inter-theoretic reduction and is primarily a matter of *connecting* concepts and *deducing* laws between scientific theories (Nagel 1949), the second has been mainly put forward by Kim as way of *causally* or *mechanistically explaining* higher-level property instances (Kim 1998, chapter 4). What interests me here is that the derivational model of representational reduction is more restrictive than the functional one, in the sense that a derivable property—or, more rigorously, a property where the propositions in which it figures are derivable from propositions in which figure only lower-level properties—is necessarily a functionally reducible property, the converse being not true.<sup>20</sup> As a consequence, non-reductive<sup>R</sup> physicalism may be divided into the following views:<sup>21</sup>

- *Non-deductive physicalism* as being the conjunction of property monism with predicate pluralism built on a failure of derivational reduction.
- *Non-reductive<sup>R\*</sup> physicalism* as being the conjunction of property monism with predicate pluralism built on a failure of (both derivational and) functional reduction.

Insofar as it meets the emergentist unity principle by construing continuity as *causal* continuity and discontinuity as *theoretical* discontinuity, non-deductive physicalism may be associated with a variety of representational emergence called “theoretical emergence”. In a similar fashion, for it is committed to a form of *explanatory* discontinuity, non-reductive<sup>R\*</sup> physicalism constitutes a proper place to conceptualize another variant of representational emergence, namely “explanatory emergence” (for further details on this distinction, see Sartenaer 2013).

### 3.3 Summary: A Taxonomy of Emergence

At this point, before turning to the next section, which is more directly dedicated to the prime objective of this paper, it may be helpful to summarize what has been said so far. From what has been considered to be the unity of emergentism—namely constituting a middle course between radical monism and pluralism through the conciliation of the continuity and discontinuity theses—, it has been possible to identify three different emergentist frameworks, viz. non-deductive physicalism, non-reductive<sup>R\*</sup> physicalism and non-reductive<sup>C</sup> materialism. These stances have then been successively associated with the following conceptualizations of emergence:

- *Theoretical emergence*—causal continuity and theoretical discontinuity  
“Theories about the whole cannot be logically derived from theories about the parts”.

<sup>20</sup> This may be justified by claiming that (i) Nagelian reductionism entails token physicalism, a view that assumes explanatory reduction (see Fodor 1974, 101) and (ii) functionally reducible properties are not necessarily type-identical with their reduction basis, for physical mechanisms in virtue of which laws of the special sciences hold can be “wildly” heterogeneous (see Fodor 1974, 107).

<sup>21</sup> “Non-deductive physicalism” is an evocative expression I borrow from Smart (1981). The superscript *R\** is meant to refer to functional or explanatory reduction—explanation being considered in a causal or mechanistic (and non-deductive-nomological) sense.

- *Explanatory emergence*—causal continuity and explanatory discontinuity  
“The behaviour of the whole cannot be adequately explained on the sole basis of a full knowledge of the behaviour of the parts”.
- *Causal emergence*—substantial continuity and causal discontinuity  
“The whole exhibits genuinely new causal powers that are not identical to any combination of the powers of the parts”

In 1999, Kim made a major contribution to making sense of emergence by resorbing the whole cluster of vague and somewhat ill-defined emergentist ideas into a unique but more or less unsatisfactory—by his own admission—characterization, namely that emergent properties are *supervenient* and *irreducible* (in the functional sense). In the present section I have pushed this result a little bit further by showing that, theoretical emergence apart, there exists more than one way to meet the supervenience and irreducibility criteria, viz. through explanatory and causal emergence.<sup>22</sup> In the next section, I will continue to push forward in this way by providing positive, consistent and non-trivial characterizations of the emergence taxa.

#### 4 Making Sense of Emergence (Again)

So far, I have just provided general benchmarks that allow us to coarsely delineate different views that have in common the rejection of radical monism and pluralism, and which consequently constitute proper frameworks for the conceptualization of emergence. While a first intuitive characterization of the emergence taxa has already been proposed above on this basis, the boundaries between them are still unclear, insofar as these characterizations are couched in negative terms—respectively as a failure of Nagelian reduction, a failure of functional (or more generally explanatory) reduction and a lack of a physical realization basis. One may then raise the question: what makes a given phenomenon, say, explanatorily emergent? Put differently, what makes a phenomenon causally continuous but explanatorily discontinuous with its underlying basis, a result of which being that the phenomenon cannot be functionally reduced?

Answering such questions—and hence providing definitional criteria for the emergence taxa—primarily requires us to rephrase the emergentist unity principle in the following operational way:<sup>23</sup>

- *The continuity thesis = the micro-determination thesis:*  
There is a determination relationship  $D_{up}$  going from the emergence basis to the higher-level putative emergent.

<sup>22</sup> To be rigorous, though it is clear that explanatory and causal emergentisms are at least committed to functional (and more generally explanatory) irreducibility, I have not yet argued that they are also committed to supervenience. This will become clear below.

<sup>23</sup> The pairing of  $D_{up}$  with the continuity requirement and  $D_{down}$  with the discontinuity requirement is vindicated by the ontological priority—both historical and constitutive—that lower levels have over higher levels, and which emergentists and reductionists alike generally take for granted. In this context, the lowest level (say, micro-physics) is the reference level with regard to which one evaluates ascriptions of continuity or discontinuity. Another justification of the preferred pairing can be made through examples. Cartesian interactionism is a form of dualism committed to the existence of some  $D_{down}$  but no  $D_{up}$ . By contrast, Reductive materialism is a form of monism committed to the existence of some  $D_{up}$  but no  $D_{down}$ .

- *The discontinuity thesis = the macro-determination thesis:*

There is a determination relationship  $D_{\text{down}}$  going from the higher-level putative emergent to the emergence basis.

Insofar as the existence of an upward determinative relation is a minimal monistic requirement, the very existence of something like  $D_{\text{up}}$  is what secures continuity in emergence. It precludes emergents from being merely broken off from their basis. Symmetrically, the determinative potency that a relation like  $D_{\text{down}}$  confers to putative emergents constitutes the minimal pluralistic commitment ensuring discontinuity in emergence.<sup>24</sup> The very existence of  $D_{\text{down}}$  precludes emergents from being identical to their basis, or mere “danglers” living in its shadow.

Positively defining the emergence taxa identified in Sect. 3 then requires the identification of metaphysical relations that adequately capture  $D_{\text{up}}$  and  $D_{\text{down}}$ . To this purpose, contemporary metaphysics constitute a perfect toolbox in which one may pick up different determination relations and assess to what extent they are tailored for the job.

