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Synchronic Vs. Diachronic Emergence: A Reappraisal

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Abstract In this paper, I put forward a benchmark account of emergence in terms of non-explainability and explicate the relationship that exists between its synchronic and diachronic declinations. I develop an argument whose conclusion is that emergence is essentially a "two-faceted" notion, *i.e.* it always encapsulates *both* synchronic and diachronic dimensions. I then compare this account with alternative recent accounts of (diachronic) emergence that define the concept through the notion of unpredictability or topological non-equivalence.

Keywords Synchronic emergence · Diachronic emergence · Constitutive explanation · Etiological explanation · Unpredictability · Determinism · Chaos · Topological equivalence

1 Introduction

In this paper, I put forward a benchmark account of emergence that proves to be faithful to the mainstream classical and contemporary construals of the concept, and explicate the relationship that exists between its synchronic and diachronic declinations. To this purpose, I set the stage by providing working definitions of synchronic and diachronic emergences in terms of constitutive and etiological non-explainability, respectively (section 2). I then develop a threefold argument devoted to showing that we have good reasons to believe

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that synchronic emergence entails diachronic emergence, and *vice versa*. Consequently, the account of emergence I propose turns out to be "two-faceted", *i.e.* it always encapsulates *both* synchronic and diachronic dimensions, hence always making sense of *both* what I refer to as constitutive and historical construals of the notion of qualitative novelty (section 3). Finally, I compare this account with alternative recent accounts – respectively endorsed by thinkers like Achim Stephan and Alexander Rueger – that characterize (diachronic) emergence in terms of unpredictability and topological non-equivalence (section 4).

2 Setting the stage

2.1 A working definition of emergence

The very possibility of formulating the argument that will be presented in section 3 primarily requires a clear construal of emergence. Without going into the details of what emergence is – or can possibly be[1] –, I outline in this section a working account of the notion that will prove to be sufficiently constraining for the discussion to follow. I also take for granted Humphreys' claim that the synchronic/diachronic distinction cuts across taxonomies of emergence that are based on the nature of the different relations an emergent may have with its emergence basis ([9] Humphreys 2008a, p. 586). As a consequence, one is free to adopt the version of the concept one prefers (*e.g.* an "inferential" or an "ontological" one), provided that it meets the following minimal requirements, which are presented here incrementally:

- (1) Emergence is a *relation* between two (sets of) *relata*, *viz.* the emergent and its emergence basis.
- (2) Emergence is an *empirical* relation, in the sense that it is either a relation obtaining within the natural world *or* it is a formal relation that has at least an empirical enforcer in the natural word[2].
- (3) Emergence is an empirical relation that reconciles two features that seems *prima facie* to be in tension. (a) The emergent is *dependent* on its emergence basis. (b) The emergent is *autonomous* from its emergence basis.

While there actually exist several ways in which one can construe and reconcile (a) and (b), I will here content myself with unpacking them in a somewhat general – and hence not (too) controversial – sense, by claiming that:

[1] For an overview of the possible varieties of the notion and the way they differ from each other, see for instance my [28] Sartenaer 2013.

[2] An example of the second case may be found as early as in George Henri Lewes' original account of emergence. While he construed the notion through a formal criterion (*viz.* non-mathematizability; [17] Lewes 1875, p. 370), this was primarily meant to reflect an empirical relation within the world itself, namely that of a (heteropathic) composition of causes.

– (4) Emergence is an empirical relation between an emergent and its emergence basis such that (a) the emergent is *ontologically determined* by its emergence basis – to the effect that it makes sense to say that the emergence basis brings about the emergent –, and (b) the emergent is *qualitatively novel* with regard to its emergence basis – to the effect that it makes sense to say that "something new" appears in the process of bringing about the emergent[3].

"Qualitative novelty" is obviously an ambiguous expression, and a great deal of emergentists' energy actually turns out to be spent on finding a precise and positive way of capturing it. In order to propose here a working account of emergence which remains as uncontroversial as possible, I construe the notion in a sense which is arguably neither *too weak* (*e.g.* so that novelty in emergence would merely amount to a mismatch between the observations of a cognitive agent and its subjective expectations) nor *too strong* (*e.g.* so that through emergence may suddenly appear new irreducible causal powers). It turns out that a reasonable compromise consists in conceiving of qualitative novelty as what may be called a *failure of determinative traceability*, which may be characterized through the following claim – which actually also constitutes the final step in setting up my working account of emergence:

– (5) Emergence is an empirical relation between an emergent and its emergence basis such that (a) the emergent is *ontologically determined* by its emergence basis, and (b) it is not possible to *trace* the determinative chain that goes from the emergence basis to the emergent (or, put differently, it is not possible to provide a complete and adequate account of the successive relations of determination that lead – or have led – from the emergence basis to the emergent).

It is noteworthy that these requirements are by no means supposed to capture what emergence *ought to be*. Rather, they help sketch an outline of a general benchmark on the basis of which each declination of the concept one finds in the literature may be measured – going from "orthodox" versions that share these minimal requirements, to more "heterodox" varieties that deny some (or all) of them.

It should also be pointed out that the working account of emergence given in (5) has been formulated neither arbitrarily, nor only for the sake of the discussion to follow. On the contrary, its very soundness as a benchmark is vindicated by the history of the concept of emergence itself, as well as through its current usage in numerous contexts, scientific and philosophical. Textual evidence may indeed be provided to support the idea that the account encapsulated in (5) is faithful to classical emergentism (*e.g.* [22] Morgan 1923;

[3] Thesis (a) actually constitutes the minimal requirement for emergentism to deny radical dualism, or the idea that an emergent and its emergence basis are radically heterogeneous or independent from one another. In a somewhat symmetric fashion, thesis (b) turns out to be a commitment that secures the rejection of radical reductionism, or the idea that an emergent and its basis are merely identical.

[3] Broad 1925; or [29] Sellars 1922) as well as contemporary construals of emergence developed by reductionist philosophers (*e.g.* [14] Kim 2006), antireductionist philosophers (*e.g.* [7] Gillett 2002) or even working scientists (*e.g.* [16] Laughlin 2005)[4].

2.2 Synchronic and diachronic emergences

Based on what has been said so far, I am now in a position to provide working definitions for synchronic and diachronic emergences. This may be achieved by interpreting theses (a) and (b) in (5) by assigning them, respectively, synchronic *constitutional* and diachronic *causal* dimensions, as follows:

- *Synchronic* emergence is an empirical relation between an emergent and its emergence basis such that (a) the emergent is *constitutively determined* by its emergence basis, and (b) it is not possible to *trace* the *constitutive* chain that goes from the emergence basis to the emergent;
- *Diachronic* emergence is an empirical relation between an emergent and its emergence basis such that (a) the emergent is *causally determined* by its emergence basis, and (b) it is not possible to *trace* the *causal* chain that goes from the emergence basis to the emergent.