With this idea in mind, I propose the following strategy. In Sect. 4.1, I identify the relations  $D_{\text{up}}$  and  $D_{\text{down}}$  that allow for the definition of the “emergentist Grail”, i.e. the version of emergence that would do justice to the emergentist promises by constituting the most balanced conciliation of monism and pluralism. In Sect. 4.2, I show that such a concept falls short of meeting the consistency challenge, and consequently needs to be amended. Two options will successively be investigated to avoid such inconsistency: (i) keeping  $D_{\text{up}}$  untouched while weakening  $D_{\text{down}}$  and (ii) weakening  $D_{\text{up}}$  while keeping  $D_{\text{down}}$  untouched. These options will respectively transform the initially inconsistent emergentist Grail into the consistent emergence taxa that are representational and causal emergence. In the meantime, these taxa will have gained a proper and positive definition. In a final section (Sect. 5), I will show how the properly defined taxa are able to meet the challenges figuring on the emergentists’ agenda.

#### 4.1 The Emergentist Grail

Let us then begin by establishing what would be the “best way” to construe the determinative relations  $D_{\text{up}}$  and  $D_{\text{down}}$ , the merit of such a way being evaluated by the extent to which it allows emergence to fulfill its promises. Without presuming that the resulting concept will be consistent, it will in any case constitute a useful benchmark, or a reference concept, against which the emergence taxa identified above will be measured.

In order to fulfill its ontological, epistemic and theoretical promises, the concept I am trying to frame, which I will from now on refer to as “emergence\*”, must be the proper ground on which the most balanced conciliation between monism and pluralism can be built. Emergence\* must at the same time be monistic enough to fit smoothly into the scientific image, and pluralistic enough to secure (at least) an ontological respectability for

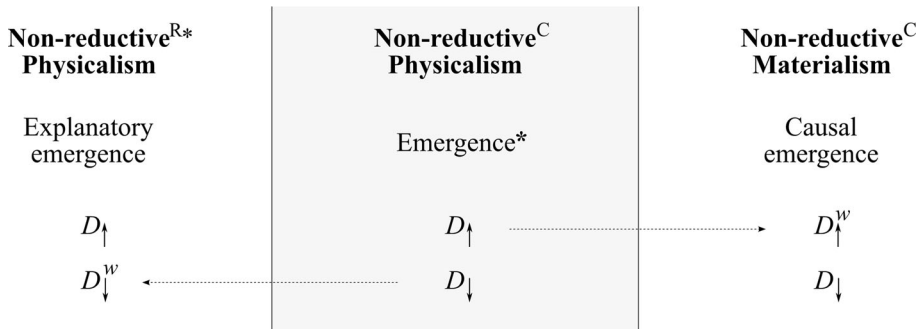
<sup>24</sup> I take for granted here a lesson coming from classic and overtly anti-epiphenomenalist emergentism, namely that emergence is primarily a matter of “making a difference” in the world (see for instance Alexander 1920, 9; Morgan 1923, 16–17; or Sellars 1933, 322). This train of thought is actually still typical of today’s emergentism. In this perspective, I leave aside varieties of emergence that would not be associated with a minimal form of high-level determinative potency. Note that it has been shown (see e.g. Kim 1992, 136) that same-level causation necessarily entails downward causation in a context where at least supervenience is assumed. This rules out the possibility for emergentism to constitute a form of pure parallelism. Note also that, as it will become clear below,  $D_{\text{down}}$  is not restricted to classic downward causation.

higher-level entities. One may reasonably suppose that the former demand will be met through *physicalism*, whereas the latter should be through *causal non-reductivism*. Should it be a consistent view, non-reductive<sup>C</sup> physicalism would indeed constitute a good compromise between radical reductionism and substance pluralism, for it would allow to vindicate the ontological genuineness of emergents without invoking any non-physical mystical entities or powers. In the words of Carl Gillett, “such a property [emergence\*, a concept called ‘strong emergence’ by Gillett] constitutes a metaphysical ‘grail’, for if it can be shown to exist, then it would be established that we can hold both PHY [physicalism] and HCE [higher causal efficacy] to be true and the reductionist’s challenge would have been answered” (Gillett 2002, 102). Such an emergentist “Grail” is to be located *between* explanatory and causal emergence in the taxonomy built in Sect. 3, for emergentism\* construes continuity (or  $D_{up}$ ) in a stronger sense than causal emergence does—physicalism entailing materialism, but not the other way around<sup>25</sup> and discontinuity (or  $D_{down}$ ) in a stronger sense than explanatory emergence does—causal irreducibility entailing explanatory irreducibility, but not the other way around (see Fig. 1).

This being said, let us now try to identify which determinative relations  $D_{up}$  and  $D_{down}$  would do the job, i.e. allowing us to define emergence\* in the way described above. As far as the monistic or continuity relation  $D_{up}$  is concerned, two options may successively be considered. To begin with, one may conceive of  $D_{up}$  as being *supervenience*, therefore considering that emergents\* are micro-determined by their bases in the sense that, when one fixes the basis, one fixes the emergent\*, and not the other way around. While many thinkers have been attracted—from the 1970s onwards—by such an option (see for instance McLaughlin 1997; Kim 1999), one may be reluctant to invoke it when framing emergence\*. A first reason for this lies in the fact that supervenience does not entail the fairly monistic stance we want for emergence\*, namely physicalism. Supervenience actually turns out to be compatible with every view described in Sect. 3, with the notable exception of (radical) substance pluralism—supervenience therefore only securing materialism in the sense understood here.<sup>26</sup> Another (but not independent) reason is that supervenience *in itself* is not a genuine and explanatory metaphysical relation; rather, it merely expresses a covariation scheme between sets of entities (Kim 1993, chapter 9; Kim 1998, chapter 1; Kim 2006; Van Gulick 1992, 2001; Stephan 1999a). Trying to explicate emergence\*—or, more precisely, the continuity or micro-determination clause of emergence\*—through supervenience then merely consists in an *obscurum per obscurius* explication, i.e. trying to solve a mystery (emergence\*) on the basis of another (supervenience). What we actually need in place of mere supervenience is a deep metaphysical relation *that grounds* supervenience, in the sense that it explains why when we fix a set of basal properties, we fix the properties that putatively emerge\* from it. This leads us to the second possible option for construing  $D_{up}$ , namely (physical) *realization*. Such a relation is suitable for the job, insofar as (i) it is a deep metaphysical relation (viz. constitution) that

<sup>25</sup> As it will be explicated below, another way of showing this is to draw one’s attention on the fact that, whereas emergentism\*’s  $D_{up}$  is realization—and hence also supervenience—, causal emergentism’s  $D_{up}$  is only brute supervenience, that is, supervenience *without* realization.

<sup>26</sup> It is noteworthy that supervenience may actually be considered as compatible with some versions of substance pluralism, an example of which is Nida-Rümelin’s dualist emergentism (Nida-Rümelin 2007). Nonetheless, more radical forms of substance pluralism that think of substances as capable of an independent existence—on the model of Stahl’s dualistic vitalism or Descartes’ dualistic interactionism—deny supervenience, insofar as they deny any form—however minimal—of bottom-up determination (see for instance Caston 2000, regarding Driesch’s vitalism). In such a context, two materially identical beings could be such that the first is inert while the second is alive, for it is gifted, say, with Stahlian *anima*.



**Fig. 1** Emergence\* within the emergence taxonomy built in Sect. 2. The concept lies between explanatory and causal emergence, insofar as it construes emergence through the conciliation of  $D_{down}$  and  $D_{up}$ , which are respectively “stronger” determinative relations than  $D_{down}^w$  and  $D_{up}^w$ —the “w” superscript standing for “weakening”. Are not represented here non-deductive physicalism and reductive<sup>R\*</sup> physicalism (on the left side of the figure) and substance pluralism (on the right side of the figure). These will be incorporated in due time

explains supervenience (Kim 1998, chapter 1)<sup>27</sup> and (ii) it allows us to define the fairly monistic view, namely (realization) physicalism (see for instance Melnyk 2003), that emergentism\* requires.

Let us now turn to  $D_{down}$ . Since higher-level determinative potency of putative emergents is a notion that has already drawn considerable attention (beginning notably with Kim 1999; see also Emmeche et al. 2000; or Hulswit 2005), it will not be necessary to discuss this notion at length here. Suffice it to say that Sperry-style downward causation—a downwardly causal relation that is *efficient, reflexive* and *diachronic*—will do the job, insofar as (i) it is a deep metaphysical relation (viz. causation) that incidentally explains why emergents are ontologically new entities in the world<sup>28</sup> and (ii) it allows us to define the fairly pluralistic view, namely causal non-reductivism, that emergentism\* requires.

Summing up, emergence\* can be properly defined as follows, here taking properties as the emergence units:

A property E emerges\* from an underlying physical basis  $\{B_i\}$  iff (1) E is realized in  $\{B_i\}$  [continuity or micro-determination clause] and (2) E downwardly acts – in Sperry’s sense – on  $\{B_i\}$  [discontinuity or macro-determination clause].<sup>29</sup>

<sup>27</sup> As a result, every physically realized property is necessarily supervenient on its realizers, but not *vice versa* (so there can be supervenient but unrealized properties, as it will become clear below). A brief definitional justification: assuming that property  $P_2$  is realized in property  $P_1$  on a given occasion, so that  $P_1$ ’s existence is constitutively sufficient for  $P_2$ ’s existence on this occasion, then  $P_2$  supervenes on  $P_1$ , insofar as (i) for each entity  $x$  having  $P_2$ , there exists at least one property  $P_1$  such that  $x$  has  $P_1$ , and (ii) when  $x$  has  $P_1$ , it necessarily has  $P_2$ . Thesis (i) merely derives from the fact that  $P_1$  is a proper candidate for  $P_1$  and thesis (ii) derives from (i) and the realization hypothesis.

<sup>28</sup> Since causation cannot be self-reflexive, in the sense that a given event cannot be its own cause and effect, emergent downward causal powers are new powers that cannot in principle be possessed by emergent bases.

<sup>29</sup> Even if it is difficult to have a clear idea of exactly what kind of emergence Sperry tried to put forward in the 1970’, it may be argued that his view amounts to something like emergence\*. By the way, the fact that emergence\* falls short of meeting the consistency challenge (see below) is probably a reason why many thinkers have regularly expressed skepticism about the coherence of Sperry’s view (see for instance Smart 1981).

So far, so good. At this point, we've come up with a positive and non-trivial definition of a reference concept of emergence. Emergence\* occurs when a high-level phenomenon is *at the same time* constituted by, or realized in, its underlying physical basis—hence it is supervenient on its basis—, *and* it has the ability to causally interact, in a downwardly fashion, on its basis—hence it is causally, and consequently also representationally, irreducible to it. Without presuming for the moment that such a concept is consistent or that its definitional clauses refer to anything in our world (for that matter, it is not implausible that no property is actually physically realized or that Sperry-style downward causation is nomologically impossible), emergence\* so defined constitutes a first qualification of Kim's (1999) emergence, conceived as the conjunction of supervenience and (functional) irreducibility. On the basis of this intermediate result, we can now return to the emergence taxa identified in Sect. 3.

## 4.2 The Emergentist Dilemma

It may be argued in different ways that emergence\* falls short of meeting the consistency challenge. First, in a very intuitive and “visual” way, it may be noted that emergence\* does not fit properly into the emergence taxonomy. While representational and causal emergences have been respectively built on the consistent conjunctions of property monism with predicate pluralism and substance monism with property pluralism—hence construing in both cases continuity and discontinuity in *different* respects—, emergence\* may only be considered as an inconsistent conciliation of property monism and property pluralism, construing both continuity and discontinuity in the very *same* causal respect. Another, equivalent way of emphasizing this is to show that physical realizationism—and hence physicalism—is incompatible with Sperry-style downward causation—and hence causal non-reductivism. This can be vindicated by mentioning the fact that realization entails causal inheritance between a realized property and its realizers, therefore implying causal reductivism that cannot reasonably be conciliated with causal non-reductivism.<sup>30</sup> More generally, the incompatibility between realization and Sperry-style downward causation can be highlighted through so-called “arguments from realization” (Gillett 2002), a particular case of which is Kim's famous and highly debated “causal exclusion argument” (see for instance Kim 1998, chapter 2). In a nutshell, these arguments tend to demonstrate that realization and Sperry-style downward causation are respectively too strong continuistic and discontinuistic requirements to be held together.

Taking for granted that such arguments are sound, amending emergence\* in order for it to properly deal with the consistency challenge requires the weakening of at least one of its definitional clauses—realization or downward causation—and hence the abandonment of either physicalism or causal non-reductivism. In what follows, I successively focus on the two horns of what clearly appears to be a serious dilemma for emergentism.