At this point, a qualification with regard to the nature of the bases involved in both cases of emergence has to be brought to light. This requires two prerequisite clarifications. First, because constitution is a synchronic relationship that may be construed in (at least) two different senses – namely *compositional* and *non-compositional* –, two corresponding declinations of synchronic emergence may be put forward, *viz. inter-level* emergence and *inter-order* (*intra*-level) emergence, respectively (see for instance [34] Vision 2011, p. 48, with a different terminology). While the former variety captures a constitutive relation between putatively emergent wholes and their parts (*e.g.* molecules and their composing atoms) that populate distinct "levels" of nature (*e.g.* the molecular level and the atomic level), the latter captures a constitutive relation between entities that are located at a same "level" of reality (say, the organismic level) – so they do not stand in a part-whole relationship – but rather at different "orders" (*e.g.* the neurobiological order and the psychological order), insofar as one set of entities fulfills the role that is defining of the other set of entities (*e.g.* neurobiological properties that fulfill the functional

[4] A reason for this is that this working account is sufficiently general to cover (i) cases where the determinative chain leading to emergents is supposed not to be traceable *tout court* – hence the advent of emergents is to be accepted with a "loyal attitude" ([22] Morgan 1923, p. 4) or the so-called "natural piety of the investigator" ([1] Alexander 1920, p. 47) –, (ii) cases where the determinative traceability *from the emergence basis only* fails insofar as there also supposedly exist determinative relations going *from the emergent* to its basis – an idea which is often referred to nowadays through the multi-faceted notion of "downward causation" –, and finally (iii) cases where the determinative traceability fails due to contingent cognitive or technical limitations.

roles that are defining of psychological properties). Second, because I take causation here as being essentially a diachronic relation, there necessarily (and of course also trivially) exists a time lapse between the instantiations of basal entities and entities that diachronically emerge from them. And contrary to the case of synchronic emergence, there isn't necessarily any difference in level or order between putative diachronic emergents and their bases.

This being said, a qualification of the working definitions of synchronic and diachronic emergences runs, in a nutshell, as follows: while synchronic emergents are constituted (compositionally or non-compositionally) – but *not* caused – by their *lower-level* or *lower-order simultaneous* emergence bases, diachronic emergents are caused – but *not* constituted (neither compositionally nor non-compositionally) – by their *antecedent* possibly (but not necessarily) *same-level* and *same-order* emergence bases.

Finally, it is also worth noting that both versions of determinative non-traceability involved in the working definitions formulated above correspond to different ways of construing the ambiguous notion of "qualitative novelty". On the one hand, the inability to trace the constitutive chain leading from a basis to its higher-level or higher-order synchronic emergent renders this emergent *constitutively novel*, in the intuitive sense that it exhibits properties that are not exhibited by its current *underlying* basis. On the other hand, the inability to trace the causal chain leading from a basis to its subsequent diachronic emergent makes this emergent *historically novel*, to the extent that it exhibit properties that were not exhibited *in the past* by its emergence basis.

2.3 Operationalising the working definitions

Before wrapping up this preliminary groundwork and turning to the argumentative part of this paper, let us render the previous, rather abstract considerations somewhat more concrete and operational. To this end, let us refer to figure 1, which represents the relationships that a given entity has with simultaneous lower-order and lower-level entities as well as past entities. The diagram may be read (and illustrated) as follows: a given property $E_{2,2}$ (say, Marie's mind) exhibited by a system S_2 (Marie) is constitutively, but not compositionally, realized in a set of lower-order macro-physical properties $E_{2,1}$ (Marie's organismic properties) at time t_2; These properties, in turn, are compositionally realized in a set of lower-level micro-physical entities and properties $\{B_2^i\}$ (Marie's ultimate constitutive physical particles and their properties) at time t_2; $S_2E_{2,2}$, $S_2E_{2,1}$ and $\{B_2^i\}$ (Marie's mental, macro-physical and micro-physical features at time t_2) are respectively determined by prior $S_1E_{1,2}$, $S_1E_{1,1}$ and $\{B_1^i\}$ (Marie's mental, macro-physical and micro-physical features at time t_1), the first being constitutively, but not compositionally, realized in the second, and the second being compositionally realized in the third at that time. The arrows with hollow heads represent synchronic relations of *constitution* (of a non-compositional type if the head is squared; of

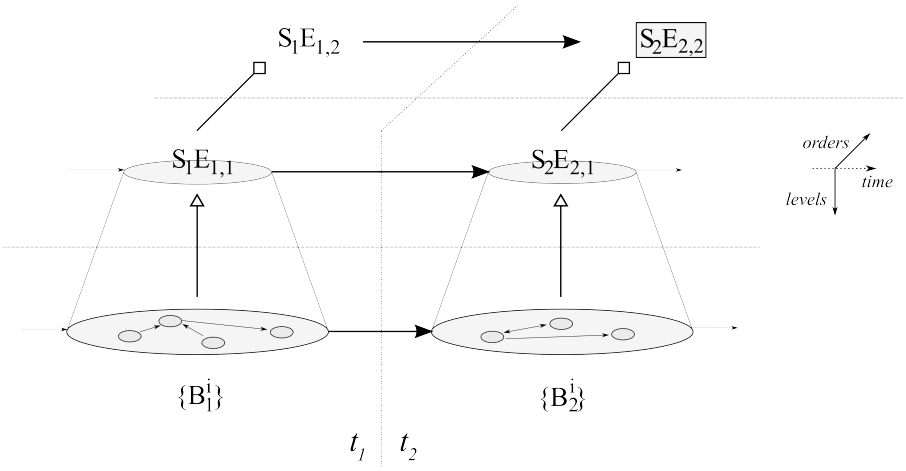

Fig. 1 Diachronic and synchronic determinative relationships whose given entity – here $S_2E_{2,2}$ (*e.g.* Marie having a mind) – is the final *relatum*.

a compositional type if it is triangular); the ones with filled heads capture diachronic relations of *causation*.

With this in mind, let us now reformulate the working definitions of synchronic and diachronic emergences in a somewhat more intuitive and operational way, by capturing the core content of the notion of determinative non-traceability through the more usual notion of *explanation* and, more precisely, through Wesley Salmon's distinction between the *constitutive* and the *etiological* facets of explanation ([27] Salmon 1984, pp. 269-270). According to Salmon, an explanation of some event E is constitutive if it describes the processes and interactions that *make up* E. By contrast, an etiological explanation of E consists in tracing the causal processes and interactions that *lead to* E. Accordingly, and provided that clauses (a) of the working definitions of synchronic and diachronic emergences given above obtain, it can now be stated that:

- $S_2E_{2,2}$ (Marie's mind in t_2) synchronically emerges if it cannot be *constitutively* explained or, put differently, if it cannot be adequately explained from the knowledge of $S_2E_{2,1}$ (Marie's macro-physical structure in t_2) [inter-order emergence] or of $\{B_2^i\}$ (Marie's micro-physical structure in t_2) [inter-level emergence];
- $S_2E_{2,2}$ (Marie's mind in t_2) diachronically emerges if it cannot be *etiologically* explained or, put differently, if it cannot be adequately explained from the knowledge of a state of S_2 at a prior time t_1, be it $S_1E_{1,2}$ (Marie's prior mental state), $S_1E_{1,1}$ (Marie's prior macro-physical state) or $\{B_1^i\}$ (Marie's prior micro-physical state).

Let us close this introductory section with two remarks. First, the working definitions formulated here are silent on the very strength of the unexplainability involved in emergence. Accordingly, both synchronic and diachronic emer-

gences so construed can come in two varieties, generally qualified as "weak" and "strong". While weak (synchronic or diachronic) emergence is to be defined through (constitutive or etiological) unexplainability *in practice – i.e.* a possibly temporary unexplainability resulting from technical or cognitive limitations at a given time –, strong (synchronic or diachronic) emergence involve (constitutive or etiological) unexplainability *as a matter of principle – i.e.* unexplainability "once and for all", independently of any present and future technical or cognitive limitations. This being said, I will focus exclusively on the strong variety of synchronic and diachronic emergences in the remainder of this paper, and leave aside its weak counterpart[5].