To begin with, a first avoidance maneuver consists in dropping emergence\*'s  $D_{up}$ —realization—in favor of a *weaker* dependance relation  $D_{up}^w$  that would tolerate a conjunction consistent with Sperry-style downward causation. What kind of micro-determination relation would do the job here? Arguably, *supervenience without realization* would,

<sup>30</sup> The causal inheritance principle states that “if a second-order property  $P_2$  is realized on a given occasion by a first-order property  $P_1$  [...], then the causal powers of this particular instance of  $P_2$  are identical to (or are a subset of) the causal powers of  $P_1$  (or of this instance of  $P_1$ )” (Kim 1998, 54, with modified notations). A qualification: this holds if one conceives of realization—as it is the case here—as token identity. Other possible accounts of realization are not envisioned here. For a comprehensive overview of these, see Baysan (2015).

for (i) it is a weaker dependance relation than realization insofar as, as I mentioned earlier, realization entails supervenience, but not vice versa, (ii) it can then be consistently held together with downward causation, as the lack of realization, or of any other constitution relation, precludes causal inheritance—and hence causal reduction –, and (iii) it is a minimal determination relationship that excludes (radical) substance pluralism. Such a strategy seems however to bring back into the picture a possible problem that I've tried to avoid earlier while I was seeking a positive definition of emergence\*, namely that supervenience without realization is not a genuine and explanatory relation, or that it is in itself as mysterious as the concept it is meant to (partly) explicate (emergence). But what has been a possible source of trouble for defining a reference concept of emergence is not necessarily one when it comes to identifying a viable middle path between inconsistent non-reductive<sup>C</sup> physicalism and outright pluralism. There is precisely a way in this context to avoid an intrinsically negative construal of supervenience, viz. postulating its radical *bruteness*. Arguing that supervenience is an *ultimate* or *brute empirical fact* is indeed not necessarily a recognition that we are ignorant of what can ground or explain supervenience, but rather that, as a matter of fact, *nothing* grounds or explains supervenience. In this context, borrowing from Lycan's terminology, a non-physically realized but supervenient property P is a supervenient but non-“superdupervenient” property, i.e. there is no (naturalism-friendly) way of explaining why P supervenes—or as Horgan puts it: “[C]ertain non-physical properties could be supervenient on physical properties and yet causally basic (in the sense that they generate fundamental causal forces over and above physical forces) [...]. All properties and facts could be supervenient on physical properties and facts even if certain supervenience facts are metaphysically *sui generis* [...]” (Horgan 1993, 560).

Of course, dropping realization ( $D_{up}$ ) for supervenience without realization ( $D_{up}^w$ ) leads to an abandonment of physicalism in favor of materialism, while keeping Sperry-style downward causation ( $D_{down}$ ) untouched maintains causal non-reductivism. As a consequence, the consistent conjunction of  $D_{up}^w$  and  $D_{down}$  is definitional of non-reductive<sup>C</sup> materialism, then conceived as a doctrine stating that there exist brute supervenient and causally irreducible properties exhibited by purely material systems. Insofar as it implies a conciliation of property pluralism with substance monism, the very existence of heterogeneous causal orders in a thoroughly materialistic context is the hallmark of what I earlier called *causal emergence*. Accordingly:

A property E causally emerges from an underlying physical basis  $\{B_i\}$  iff (1) E supervenes on – but is not realized in –  $\{B_i\}$  [substantial continuity] and (2) E downwardly acts – in Sperry's sense – on  $\{B_i\}$  [causal discontinuity].

As a historical illustration, it may be argued that early British emergentists like Samuel Alexander, Lloyd Morgan or Charlie Dunbar Broad had in mind something very similar to causal emergence, insofar as they were clearly committed to brute supervenience and downward causation.<sup>31</sup> The “bruteness” of the (implicit version of) supervenience they invoked was actually the very core of their doctrine—as well as, incidentally, one of the

<sup>31</sup> For textual evidence, see for instance Broad (1925, 67–68) (for supervenience), and Morgan (1923, 16–17) (for downward causation). It should nevertheless be noted that, while it is clear that British emergentists were committed to brute supervenience, it is not obvious that they construed downward causation in the same way as Sperry did latter. It is a matter of exegesis to establish if their idea of macro-determination was not more akin to what I will call below “Sellars-style” downward causation.



possible reasons of the movement's premature decline at the end of the 1920s.<sup>32</sup> The supervenience of emergent entities was indeed something to be noted with a "loyal attitude" (Morgan 1923, 4) or a "natural piety" (Alexander 1920, 46), or was the expression of an "unique and ultimate [trans-ordinal] law" (Broad 1925, 65). It was even suggested that the bruteness of supervenience was the expression of an (immanent) divine activity (Morgan 1923, 13), an idea that may lead us to conceive of non-reductive<sup>C</sup> materialism as a reappraisal of Malebranche's occasionalism or Leibniz' pre-established harmony, but in a version that is relative to heterogeneous orders of *properties* instead of a diversity of *substances*.<sup>33</sup>

So much for the first horn of the emergentists' dilemma. Avoiding emergence\*'s inconsistency may also be achieved through a second maneuver, namely dropping  $D_{\text{down}}$ —Sperry-style downward causation—in favor of a weaker macro-determination relation  $D_{\text{down}}^w$  that would tolerate physicalism.

Conveniently enough, there already exist hints as to which macro-determination relation  $D_{\text{down}}^w$  would do the job in classical emergentism (and actually even further back all the way to Aristotle). As early as 1909, Sellars already urged for the enlargement of the category of causation (Sellars 1909) in order for it to encompass the irreducibly effective and determinative action that modes of organization—or Morgan's "relatedness"—can exert on emergence bases (Sellars 1922). Sellars' campaign for enlarging the scope of causation—a campaign that he actively pursued throughout his career (see for instance Sellars 1959)—pointed towards a steady goal, namely that of considering emergent potency, *contra* Sperry, as *different in kind* from "usual" intra-level determination (viz. *efficient* causation, however one construes it precisely). According to what can be from now on referred to as "Sellars' view", there would then exist (at least) two distinct and irreducible modes of causal determination in nature, namely (i) intra-level *efficient* causation that governs the succession of physical events through time, and (ii) inter-level *emergent* causation—*other than efficient*—that regulates (or harnesses, restraints, constrains, orientates, etc.) the way in which underlying intra-level causal relations unfold.

The general idea according to which there is maybe more than one form of determination that we refer to while using the single word "causation" has some proponents in contemporary metaphysics (see for instance Cartwright 2004; or Hall 2004). However, the return to an Aristotle-style causal eclecticism particularly attracts today philosophers in an attempt to reframe *downward* causation to render it physicalism-friendly and immune to realization arguments. In such a context, Sperry-style *efficient* downward causation, working in the same way as intra-level "usual" causation (e.g. by involving energy transfer), has been regularly replaced by alternative macro-determination relations like—to name here but a few examples—"medium downward causation" (in contrast with the strong version of the concept; see Emmeche et al. 2000), "formal causation" (Scott 2007),

<sup>32</sup> While it is certain that British Emergentism dramatically suffered from a lack of empirical support (McLaughlin 1992), it is also clear that the radical bruteness—and thus the absolute inscrutability—of supervenience (and consequently emergence) also played a major role in the movement's fall. Early commentators already considered this move as a "scientific betrayal" (Montague, 1929) or as the "weightiest defect in the entire theory" (Ablowitz 1939, 14).

<sup>33</sup> In a quite similar fashion, proponents of materialistic vitalism (e.g. Bordeu, Ménéret, La Caze, Fouquet or Bichat) may be considered as causal emergentists. While they obviously considered vital properties as causally potent, they also construe them as brutally supervenient on physical properties, as such kind of claim suggests: "To create the universe God endowed matter with gravity, elasticity, affinity, etc., and furthermore one portion received as its share sensibility and contractility" (Bichat 1805, quoted in Bechtel and Richardson 2010, 102). It may also be argued that Aristotle was a causal emergentist in the sense defined here (see Caston 2000).

top-down “constraint” (Kistler 2009), the “machretic determination” (which is actually considered as *non-causal* by Gillett, but this seems essentially to be terminological; Gillett 2010), or “reflexive downward regulation” (Walsh 2012).

But how can we characterize such a Sellars-style downward causation? Since doing otherwise would lead us too far away from my initial objective, and since there clearly lacks to this day an extensive philosophical analysis of the possible non-efficient forms of causation, I shall content myself here with providing a concise sketch of what appears to be a very promising path towards the elaboration of a non-trivial and physicalism-friendly version of emergentism. In a nutshell, while one may consider intra-level efficient causation as the effective manifestation of property dispositions, emergent inter-level determination may be associated with the specific conditions that trigger the manifestation of these dispositions. The emergent triggering conditions are specific here in the following sense: it is by virtue of being part of a certain whole—so it is by virtue of being part of the basis of a given emergent *E*—that basal dispositions are triggered in a certain way. In this context, emergent determination can be said to be causal, but not in the “usual” intra-level sense (e.g. it does not involve energy transfer; it is not “productive”), so it does not entail overdetermination troubles or causal inheritance while being conciliated with realization. At the same time, emergent determination makes a genuine difference in the course of events that renders it explanatorily indispensable (it actually supports counterfactuals of the form: if *E* had not emerged, basal events  $\{B_i\}$  would have run their course differently).<sup>34</sup>

Construed in this way, Sellars-style downward causation is a good candidate for  $D_{\text{down}}^w$ , for it does not conflict with realization ( $D_{\text{up}}$ ) and hence physicalism and causal reduction, and it nonetheless secures a non-trivial form of irreducibility, viz. representational irreducibility. Put differently, the consistent conjunction of Sellars-style downward causation ( $D_{\text{down}}^w$ ) and realization ( $D_{\text{up}}$ ) allows for *avoiding* causal exclusion while *opposing* explanatory exclusion, insofar as it grants causal relevance to non-efficiently-causal emergent properties. Such a conjunction is thus definitional of non-reductive<sup>R</sup> physicalism, then conceived as a doctrine that states that there exist physically realized properties that may non-efficiently constrain their own basal conditions, rendering these realized properties representationally irreducible. For it implies a conciliation of property monism and predicate pluralism, this view is committed to representational emergentism. Accordingly:

A property *E* representationally emerges from an underlying physical basis  $\{B_i\}$  iff  
 (1) *E* is realized in  $\{B_i\}$  [causal continuity] and (2) *E* downwardly acts – in Sellars’ sense – on  $\{B_i\}$  [representational discontinuity].<sup>35</sup>

<sup>34</sup> So this view is actually consistent with British emergentism, considering the following kind of assertion: “[W]hen some new kind of relatedness is supervenient (say at the level of life), the way in which the physical events which are involved run their course is different in virtue of its presence—different from what it would have been if life had been absent [...]. The new relations emergent at each higher level guide and sustain the course of events distinctive of that level [...]” (Morgan 1923, 16–17). The sketch proposed here also seems to be consistent with Gillett’s recent proposal of “conditioned aggregation”, which “allows that component entities, like lower-level realizer properties, only contribute certain powers when aggregating into and composing a certain “whole” such as a realized property. As a result, where we have Conditioned aggregation a realized property instance can be efficacious not by contributing powers *itself*, but by determining the contributions of powers by *other* property instances in its own realizers (i.e. its own components). Though composed, such a realized property would still determine the powers of individuals and be efficacious” (Gillett 2010, 33. Italics in the original).

<sup>35</sup> It should be clear in which sense representational and causal emergentisms are said to be respectively committed to causal continuity and discontinuity. I do not consider that there is some causal discontinuity by virtue of the possible co-existence of two different types of causal relation—*intra-level efficient causation*

It should be noted that adopting a realistic attitude towards representational emergents demands the enlargement of the scope of classical causal realism built on the basis of what Kim once called “Alexander’s dictum”, stating that “to be real is [...] to possess causal powers” (Kim 1992, 134). In order to encompass emergent causation, one should rather assert that “to be real is to have a determinative influence—and consequently to play irreducible roles in adequate explanations of the world” (inspired from Peacocke 2007, 272).

Before synthesizing the results of the analysis pursued so far, a qualification should be brought to light. One may indeed wonder if it is possible to identify a distinction criterion associated with Sellars-style downward causation that would allow to distinguish between both sub-types of representational emergence described in Sect. 3, viz. theoretical and explanatory emergence. Because addressing this issue properly would certainly require a detailed analysis that I leave for the moment to another paper, I simply point here to a possible way of achieving this goal. In a nutshell, one could think of making a distinction between the two following varieties of emergent causation: (i) *reflexive* emergent causation whose relata are (instances of) emergent properties and their own emergence bases, and (ii) *non-reflexive* and *selective* emergent causation that consists in the action exerted on emergent bases by (instances of) properties that pertain to a selective environment. The notion of “selection” is understood here in a very broad sense, namely as any kind of environmental process that gives rise to—or that merely reinforces—some higher-level (functional) properties independently of their lower-level (structural) properties,<sup>36</sup> therefore producing genuine cases of multiple realization (Papineau 2010). While the first variety of Sellars-style downward causation, reflexive emergent causation, is a sufficient condition to secure functional or explanatory irreducibility—and hence to define, together with realization, *explanatory* emergence –, non-reflexive and selective emergent causation is sufficient to lead to a failure of Nagelian inter-theoretical reduction—and hence to define, together with realization, *theoretical* emergence—, insofar as the multiple realizability it gives rise to precludes the establishment of type-identities between higher-level properties and their bases (see for instance Fodor 1974). Accordingly:

A property E explanatorily emerges from an underlying physical basis  $\{B_i\}$  iff (1) E is realized in  $\{B_i\}$  [causal continuity] and (2) E downwardly acts – in Sellars’ reflexive sense – on  $\{B_i\}$  [explanatory discontinuity];

A property E theoretically emerges from an underlying physical basis  $\{B_i\}$  iff (1) E is realized in  $\{B_i\}$  [causal continuity] and (2) environmental properties tend to select E through downwardly acting – in Sellars’ non-reflexive and selective sense – on  $\{B_i\}$  [theoretical discontinuity]

It is now time to summarize what has been said so far. In Fig. 2 are presented and ordered the emergence taxa identified in Sect. 3. Each of them is properly defined through the conciliation of a micro-determination relation  $D_{up}$  that grounds emergents in their

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Footnote 35 continued

and inter-level emergent causation—but by virtue of brute gaps in the way that (one type of) causal powers combine. “Causal discontinuity” thus captures the lack of causal inheritance rather than causal eclecticism.