Second, the reader may be concerned that diachronic emergence is defined here through an interpretation of the requirement of historical qualitative novelty expressed in terms of the related notions of causal non-traceability and etiological non-explainability, and not through some particular declination of *unpredictability* (as it is the case, for example, in [32] Stephan 1999). However subtle the difference between etiological non-explainability and unpredictability turns out to be, it can actually prove to be crucial in certain contexts as a definitional criterion for diachronic emergence. Accordingly, I will address this point in due time (section 4.1).

3 Against *purely* synchronic and *purely* diachronic emergences

Now that the stage has been extensively set, let us try to figure out the extent to which both synchronic and diachronic emergences are independent from one another. The thread I will follow here consists in successively showing that :

- Synchronic emergence is also necessarily diachronic emergence, except if one is committed to some thesis T_1 that I will explicate (section 3.1);
- Diachronic emergence is also necessarily synchronic emergence, except if one is committed to some thesis T_2 that I will explicate (section 3.2);
- Because T_1 and T_2 are either (arguably) false or supposedly controversial, there are no good reasons to believe that there is anything in the natural world that may count either as *purely* synchronic emergence or *purely* diachronic emergence (section 3.3).

For the sake of simplicity, and because it has no impact on the three steps of the argument developed below nor the consequences that follow from it, I will only focus on the inter-level version of emergence and set aside the inter-order one (and consequently, I will from now on simplify the notations used in the previous section by omitting the subscripts corresponding to orders).

[5] A threefold motivation for this is that strong emergence is more widespread, more philosophically interesting – in the sense that its existence would have more radical consequences on our understanding of nature –, and consists of the variety of the notion that was originally put forward by classical emergentists in the early 20th century ([4] Chalmers 2006).

3.1 From synchronic to diachronic emergence

Coming back to the situation sketched out in figure 1, it can first be shown that if S_2E_2 is synchronically emergent, it is also diachronically emergent, except if one is ready to accept an assumption T_1 that I explicate below. Put differently, assuming one cannot constitutively explain Marie's macro-physical features from Marie's micro-physical features at a given moment, it follows that, at least under a certain assumption ($\neg T_1$), one cannot etiologically explain it either from Marie's state at a prior time, be it macro-physical or micro-physical.

Vindicating this idea may be achieved on the basis of a twofold argument whose overall structure is schematized in figure 2. Given the hypothesis that S_2E_2 synchronically emerges on $\{B_2^i\}$, let us figure out if S_2E_2 is etiologically explainable from a prior state of the system, either (1) from an explanatory path going through $\{B_2^i\}$ or (2) from an explanatory path going through S_1E_1 [diagram (a)].

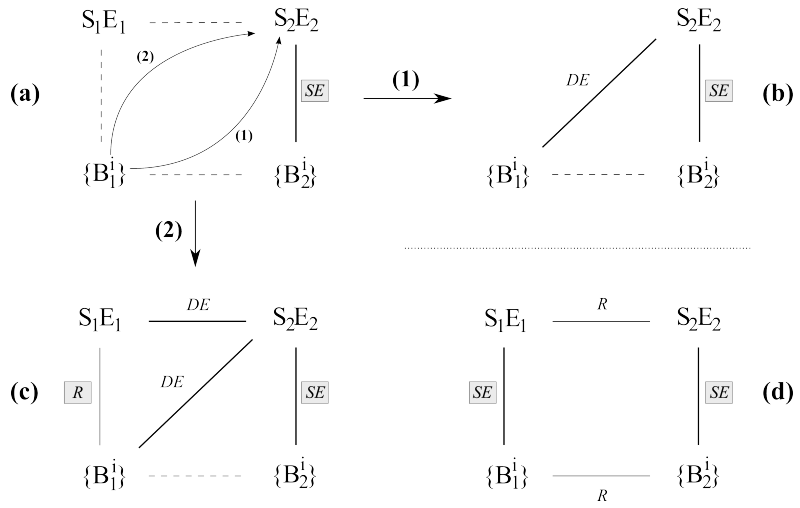

Fig. 2 Overall structure of the argument. The relationships between items in the diagrams may be relations of synchronic emergence (SE), diachronic emergence (DE), or reduction (R), a relation which is loosely used here to refer to both failures of synchronic emergence and diachronic emergence. In cases where the relationship between items may remain indeterminate – either reduction or (synchronic or diachronic) emergence –, dashed lines are used. Relations with a label in a shaded square hold by hypothesis.

Case (1) – assessing the possibility of explaining S_2E_2 from $\{B_1^i\}$ through $\{B_2^i\}$ – is straightforward, for even in the case where $\{B_1^i\}$ allows us to etiologically explain $\{B_2^i\}$, $\{B_2^i\}$ cannot be used, by hypothesis of synchronic emergence, as a basis for constitutively explaining S_2E_2. Consequently, S_2E_2

cannot be explained from $\{B_1^i\}$, so that the former diachronically emerges on the latter [diagram (b)].

Dealing with case (2) – assessing the possibility of explaining S_2E_2 from $\{B_1^i\}$ through S_1E_1 – requires some more subtlety. Two different options have to be evaluated, namely when S_1E_1 is reducible to $\{B_1^i\}$ [diagram (c)] or when, on the contrary, S_1E_1 synchronically emerges on $\{B_1^i\}$ [diagram (d)]. Tackling the former option first, it may be shown that it essentially amounts to the case we have just described in diagram (b) with regard to the explanatory path going through $\{B_2^i\}$. In a nutshell, the rationale for this consists in pointing out that S_1E_1 cannot have an explanatory relevance that its own hypothesised reduction base, $\{B_1^i\}$, does not have either. This can be shown more convincingly through the following *reductio ad absurdum* (see figure 3). If we suppose, contrary to what we want to demonstrate here, that S_2E_2 does *not* diachronically emerge on S_1E_1, so that S_1E_1 may be used to etiologically explain S_2E_2 while being, by hypothesis, reducible to $\{B_1^i\}$, then, no matter the relationship between $\{B_1^i\}$ and $\{B_2^i\}$ – either one of reduction or diachronic emergence –, there is a conflict with the initial assumption according to which S_2E_2 synchronically emerges on $\{B_2^i\}$. On the one hand, and as we have seen, this initial assumption implies that S_2E_2 diachronically emerges on $\{B_1^i\}$, so the former is unexplainable from the latter. On the other hand, the putatively absurd hypothesis leads to the opposite result according to which S_2E_2 is reducible to – and hence explainable from – $\{B_1^i\}$. Resolving this conflict requires us to reject the absurd hypothesis. Hence S_2E_2 diachronically emerges on S_1E_1.

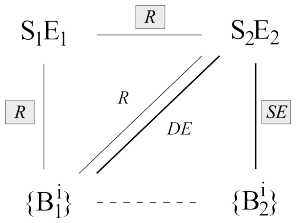

Fig. 3 Conflicting situation where the initial hypothesis – S_2E_2 synchronically emerges on $\{B_2^i\}$ – is combined with the (absurd) assumption that S_2E_2 is reducible to S_1E_1, in a context where S_1E_1 is also supposed to be reducible to $\{B_1^i\}$.