<sup>36</sup> This notion then encompasses the intentional selection of artifacts, the natural selection of organic traits, the “learning” selection of behaviors, the cultural selection of institutions, physico-chemical sorting processes, etc.

<b>Reductive<sup>R*</sup> Physicalism</b>	<b>Non-deductive Physicalism</b>	<b>Non-reductive<sup>R*</sup> Physicalism</b>	<b>Non-reductive<sup>C</sup> Physicalism</b>	<b>Non-reductive<sup>C</sup> Materialism</b>	<b>Substance Pluralism</b>
No emergence	Representational emergence	Emergence*	Causal emergence	No emergence	
	theoretical	explanatory			
Representational, causal, substantial continuity	Causal continuity & theoretical disc.	Causal continuity & explanatory disc.	Causal continuity & causal discontinuity	Substantial continuity & causal discontinuity	Substantial, causal, representational discontinuity
<i>Identity</i> <i>No D<sub>1</sub></i>	<i>Realization</i> <i>N-R Down. Constraint</i>	<i>Realization</i> <i>R. Down. Constraint</i>	<i>Realization</i> <i>Down. Causation</i>	<i>(Brute) supervenience</i> <i>Down. Causation</i>	<i>No D<sub>1</sub></i> <i>Down. Causation</i>

**Fig. 2** A comprehensive taxonomy of emergence, where each taxon has been properly defined on the basis of a continuistic (or monistic) and discontinuistic (or pluralistic) clause. To avoid ambiguities, I refer to Sperry-style and Sellars-style downward causation as “downward causation” and “downward constraint”, respectively

lower-level bases, and a macro-determination relation  $D_{\text{down}}$  that secures some autonomy for emergents from their bases. The table goes from radical monism (on the left), where  $D_{\text{down}}$  is inexistent and  $D_{\text{up}}$  “maximal”, to radical pluralism (on the right), where  $D_{\text{down}}$  is “maximal” and  $D_{\text{up}}$  inexistent. The emergentist options in between are distinguishable from each other based on the strength they respectively confer to  $D_{\text{down}}$  and  $D_{\text{up}}$ , the ratio of  $D_{\text{down}}$ ’s strength/ $D_{\text{up}}$ ’s strength (or  $D_{\text{up}}$ ’s strength/ $D_{\text{down}}$ ’s strength) being the mark of the type of emergence (or reduction) involved. In the middle of the table, emergence\* crystallizes the inconsistent attempt to conciliate the too strong versions of  $D_{\text{down}}$  and  $D_{\text{up}}$ , namely realization and Sperry-style downward causation.

## 5 Emergence to the Test

Now that the emergence taxa identified in Sect. 3 have been properly defined and ordered, let us close this paper by examining the way in which they deal with the emergentists’ challenges described in the introduction. To begin with, each taxon properly meets the *positivity challenge*, for they are defined on the basis of determinative relations—constitutive ( $D_{\text{up}}$ ) or causal ( $D_{\text{down}}$ )—and not through, say, some failure of reducibility. A qualification is necessary, though: causal emergence appeals to brute supervenience, which is arguably not a deep, instructive and positive relation. However, this is not as negative a characterization as it may *prima facie* appear, insofar as, as we saw in Sect. 4.2, there is, so to speak, no positivity to be found in such a context, causal emergentism being precisely construed as the recognition of inscrutable (causal) gaps in nature that we have to accept devotedly. Theoretical, explanatory and causal emergences also meet the *novelty challenge* (see footnote 8), for their newness is always grounded in an empirical process, and this process precisely explains why they are associated with, respectively, *new* predicates (because multiply realized properties cannot be type-identified with their realizer’s properties), *new* constraining individuals (because emergent constraining powers cannot be exerted by emergent bases), and *new* causal powers (because emergent causal powers cannot be possessed by emergent bases).

Second, the way in which I have built the emergence taxa—namely through the conjunction of *different* forms of monism and pluralism—makes these taxa *consistent*, therefore meeting the emergentists’ second challenge. In particular, representational and causal versions of emergence have been purposively framed so that they also meet Kim’s *causal challenge* (see footnote 9) by dissolving from the outset the overdetermination problem, by dropping, respectively, efficient downward causation and realization.

Turning now to the *triviality/liberality challenge*, it is clear that the way in which the emergence taxa have been defined offers non-trivial demarcation criteria to distinguish between emergent and non-emergent phenomena. This proceeds from the fact that it is *prima facie* plausible that, for example, some limited class of phenomena exhibits Sellars-style reflexive downward causation, rendering explanatory emergence neither ubiquitous nor merely inexistent.

Consequently, theoretical, explanatory and causal emergences are consistent, non-trivial and positively defined concepts that are, each in their own way, faithful to the emergentist unity principle, making them proper and genuine varieties of emergence.

## 6 Conclusion

Sixteen years after Kim's seminal paper offering a welcome analysis of the concept of emergence, I have proposed in this paper a needed extension of Kim's work that does greater justice to the actual diversity of emergentism. Rather than defining emergence as a monolithic middle path between reductive physicalism and substance pluralism through a conjunction of supervenience and (functional) irreducibility, I have developed a comprehensive taxonomy of the possible varieties of emergence in which each taxon—theoretical, explanatory and causal emergence—has been properly identified and defined. This taxonomy has the advantage of being unificatory, in the sense that the taxa it contains derive from a common unity principle, which consequently constitutes the very hallmark of emergentism. Furthermore, the emergence taxa properly deal with the challenges that figure on the emergentists' agenda, namely the positivity, the consistency and the triviality/liberality challenges. The overall picture of this analysis synthesized in Fig. 2 constitutes the desired contribution in making sense of emergence (again).

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## References

- Ablowitz, R. (1939). The theory of emergence. *Philosophy of Science*, 6, 1–16.
- Alexander, S. (1920). *Space, time, and deity, the Gifford lectures at Glasgow, 1916–1918*. London: Macmillan.
- Baysan, U. (2015). Realization relations in metaphysics. *Minds and Machines* 1–14. doi:10.1007/s11023-015-9366-x.
- Bechtel, W., & Richardson, R. C. (2010). *Discovering complexity: Decomposition and localization as strategies in scientific research*. Cambridge, MA: MIT Press.
- Bedau, M. A. (1997). Weak emergence. *Philosophical Perspectives*, 11, 375–399.
- Bedau, M. A. (2010). Weak emergence and context-sensitive reduction. In A. Corradini & T. O'Connor (Eds.), *Emergence in science and philosophy* (pp. 46–63). New York: Routledge.
- Berenda, C. W. (1953). On emergence and prediction. *The Journal of Philosophy*, 50, 269–274.
- Blitz, D. (1992). *Emergent evolution: Qualitative novelty and the levels of reality*. Dordrecht: Kluwer.
- Broad, C. D. (1925). *The mind and its place in nature*. New York: Harcourt, Brace & Company.
- Bunge, M. (1977). Emergence and the mind. *Neuroscience*, 2, 501–509.
- Bunge, M. (1982). Is chemistry a branch of physics? *Journal for General Philosophy of Science*, 13, 209–223.
- Cartwright, N. (2004). Causation: One word, many things. *Philosophy of Science*, 71, 805–819.
- Caston, V. (1997). Epiphenomenalisms, ancient and modern. *Philosophical Review*, 106, 309–363.
- Caston, V. (2000). Commentary on Miller. In J. J. Cleary & G. M. Gurtler (Eds.), *Proceedings of the Boston area colloquium in ancient philosophy* (Vol. XV, pp. 214–230). Leiden: Brill.
- Chalmers, D. J. (2006). Strong and Weak Emergence. In P. Clayton & P. Davies (Eds.), *The re-emergence of emergence. The emergentist hypothesis from science to religion* (pp. 244–254). New York: Oxford University Press.
- Clayton, P. (2004). *Mind and emergence: From quantum to consciousness*. New York: Oxford University Press.
- Crane, T. (2001). The significance of emergence. In C. Gillett & B. M. Loewer (Eds.), *Physicalism and its discontents* (pp. 207–224). Cambridge: Cambridge University Press.

- Cunningham, B. (2001). The reemergence of 'emergence'. *Philosophy of Science*, 3, S63–S75.
- Deacon, T. W. (2007). Three levels of emergent phenomena. In N. C. Murphy & W. R. Stoeger (Eds.), *Evolution and emergence: Systems, organisms, persons* (pp. 88–110). New York: Oxford University Press.
- Delehanty, M. (2005). Emergent properties and the context objection to reduction. *Biology and Philosophy*, 20, 715–734.
- Dewey, J. (1929). *The quest for certainty: A study of the relation of knowledge and action*. New York: Minton, Balch & Company.
- Emmeche, C., Koppe, S., & Stjernfelt, F. (1997). Explaining emergence: Toward an ontology of levels. *Journal for General Philosophy of Science*, 28, 83–119.
- Emmeche, C., Koppe, S., & Stjernfelt, F. (2000). Levels, emergence, and three versions of downward causation. In P. B. Andersen, C. Emmeche, N. O. Finnemann, & P. V. Christiansen (Eds.), *Downward causation: Minds, bodies and matter* (pp. 13–34). Aarhus: Aarhus University Press.
- Fagot-Largeault, A. (2002). L'émergence. In D. Andler, A. Fagot-Largeault, & B. Saint-Sernin (Eds.), *Philosophie des sciences* (Vol. II, pp. 939–1048). Paris: Gallimard.
- Fodor, J. A. (1974). Special sciences (or: The disunity of science as a working hypothesis). *Synthese*, 28, 97–115.
- Ganeri, J. (2011). Emergentisms, ancient and modern. *Mind*, 120, 671–703.
- Garrett, B. (2013). Vitalism versus emergent materialism. In S. Normandin & C. Wolfe (Eds.), *Vitalism and the scientific image in post-enlightenment life science, 1800–2010* (pp. 127–154). Dordrecht: Springer.
- Gillett, C. (2002). The varieties of emergence: Their purposes, obligations and importance. *Grazer Philosophische Studien*, 65, 95–121.
- Gillett, C. (2003). The metaphysics of realization, multiple realizability, and the special sciences. *Journal of Philosophy*, 100, 591–603.
- Gillett, C. (2010). On the implications of scientific composition and completeness. Or the troubles, and troubles, of non-reductive physicalism. In A. Corradini & T. O'Connor (Eds.), *Emergence in science and philosophy* (pp. 25–45). New York: Routledge.
- Hall, N. (2004). Two concepts of causation. In J. Collins, N. Hall, & L. A. Paul (Eds.), *Causation and counterfactuals* (pp. 225–276). Cambridge, MA: The MIT Press.
- Heinaman, R. (1990). Aristotle and the mind-body problem. *Phronesis*, 35, 83–102.
- Hempel, C. G., & Oppenheim, P. (1948). Studies in the logic of explanation. *Philosophy of Science*, 15, 135–175.
- Horgan, T. E. (1993). From supervenience to superdupervenience: Meeting the demands of a material world. *Mind*, 102(408), 555–586.
- Hulswit, M. (2005). How causal is downward causation? *Journal for General Philosophy of Science*, 36, 261–287.
- Huneman, P. (2008). Emergence made ontological? Computational versus combinatorial approaches. *Philosophy of Science*, 75, 595–607.
- Jennings, H. S. (1927). Diverse doctrines of evolution. Their relation to the practice of science and life. *Science*, 65, 19–25.
- Kauffman, S. A. (2008). *Reinventing the sacred: A new view of science, reason and religion*. New York: Basic Books.
- Kim, J. (1992). "Downward causation" in emergentism and non-reductive physicalism. In A. Beckermann, H. Flohr, & J. Kim (Eds.), *Emergence or reduction? Essays on the prospects of nonreductive physicalism* (pp. 119–138). Berlin: de Gruyter.
- Kim, J. (1993). *Supervenience and mind*. Cambridge: Cambridge University Press.
- Kim, J. (1998). *Mind in a physical world: An essay on the mind-body problem and mental causation*. Cambridge, MA: MIT Press.
- Kim, J. (1999). Making sense of emergence. *Philosophical Studies*, 95, 3–36.
- Kim, J. (2002). The layered model: Metaphysical considerations. *Philosophical Explorations*, 5, 2–20.
- Kim, J. (2006). Emergence: Core ideas and issues. *Synthese*, 151, 547–559.
- Kim, J. (2010). *Essays in the metaphysics of mind*. Oxford: Oxford University Press.
- Kistler, M. (2009). Mechanisms and downward causation. *Philosophical Psychology*, 22, 595–609.
- Laughlin, R. B. (2005). *A different universe: Reinventing physics from the bottom down*. New York: Basic Books.
- Lestienne, R. (2012). *Dialogues sur l'émergence*. Paris: Le Pommier.
- Loewer, B. M. (2001). From physics to physicalism. In C. Gillett & B. M. Loewer (Eds.), *Physicalism and its discontents* (pp. 37–56). Cambridge: Cambridge University Press.
- Lovejoy, A. O. (1927). The meanings of "emergence" and its modes. *Journal of Philosophical Studies*, 2, 167–181.