Finally, there remains the case where S_1E_1 happens to be synchronically emergent on $\{B_1^i\}$ [diagram (d) on figure 2]. In such a situation, the assumption that S_2E_2 synchronically emerges on $\{B_2^i\}$ does *not* necessarily entail the etiological non-explainability of S_2E_2 from S_1E_1, a fact that seems *prima facie* to undermine the whole argumentative project that this section is about. *Nevertheless*, the very plausibility of the picture captured by diagram (d) rests on a controversial metaphysical assumption that I will show to be out of place in section 3.3, *viz.* what I will refer to here as the thesis T_1 of *fixist parallelism*. In a nutshell, fixist parallelism is a commitment to the idea according to which

high-level or high-order entities or properties (like Marie's mind) have *always* been somehow existent (even before, say, Marie's own birth). In such a context, high-level or high-order entities or properties would not have to appear at some point in the history of the evolving universe (or, to give follow-up to our illustration, in the history of the growing embryo that will eventually turn out to be Marie), so that their supposed synchronic emergence would *always* be preceded by prior synchronic emergences, *ad infinitum*. If one rejects such a thesis, to the effect that there will always exist a particular time t_*, prior to t_2, when S_*E_* does *not* synchronically emerge on its underlying basis $\{B^i_*\}$, then the case depicted in diagram (d) is tantamount to the one we have just discussed in diagram (c) (with $t_* = t_1$), where the diachronic emergence of S_2E_2 on S_*E_* necessarily follows from its hypothesized synchronic emergence on $\{B^i_2\}$ (see figure 4).

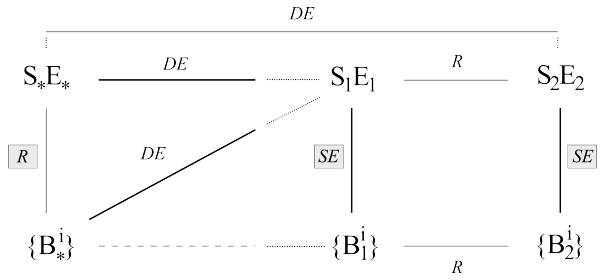

Fig. 4 If one rejects fixist parallelism, there will always exist a given moment t_* in the past when S_*E_* does not synchronically emerge on $\{B^i_*\}$, so the argument put forward earlier – where S_1E_1 was supposed to be reducible to $\{B^i_1\}$ – can be repeated identically (with $t_* = t_1$).

So synchronic emergence is also necessarily diachronic emergence, except if one is committed to thesis T_1 of fixist parallelism, a thesis that I will show in section 3.3 to be, if not merely false, at least drastically inconsistent with the common naturalistic assumptions of both hard-core reductionists and emergentists. In any case, what has been shown so far is not really great news, for it actually merely encapsulates the quite common intuition that every case of constitutive novelty is also – or has also been at some point in the past – a case of historical novelty.

3.2 From diachronic to synchronic emergence

Let us now turn to the argument aiming to show that if S_2E_2 is diachronically emergent, it is also synchronically emergent, except if one is committed to a thesis T_2 that I will explicate below. Put differently, assuming one cannot etiologically explain Marie's macro-physical features in t_2 from Marie's features at a previous time t_1 – be they macro- or micro-physical –, it follows that, at

least under a certain assumption ($\neg T_2$), one cannot constitutively explain it either from Marie's micro-physical features at t_2.

In order to vindicate such a claim, I put forward an argument that runs differently from the one exposed in section 3.1. I proceed "backwardly" here, in the sense that, instead of directly trying to show that diachronic emergence entails synchronic emergence, I show that diachronic emergence *without* synchronic emergence is implausible (provided that T_2 is rejected).

Figure 5 shows the only three possible options where "pure" diachronic emergence – *i.e.* diachronic emergence without synchronic emergence – is at stake. These options respectively involve diachronic emergence at the micro-level [diagram (a)], at the macro-level [diagram (b)], or at both levels [diagram (c)].

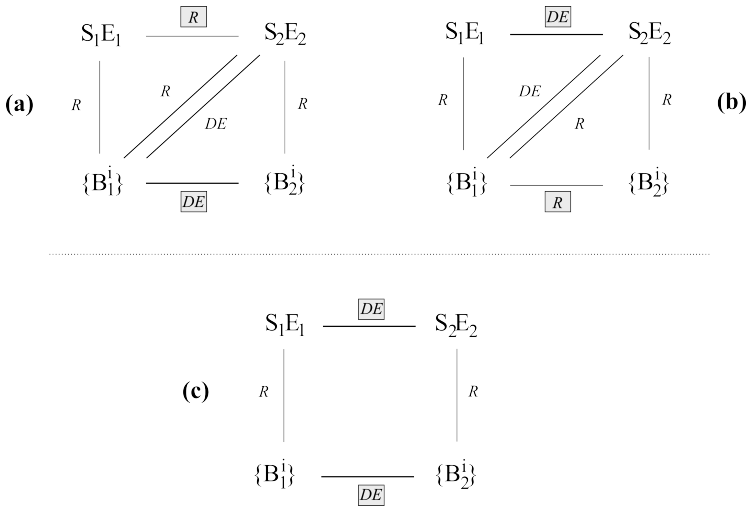

Fig. 5 The only three possible situations where diachronic emergence is at stake without any synchronic emergence. Because diagrams (a) and (b) represent impossible situations, diagram (c) depicts the only plausible scenario for "pure" diachronic emergence.

From the outset, it can be argued that diagrams (a) and (b) depict impossible situations, insofar as they encapsulate a contradiction in the way S_2E_2 is to be considered as explainable or unexplainable from $\{B_1^i\}$. While in scenario (a), S_2E_2 is supposed to be explainable from $\{B_1^i\}$ through S_1E_1 and unexplainable from $\{B_1^i\}$ through $\{B_2^i\}$, in scenario (b), S_2E_2 is supposed to be unexplainable from $\{B_1^i\}$ through S_1E_1 and explainable from $\{B_1^i\}$ through $\{B_2^i\}$. Resolving these conflicting situations *without* adding synchronic emergence to the picture (otherwise one will merely assume what this whole section aims at demonstrating) requires us to posit diachronic emergence at *both* the

micro- and the macro-levels. Consequently, diagram (c) is the only possible scenario for "pure" diachronic emergence[6].

Accordingly, in order to claim that diachronic emergence entails synchronic emergence, one has to show that the situation depicted in diagram (c) is actually implausible. To this purpose, it is primarily necessary to identify and explicate the thesis on which such a situation rests, namely what I will refer to here as the thesis T_2 of *(multi-level) epistemic indeterminism*. I take "epistemic determinism" ($\neg T_2$) to refer to the conjunction of the ideas that (i) there exists a uniform determinative relationship (*viz.* causation) between every subsequent states of a given system (or the entire universe, if determinism is taken to be global) – to the extent that every state of the system (or the universe) is univocally determined by one of its prior states –, and (ii) such relationship is traceable in principle by a cognitive agent – to the extent that she may be in a position to precisely *explain* (etiologically) why every state of the system (or the universe) is to follow from one of its prior states. Clause (i) captures what may be referred to as *ontological determinism*, which then constitutes a necessary but not sufficient condition for epistemic determinism[7]. It is also quite intuitive that *multi-level* epistemic determinism is a commitment to (i) and (ii) where the states involved span all the compositional levels of nature.

This being said, it should be obvious that being committed to T_2 so construed is a requirement for a situation as depicted in diagram (c) of figure 5 to obtain, for endorsing multi-level indeterminism is a necessary (and sufficient) condition for $\{B_2^i\}$ to diachronically emerge on $\{B_1^i\}$ and S_2E_2 to diachronically emerge on S_1E_1, respectively, *provided that* such diachronic emergences are *not* merely a result of S_2E_2 synchronically emerging on $\{B_2^i\}$.