- Malaterre, C. (2007). Le “néo-vitalisme” au XIX<sup>ème</sup> siècle: une seconde école française de l'émergence. *Bulletin d'histoire et d'épistémologie des sciences de la vie*, 14, 25–44.
- Malisoff, W. M. (1939). Emergence without mystery. *Philosophy of Science*, 6, 17–24.
- Mayr, E. (2004). *What makes biology unique? Considerations on the autonomy of a scientific discipline*. Cambridge: Cambridge University Press.
- McLaughlin, B. P. (1992). The rise and fall of British emergentism. In A. Beckermann, H. Flohr, & J. Kim (Eds.), *Emergence or reduction? Essays on the prospects of nonreductive physicalism* (pp. 49–93). Berlin: de Gruyter.
- McLaughlin, B. P. (1997). Emergence and supervenience. *Intellectica*, 25, 25–43.
- Melnyk, A. (2003). *A physicalist manifesto: Thoroughly modern materialism*. Cambridge: Cambridge University Press.
- Montague, W. P. (1929). A materialistic theory of emergent evolution. In J. Dewey (Ed.), *Essays in honor of John Dewey, on the occasion of his seventieth birthday, October 20, 1929* (pp. 257–273). New York: Henri Holt.
- Morgan, C. L. (1923). *Emergent evolution*. London: Williams and Norgate.
- Morowitz, H. J. (2002). *The emergence of everything: How the world became complex*. New York: Oxford University Press.
- Nagel, E. (1949). The meaning of reduction in the natural sciences. In R. C. Stauffer (Ed.), *Science and civilization* (pp. 97–135). Madison: University of Wisconsin Press.
- Nida-Rümelin, M. (2007). Dualist emergentism. In B. P. McLaughlin & J. D. Cohen (Eds.), *Contemporary debates in philosophy of mind* (pp. 269–286). Oxford: Blackwell Publishing.
- Papineau, D. (2010). Can any sciences be special? In C. Macdonald & G. Macdonald (Eds.), *Emergence in mind* (pp. 179–197). Oxford: Oxford University Press.
- Peacocke, A. (2007). Emergent realities with causal efficacy: Some philosophical and theological applications. In N. C. Murphy & W. R. Stoeger (Eds.), *Evolution and emergence: Systems, organisms, persons* (pp. 267–283). New York: Oxford University Press.
- Reece, J. B., et al. (2010). *Campbell biology* (9th ed.). San Francisco: Benjamin Cummings. 2010.
- Reisse, J. (2006). *La longue histoire de la matière. Une complexité croissante depuis des milliards d'années*. Paris: Presses universitaires de France.
- Ronald, E. M., Sipper, M., & Capcarrere, M. S. (1999). Design, observation, surprise! A test of emergence. *Artificial Life*, 5, 225–239.
- Sartenaer, O. (2011). Entre monisme et dualisme: Deux stratégies pour l'émergence. *Philosophiques*, 38(2), 543–557.
- Sartenaer, O. (2013). Neither metaphysical dichotomy nor pure identity. Clarifying the emergentist creed. *Studies in History and Philosophy of Biological and Biomedical Science*, 44(3), 365–373.
- Sartenaer, O. (2015). Synchronic vs. diachronic emergence. A reappraisal. *European Journal for Philosophy of Science*, 5(1), 31–54.
- Sawyer, R. K. (2002). Emergence in psychology: Lessons from the history of non-reductionist science. *Human Development*, 45, 2–28.
- Scott, A. (2007). Nonlinear science and the cognitive hierarchy. In N. C. Murphy & W. R. Stoeger (Eds.), *Evolution and emergence: Systems, organisms, persons* (pp. 173–197). New York: Oxford University Press.
- Sellars, R. W. (1909). Causality. *Journal of Philosophy, Psychology and Scientific Methods*, 6, 323–328.
- Sellars, R. W. (1922). *Evolutionary naturalism*. New York: Russell & Russell.
- Sellars, R. W. (1933). L'hypothèse de l'émergence. *Revue de Métaphysique Et de Morale*, 40, 309–324.
- Sellars, R. W. (1959). Levels of causality: The emergence of guidance and reason in nature. *Philosophy and Phenomenological Research*, 20, 1–17.
- Silberstein, M., & McGeever, J. (1999). The search for ontological emergence. *Philosophical Quarterly*, 50, 182–200.
- Smart, J. J. (1981). Physicalism and emergence. *Neuroscience*, 6, 109–113.
- Sperry, R. (1983). Changed concepts of brain and consciousness: Some value implications. *Perkins Journal*, 36, 21–32.
- Stephan, A. (1992). Emergence—A systematic view on its historical facets. In A. Beckermann, H. Flohr, & J. Kim (Eds.), *Emergence or reduction? Essays on the prospects of nonreductive physicalism* (pp. 25–48). Berlin: de Gruyter.
- Stephan, A. (1999a). Varieties of emergentism. *Evolution and Cognition*, 5, 49–59.
- Stephan, A. (1999b). *Emergenz: Von der Unvorhersagbarkeit zur Selbstorganisation*. Dresden: Dresden University Press.



- van Gulick, R. (1992). Nonreductive materialism and the nature of intertheoretical constraint. In A. Beckermann, H. Flohr, & J. Kim (Eds.), *Emergence or reduction? Essays on the prospects of nonreductive physicalism* (pp. 157–179). Berlin: de Gruyter.
- van Gulick, R. (2001). Reduction, emergence and other recent options on the mind/body problem: A philosophic overview. *Journal of Consciousness Studies*, 8, 1–34.
- Walsh, D. (2012). Mechanism and purpose: A case for natural teleology. *Studies in History and Philosophy of Science Part C*, 43, 173–181.
- Weinberg, S. (1992). *Dreams of a final theory*. New York: Pantheon Books.
- Williams, R. J. P. (1998). Reductionism in physical sciences. In G. R. Bock & J. A. Goode (Eds.), *The limits of reductionism in biology* (pp. 15–23). Chichester: Wiley.