So diachronic emergence is also necessarily synchronic emergence, except if thesis T_2 of multi-level epistemic indeterminism turns out to be true – a fact that I contest in the section to come.

3.3 On the possibility of *purely* synchronic and *purely* diachronic emergences

Both previous sections have been devoted to explicating the theses one has to be committed to in order to argue that synchronic and diachronic emergences

[6] This purely formal result should be consistent with the way the natural world turns out to be. It actually seems to be the case, insofar as if there is (i) a relation of diachronic emergence between, say, subsequent quantum events ($\{B_1^i\}$ and $\{B_2^i\}$) and (ii) a coupling of these with macroscopic events (S_1E_1 and S_2E_2, respectivelly), then there *must be* a relation of diachronic emergence between these macroscopic events ([15] Ladyman and Ross 2007, p. 28; with what I call here "diachronic emergence" referred to by the equivalent expression of "indeterminism").

[7] A note of clarification: epistemic determinism is defined here as a conjunction of ontological determinism and etiological traceability. Epistemic determinism then entails ontological determinism, but not *vice versa*. Equivalently, ontological indeterminism entails epistemic indeterminism, but not *vice versa*. As a result, it is logically consistent to be committed to ontological determinism together with epistemic indeterminism, a view which is actually nothing else than diachronic emergentism.

are not merely coextensional. In a nutshell, the situation we have come up with is the following:

- Synchronic emergence is *not* also diachronic emergence – *i.e.* emergence is *purely* synchronic – if T_1 (fixist parallelism) is true.
- Diachronic emergence is *not* also synchronic emergence – *i.e.* emergence is *purely* diachronic – if T_2 (multi-level epistemic determinism) is true.

In this section, I provide reasons to think that T_1 and T_2 are not well-grounded, and hence too controversial to justify a sharp demarcation between synchronic and diachronic emergences.

3.3.1 Against purely *synchronic emergence*

Obviously, the truth or falsity of fixist parallelism (T_1) is not something one can expect to be definitely fixed by any empirical investigation. Nevertheless, for the purpose of this paper, one can discard this thesis solely by pointing out that its very denial is a common assumption of *both* antagonist views that are "emergentism" and "reductionism" (broadly construed). The reason for this is that emergentists and reductionists alike share an (at least minimal form of) ontological *naturalism* – to the extent that they are all ready to take (cosmological) evolution seriously as a scientific theory telling us something (at least approximately) true about the world – combined with an (at least minimal form of) ontological *monism* – to the extent that they all agree with the idea that high-level entities are somewhat brought into existence *by* their lower-level bases, and *only when* their lower-level bases (be they emergence or reduction bases) obtain.

So in the naturalistic and minimally monistic context that classical and contemporary emergentists and reductionists usually take for granted, synchronic emergence is diachronic emergence.

3.3.2 Against purely *diachronic emergence*

Undermining T_2 is a more complex issue, insofar as this thesis may fit into the minimally naturalistic and monistic framework that is usually shared by emergentists and reductionists alike. There might indeed exist empirical evidence vindicating the view that multi-level epistemic determinism fails in some particular situations. In this section, I address what appear to be the most convincing case where it is sometimes claimed that such a failure occurs – *viz.* chaos theory – and show how it actually fails to convincingly vindicate T_2, leaving the very plausibility of *pure* diachronic emergence without any uncontroversial empirical support.

But before turning to this, let us primarily evaluate – and then rapidly discard – a first strategy that could be used to argue for T_2. It consists in vindicating epistemic indeterminism (at the micro-physical level and at higher levels) by endorsing the stronger thesis of *ontological* indeterminism, *i.e.* the claim that there isn't any univocal and uniform determinative relationship that

links the successive states of a given system (or the entire universe) through time, to such an extent that no cognitive agent whatsoever could ever explain why a given state of that system (or the universe) is to follow from one of its prior states. It seems to me that such a radical strategy is not worth pursuing for reasons that are similar to the ones invoked above for dismissing fixist parallelism. On the one hand, ontological indeterminism is not empirically uncontroversial[8]. On the other hand, a *denial* of (multi-level) ontological indeterminism is usually and precisely a common ground of *both* emergentism and reductionism[9].

Let us then turn to a more promising strategy that would be suited for the job of vindicating *epistemic* indeterminism *in the ontologically deterministic context* that is usually shared by emergentists and reductionists alike. A theory that is often invoked in this respect is chaos theory. Given the fact that chaotic systems exhibit sensitivity to initial conditions, two argumentative threads are generally put forward. First, cognitive agents like human scientists do have, as a matter of fact, epistemic limitations, to the extent that they cannot operate infinitely precise measurements of a given system's initial conditions ([11] Hunt 1987, p. 132) or they cannot even represent accurately, through an indefinitely long series of digits, the (real) numbers that are the results of measurements and that are used in calculations ([33] Stone 1989, p. 125). Second, the behavior of chaotic systems cannot be expressed in a closed-form solution, so that there cannot be a shorter predictive algorithm to know a future state of a system than the one that contains *complete* information about the system under consideration and its evolution. Surely, the latter claim implies that cognitive agents have to confine themselves to merely "inspect" – rather than "predict" – what a future state of a chaotic system will turn out to be, for there is no possible shortcut for knowing such state "ahead of time", *i.e.* before the state in question actually obtains ([33] Stone 1989, pp. 125-128).

Although I am not contesting the truth of these claims, there are reasons to doubt that they actually imply the failure of (the required form of) epistemic determinism. To begin with, arguments on the model of the one put forward by

[8] As far as I know, the only serious option to vindicate an ontological form of indeterminism that percolates from the micro-physical level to higher levels is through quantum mechanics. However, contrary to what seems to be the folkloric picture on that matter, it is far from consensual that quantum mechanics actually implies such an indeterminism (see, for instance, [5] Earman 2007, p. 1399). In a nutshell, if it makes sense to talk about the quantum world as being the place of objectively chancy events, it is only to the extent that one is ready to adopt a controversial solution to the measurement problem, *viz.* by invoking the so-called "collapse" of the wave function. Alternative "non-collapse" pictures (*e.g.* Bohmian or Everetian) turn out to be fully (ontologically) deterministic.

[9] For example, and contrary to what is sometimes supposed, classical emergentism was a thoroughly (ontologically) deterministic doctrine (see [20] Mill 1898 [1843], p. 201; [13] Jennings 1927, p. 24; [30] Sellars 1933, p. 319; or even [23] Nagel 1961, p. 377). A notable exception to what has then become a deterministic "orthodoxy", but whose construal has however not been subsequently nurtured, is the case of Popper and Eccles ([25] 1977), who claim that "the positions and velocities of the various electrons within this cloud [the cloud round the atomic nucleus] are *indeterminate* [claim of ontological indeterminism] and therefore *indeterminable* [claim of epistemic indeterminism]" (p. 33; emphasis mine).

Hunt are logically flawed. If one defines epistemic determinism by saying that "[i]f the state of the system at a particular time is known [call this hypothesis "p"] then its state at a later time can be predicted [call this consequent "q"]" ([11] Hunt 1987, p. 132), then claiming that one cannot precisely know the state of the system at a particular time – to the extent that p is false – and that, consequently, its state at a later time cannot be predicted – so that q is false – doesn't imply the falsity of determinism so construed ($p \rightarrow q$), for an implication is true as soon as its antecedent is false. Showing that $p \rightarrow q$ is false actually requires one to show that q is false *when* p *is true*, *i.e.* when it is supposed, by hypothesis, that we *do* precisely know the state of the system at a given time. Surely, this first objection of mine turns out to be rather weak, insofar as it doesn't convincingly show that determinism is immune to Hunt-style arguments, but rather that Hunt-style determinism is badly formulated and has to be qualified, supposedly as follows : "the state of the system at a particular time is *knowable* [call this new clause "o"] and, if such state is known (p) then its state at a later time can be predicted (q)"[10].

This being said, there are more serious reasons to doubt of the soundness of the arguments exposed above. With regard to the first one that pertains to the impossibility of perfectly accurate measurements and representations (to the effect that o is supposed to be false), it is enough for my overall purpose to stress that the fact that such an impossibility is *absolute* instead of *merely practical* is highly controversial. As Arthur Fine puts it, "one could find some justification for going either way" ([6] Fine 1996, p. 243). While, as we have seen, thinkers like Hunt and Stone argue that our limited cognitive or technical capabilities are a matter of principle, other convincingly argue otherwise (see, for instance, [5] Earman 2007, pp. 1388-1391). It is worth mentioning that such unsettled controversy is also vivid in contemporary discussions more directly pertaining to emergence. Against the idea that chaotic systems are epistemically indeterministic and hence diachronically emergent – a claim endorsed, for example, by Newman ([24] 1996) –, it has been claimed that such systems do *not* exhibit emergence as a matter of *principle* ([12] Hüttemann and Terzidis 2000, p. 268).

At the end of the day, it turns out that the way of thinking about this matter – *viz.* whether or not the state of a given chaotic system is perfectly knowable *in principle* – is only sensitive to the kind of cognitive and technical powers one is ready to confer to an ideal investigator (*e.g.* a Laplacean "demon" or a Broadian "mathematical archangel"). Truly, if one grants this kind of exceptional being with the ability to perform perfect measurements and compute infinitely long numbers, then Hunt-style arguments are no threat to epistemic determinism ([31] Stephan 1992, p. 33; [32] Stephan 1999, p. 54). But proponents of epistemic indeterminism like Hunt, Stone, Newman and Stephan himself will probably not be worry about this, for they can rightly

[10] Under this form, Hunt's argument is valid, insofar as $o \wedge (p \rightarrow q)$ is false as soon as o turns out to be false.

contest that having such powers is pure phantasm to begin with, and that all that really matters is that such powers are inaccessible to *human* beings.

Even if at this point, what matters for my initial purpose – namely that it is highly controversial whether or not one could in principle perform perfect measurements and compute infinitely long numbers – has already been exposed, I can allow myself to push a little further by arguing that there actually is a way of settling this dispute in favor of determinism. In order for the dispute not to end up being purely verbal, one can indeed decide to cook up a criterion for demarcating what ability would count as practically and principally possible or impossible for a cognitive agent to perform. The criterion I propose in this respect is the following: relatively to a given theory (say, chaos theory), a given ability (*e.g.* making perfect measurements) is impossible "in principle" – to the extent that, in the case that matters here, epistemic determinism fails – if and only if there is an explanation *within the theory itself* of why no cognitive agent whatsoever cannot have this ability. According to me, the criterion proposed here has a major advantage. For it is theory-relative and therefore theory-constrained, any claim about the power an ideal agent could have in principle has to be *naturalistically* explained and justified, rather that merely being stipulated from a metaphysician's armchair. And if one is ready to take such a criterion seriously, then it turns out that chaos theory is no threat to epistemic determinism, for, as far as I know, nothing *in chaos theory* entitle us to think that perfectly accurate measurements are impossible in principle.

Now that I have tackled the issue of the in principle non-knowability of particular states of chaotic systems (*i.e.* clause *o* of the aforementioned characterization of determinism), let us turn to Stone's argument according to which the right sort of predictive algorithms – *viz.* compressible algorithms – are not available in chaos theory, so that it is not possible in principle to predict a future state of a system, even given a perfect knowledge of its prior states (to the effect that, even given the truth of *o*, $p \rightarrow q$ should be false). In a nutshell, suffice it to point out that such an argument turns out to be toothless with respect to what I have taken to be epistemic determinism in this paper, namely a thesis that grants cognitive agents with the ability to *etiologically explain* – rather than *predict* – a state of a system from a precise knowledge of one of its prior states (see section 3.2). In this context, even if one endorses Stone's argument, it leaves *this* version of epistemic determinism untouched, for *this* version places no restriction on the "efficiency" or the "rapidity" of the cognitive process of explaining a state of a chaotic system from the knowledge of one of its prior states. It actually only requires this explanation to be *possible* in principle, a fact that is acknowledged by Stone himself when he asserts that "[t]o say that chaotic systems are unpredictable is not to say that science cannot explain them" ([33] Stone 1989, p. 128). Put differently, the fact that there is no possible "shortcut" for getting to know the future state of a chaotic system from the knowledge of one of its prior states doesn't imply that it is not possible to precisely *trace* – in principle but also in practice – *the determinative chain* that goes from the latter to the former, a

possibility that is plainly sufficient to entail epistemic determinism as defined in section 3.2.

Before closing this section, it may be worth summarizing what has been claimed here. Rather than construing epistemic determinism on the model of Stone and (an amendment of) Hunt, namely as $o \wedge (p \rightarrow q)$, where o stands for "the states of the system are *knowable*", p for "a given state is *known*", and q for "a given future state can be *predicted*", I have considered epistemic determinism to be $o \wedge (p \rightarrow q^*)$, where the clause q^* stands for "a given future state can be *etiologically explained*". Showing that *this* version of determinism fails when it comes to chaos theory requires showing that either o or $p \rightarrow q^*$ is false. On the one hand, I have shown that the falsity of o is highly controversial, if not excluded if one is ready to adopt a reasonable naturalistic and theory-relative criterion to demarcate what is feasible in practice and in principle by cognitive agents. On the other hand, there is no reason to suspect, even if predictive algorithms in chaos theory are incompressible – so that $p \rightarrow q$ is certainly false –, that $p \rightarrow q^*$ turns out to be equally false[11].

Finally, it is worth reminding that construing epistemic determinism through etiological explainability (q^*) rather than predictability (q) has not been done only for the sake of the present discussion. Rather, it has been motivated by our prior choice of a working definition for diachronic emergence, a definition that, according to me, is the most faithful to the classical and contemporary mainstream way of making sense of emergence.

In conclusion, in an epistemically deterministic context that has not yet been convincingly undermined, diachronic emergence is also synchronic emergence.

3.4 Consequence: Two-faceted emergence

The upshot of the discussion carried out in sections 3.1, 3.2 and 3.3 is that synchronic and diachronic emergences as defined in section 2 have been shown to be *coextensional*. Therefore, if there is something in the world like (strong) emergence (in the sense encapsulated in (5)), then it is *both* synchronic and diachronic. Put differently, putative emergent-engendering processes have the effect of bringing about constitutive *and* historical novelties in nature. In such a context, the distinction between notions of synchronic and diachronic emergences must not be taken too seriously, in the sense that, at best, it consists in a pragmatic demarcation on the basis of which one can delineate two epistemic

[11] It is noteworthy that the fact that algorithmic incompressibility is no threat to the truth of $p \rightarrow q^*$ is *not* sensitive to the distinction between weak and strong emergence. What is relevant here is the difference between diachronic emergence defined as unpredictability and diachronic emergence defined as unexplainability. One can indeed think of cases involving unpredictability but not unexplainability, in principle *and* in practice (*e.g.* a random sequence of numbers generated by a computer). By contrast, the truth or falsity of thesis o *is* sensitive to the in practice/in principle distinction, so the fact that I have chosen in this paper to focus on strong (diachronic) emergence – instead of its weak counterpart – is of particular importance at this point.

facets of one and the same concept of emergence, *viz.* one causal and hence historical, the other constitutive and hence unhistorical.

It is noteworthy that such a two-faceted construal of emergence can be traced back to the classical emergentism of the early 20th century. When one of the pioneers of the doctrine of emergent evolutionism claims the following:

> What emerges at any given level affords an instance of what I speak of as a new kind of relatedness of which there are no instances at lower levels ([22] Morgan 1923, pp. 15-16),

or:

> In all true evolution there is more in the conclusion than is given in the premises ; which is only a logical way of saying that there is more in the world to-day than there was in the primitive fire-mist ([21] Morgan 1913, p. 30),

he explicitly encapsulates both the constitutive and historical facets of emergence, facets which were, according to him, completely inextricable[12].

4 Alternative accounts of (diachronic) emergence

In this last section, I focus on alternative accounts of the synchronic/diachronic distinction one can find in the literature, and explicate their relation to the account developed in this paper. In section 4.1, I focus on a view that takes *unpredictability* as the essential part of the *definiens* of diachronic emergence. In section 4.2, I examine a more idiosyncratic proposal according to which diachronic emergence may be precisely construed through a *topological* notion.

4.1 (Diachronic) emergence and predictability

In the present paper, I have construed diachronic emergence and epistemic indeterminism through the equivalent notions of causal non-traceability and etiological non-explainability (from now on, let us refer to this account by "$e-$emergence", "e" standing for "explanation"). Nonetheless, there exists another trend in contemporary literature that takes *unpredictability* as the essential criterion for diachronic emergence and epistemic indeterminism (let us call this account "$p-$emergence", "p" standing for "prediction"). An example of diachronic $p-$emergence is Stephan's "diachronic structure emergence" (see figure 6), which occurs when the rise of a given structure is unpredictable in principle, a case that typically obtains when the forming of this structure is the result of a chaotic process ([32] Stephan 1999, pp.53-54)[13]. The question that interests me here is the following: to what extent are $e-$ and $p-$emergences different from one another?

[12] A fact that is also stressed, for example, by Horgan ([8] 1993, p. 558).

[13] It is worth noting that, so construed, $p-$emergence – like $e-$emergence – is a variety of strong emergence, for the unpredictability involved is supposed to hold as a matter of principle.

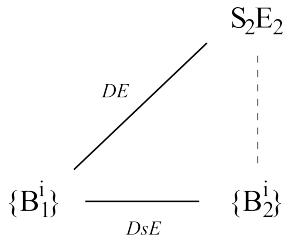

Fig. 6 Stephan's "diachronic structure emergence" (DsE), or $p-$emergence, of $\{B_2^i\}$ on $\{B_1^i\}$. Such emergence (i) necessarily entails the diachronic $p-$emergence of S_2E_2 on $\{B_1^i\}$, for S_2E_2 is also unpredictable from $\{B_1^i\}$, but (ii) does not necessarily entail what would be a synchronic $p-$emergence of S_2E_2 from $\{B_2^i\}$.

In a nutshell, the difference between these accounts lies in the fact that unpredictability is a more liberal criterion than etiological non-explainability, so the extension of $p-$emergence is larger than the extension of $e-$emergence. Equivalently, while $e-$emergence entails $p-$emergence, $p-$emergence does not necessarily lead to $e-$emergence. As it has already been stressed in section 3.2, a given phenomenon can indeed be unpredictable (in practice but also in principle) but nonetheless causally traceable or etiologically explainable (in principle but also in practice). The reason for this is that being able to predict "what comes next" in the evolution of a given system is more demanding that being able to explain "why such-and-such has finally come next", insofar as the former requires a cognitive agent to do something harder than the latter does, namely to perform her epistemic task *more rapidly* than the very evolution of the system under study. Such an additional restriction, which bears on the *efficiency* of the epistemic task to be performed, can also be rendered explicit in the way historical novelty is conceived of in $e-$ and $p-$emergences. While the former account captures the novelty of a given state like $\{B_2^i\}$ through some lack of knowledge of $\{B_2^i\}$, the latter does so on the basis of a (more liberal) lack of *advance* knowledge of $\{B_2^i\}$.

So $p-$ and $e-$ emergences are different – though not completely independent – concepts. This observation actually turns out to constitute the occasion for clarifying a confusion that can sometimes obscure the literature, especially when it comes to an exegesis of classical (so-called "British") emergentism. It is indeed not rare in this context to find philosophers or scientists claiming that classical emergentists, like Morgan, Alexander or Broad, did primarily conceive of emergence as $p-$emergence, to the effect that they should be considered as being part of the "unpredictability tradition". Surely, classical emergentists notably *did* consider emergent entities to be unpredictable. But their unpredictability-talk should not be confused with $p-$emergence, for emergent entities were then conceived of as being unpredictable *only to the extent that* they were primarily constitutively unexplainable and, therefore – as I have

shown in section 3.1 –, etiologically unexplainable[14]. The unpredictability of emergents then simply came "for free", for, as I have stressed above, etiological unexplainability necessarily entails unpredictability[15].

4.2 (Diachronic) emergence and topological equivalence

Another, quite idiosyncratic account of emergence has been recently put forward on different occasions by Alexander Rueger (see, for instance, [26] Rueger 2000; and [18] McGivern and Rueger 2010). This account consists in an original attempt to make sense of the ambiguous notion of qualitative novelty in emergence by capturing it through a precise mathematical notion, namely *topological (non)equivalence*. In this section, I focus on the diachronic variety of Rueger's emergence – called here $t-$emergence, "t" standing for "topological" – and evaluate how it relates to $e-$ and $p-$ emergences.

In a nutshell, diachronic $t-$emergence may be characterized as follows: S_2 (a given system S at time t_2) diachronically $t-$emerges on S_1 (the same system S at time t_1) if the trajectory that S_2 would have in a state space representation (for a time lapse t^* during which no environmental parameter is modified) is not topologically equivalent to the trajectory S_1 would have in a state space representation (for a time lapse t^* during which no environmental parameter is modified). By topological non-equivalence between trajectories in the state space, it is meant here that there is no homeomorphism that could convert one trajectory into the other. Typically, for S_2 to diachronically $t-$emerge on S_1, it is necessary that some control parameter evolves between t_1 and t_2 such that it crosses a particular value that corresponds to a bifurcation in the behavior of S, to the effect that the state space trajectory (S would have for a time lapse t^* during which no environmental parameter is modified) changes qualitatively, *i.e.* the trajectories (S would have for a time lapse t^* during which no environmental parameter is modified) pre- and post-bifurcation are not topologically equivalent. Put differently, the transition between the pre-

[14] So when Morgan claimed that "[l]iquidity and solidity are what we speak of as emergently new and unpredictable before the event" ([22] Morgan 1923, p. 64), this fact is a collateral consequence of the in principle constitutive (and hence causal) non-traceability of liquidity and solidity, which an investigator – human or demonic – has to accept devotedly.

[15] An example of the confusion discussed here is the following claim from Humphreys ([10] 2008b, p. 434): "The philosophical motivation for accepting this criterion [computational incompressibility] as capturing a certain kind of emergence draws on the philosophical tradition that emphasizes the essential unpredictability of emergent phenomena. The work of C.D. Broad, for example, lies in the essential unpredictability tradition, although he, of course, did not make use of computational criteria". If it is certainly true that Charlie Broad, among other emergentists, argued for the unpredictability of emergents, it is however clear that he did not focus on unpredictability, or that he did not lie within "the unpredictability tradition" that construes emergence as $p-$emergence, for his very *definiens* of emergence was primarily (constitutive) *non-deducibility* (see for instance [3] Broad, 1925 p. 61; or [19] McLaughlin 1992), which entails causal non-deducibility and, consequently, $e-$emergence.

and post-bifurcation behavior that S would have (for a time lapse t^* during which no environmental parameter is modified) is discontinuous[16].

Rueger illustrates his account through the simple physical situation of an initially damped oscillator S that becomes undamped, so that the control parameter – the damping d – has progressively decreased until it became null. The behavior of S before the damping has vanished, say in t_1, may be represented in the state space by a spiral trajectory ending in $(0, 0)$, a trajectory that represents the future behavior S would have from t_1 onwards if the damping were held constant (or a least would not cross the bifurcation point). The behavior of S when the damping has vanished, say in t_2, may be represented in the state space by an ellipse – a trajectory that represents the future behavior S would have from t_2 onwards if the damping were held at its null value. Then S_2 $t-$emerges on S_1, insofar as an ellipse is not topologically equivalent to a spiral. Such an emergence captures the idea that the behavior of the undamped oscillator is "qualitatively novel" with respect to the behavior it had when it was damped. While in the former (possible) case the oscillator would have oscillated indefinitely, in the latter (actual) case it will invariably tend to a resting position.

Now one may wonder: how does $t-$emergence relate to more widespread accounts like $e-$emergence and $p-$emergence? In a word, and by putting it somewhat bluntly, there is no non-trivial relation whatsoever between them; $t-$emergence simply turns out to be at right angle with *both* $e-$ and $p-$emergences.

The first and main reason for this is merely that the behavior of S_2 (*e.g.* the undamped oscillator) is thoroughly etiologically explainable *and* predictable from a knowledge of the behavior of S_1 (the damped oscillator) and the way the control parameter (the damping) is supposed to behave. This is not surprising, as one should not expect a classical oscillator to be a real threat to epistemic determinism – construed through q^* or q.

But other reasons may be invoked here, to the effect that $t-$emergence eventually appears to be quite an odd variety of emergence. To begin with, the criterion of topological non-equivalence is purely formal, and it isn't clear that it has any empirical enforcer in the natural world. Arguably, $t-$emergence only has to do with novelty or discontinuity *within the space state representation* of a system's behavior, not in its behavior itself. I doubt that any cognitive agent who actually observes a damped oscillator becoming undamped would claim that, when the damping vanishes, she has been strucked by a discontinuity or a

[16] I acknowledge the cumbersome nature of the repetitive expression "would have for a time lapse t^* during which no environmental parameter is modified", which is mine and not from Rueger's original account. I just can't think of a better way of accurately specifying that there is a difference between (a) the *actual* behavior of S (and therefore its *actual* trajectory in the state space) when it $t-$emerges – and so when the value of the control parameter is *changing* and passes some bifurcation point – and (b) the *possible* behavior of S (and therefore its *possible* trajectory in the state space) when the control parameter is supposed to remain *constant* (or at least not to cross the bifurcation point). This is actually one strange – but not problematic – aspect of Rueger's account, *viz.* the topological criterion that is used to assess the possible $t-$emergence of S_2 on S_1 applies to trajectories in the state space that do not represent the *actual* behavior of S.

novelty in the oscillator's very behavior. And she would certainly be right, for she would even be able to describe and account for the *complete* evolution of the oscillator without even employing its space state representation. For that matter, she could even be ignorant that such a representation exists. Would it mean that she merely missed the $t-$emergence involved, even if she knows *everything* there is to know about the evolution of the system she is observing?

Another feature of $t-$emergence that is at odds with more classical accounts of emergence is that the causal factor which is responsible for bringing about the $t-$emergent is essentially *extrinsic* to the putatively emergent system. In the case of the oscillator, it is clear that $t-$emergence only occurs due to the elimination of the damping. Surely, there is a mechanism that causes such an elimination (say, a vacuum pump), and surely also, this mechanism does not belong to the $t-$emergence basis (S_1), which then fails to be responsible for the bringing about of the $t-$emergent (S_2).

Finally, $t-$emergence is *reversible*. We have as much reason to think that S_2 $t-$emerges on S_1 as to think that S_1 t-emerges on S_2, insofar as, still in the case of the oscillator, if an ellipse is topologically non-equivalent to a spiral, a spiral is topologically non-equivalent to an ellipse. This is actually tantamount to a very weird construal of the notion of novelty, where we have to accept that S_1 is novel to S_2, and S_2 is novel to S_1. If "novelty" merely meant "difference", this could be fine. But I suspect that a minimal requirement for novelty is that the notion encapsulates a form of order between what is "new" and what is "old", in the sense that what is new has something "more" than what is old[17].

Of course, emergence is arguably a term of art, to the effect that one may feel free to adapt or transform its canonical characterization for it to serve fruitful purposes. But while one can surely consider $p-$emergence as a genuine form of emergence – insofar as, as we have seen in section 4.1, it shares a lot with the benchmark account of emergence ($e-$emergence) encapsulated in the working definition given in section 2 –, one could also be reluctant to add more confusion to an (already somewhat confused) debate by cooking up new varieties of emergence that are too radically remote from the mainstream construal of it. And in such a context, taking into account the facts that $t-$emergence (i) is completely explainable and predictable (in principle but even trivially in practice), (ii) is not an empirical relation, (iii) is not a relation between a putative emergent and its emergence basis (for it is essentially caused by an extrinsic mechanism), and (iv) doesn't even make (a non-trivial) sense of the idea of historical novelty[18], it seems to be a little more than a verbal point to suspect that $t-$emergence – however illuminating in its own way – is simply not emergence at all.

[17] Borrowing from Anderson's emergentist slogan "More is different" ([2] Anderson 1972), we could just say that, when it comes to $t-$emergence, "Different is different" (which is an even more radical truism).

[18] A symptom of this discrepancy between $t-$emergence and "canonical" $e-$emergence is that $t-$emergence is not well suited for making sense of the usual criteria that are often invoked to explicate $e-$emergence like, for instance, supervenience (a fact that is acknowledged by McGivern and Rueger themselves ([18] 2010, p. 226).

5 Conclusion

The prime objective of this paper has been to put forward an account of emergence – later on referred to as $e-$emergence – that is faithful to the mainstream classical and contemporary construals of the concept, and to evaluate the relationship between its synchronic and diachronic declinations. After having explicated this account and these declinations in section 2, I developed in section 3 a threefold argument intending to show that synchronic and diachronic $e-$emergences are coextensional, provided that one is committed to two theses ($\neg T_1$ and $\neg T_2$) that I have shown to be well-grounded. As a result, $e-$emergence is essentially a "two-faceted" notion, capturing both constitutive and historical dimensions of the idea of qualitative novelty. Finally, in section 4, I compared $e-$emergence with two alternative accounts recently proposed in the literature, namely (diachronic) emergences built through the notion of unpredictability ($p-$emergence) and topological non-equivalence ($t-$emergence). On the one hand, it has been shown that $e-$ and $p-$emergences are different concepts, and that the former entails the latter, but not the other way around. On the other hand, I have emphasized the fact that $t-$emergence is at right angle with both $e-$ and $p-$emergences, to the effect that one may suspect that it is not emergence at all.

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