Emergence: Postulates and Candidates

Introduction

In the first part of this article we will formulate postulates, which must be satisfied by a reasonable concept of emergence. The postulates will articulate conditions of adequacy for an appropriate explication of the concept of emergence. These conditions of adequacy are based primarily upon the philosophical and scientific history of the concept of emergence, in which the intended role of the concept is expressed. In the second part we will discuss and evaluate some candidates for the concept of emergence in light of these conditions of adequacy.

I. Postulates for the concept of emergence

Before we begin to discuss the postulates in detail it should be made clear what one can expect, as well as what one can not expect. We are searching for a reasonable concept of emergence (we will explain shortly what 'reasonable' means exactly in this context). As the concept of emergence is already being used, we should not suggest an arbitrary ('stipulative') definition, but must tie it in with existing language usage: there is an inherent understanding of the concept of emergence and this should be made explicit so that, subsequently, one knows exactly what is meant by the use of 'emergence'. In what follows we will presuppose an inherent understanding for the concept of emergence, but will not explain it any further. Orientation in the concept of emergence is offered in the comprehensive literature[1].

It now appears that it can be problematic to make an inherent understanding explicit, as the result could be, that a few aspects of this inherent understanding are vague, ambiguous or mixed up. If this were the case, then we would still not reach a reasonable concept of emergence, but discover vagueness, ambiguousness or conceptions incompatible with each other. In order to articulate a concept of emergence, which is reasonable in the context of science and philosophy, we must exclude such things. However, in the process we should not diverge too far from our inherent understanding if we do not want to lose track of our original goal. In which way should we be prepared to correct our inherent understanding in favor of a reasonable concept of emergence? This should happen in such a way that the resulting concept of emergence is more

[1] See, e.g., Bedau and Humphreys 2008; Hoyningen-Huene 2007; McLaughlin 1992; Stephan 1999.

precise where needed and more fruitful for the relevant scientific disciplines than the original concept, nevertheless bearing sufficient resemblance to it. This transition (from inherent understanding to a precise concept) is interpreted by Carnap as an 'explication' (Carnap 1959, p. 12); the explicated concept is also known as 'explicate'.

Let us examine a practical, to some extent technical resource, which makes the explication of concepts easier, namely conditions of adequacy. Conditions of adequacy are postulates on the wanted explicate, so that it is adequate. The explication is supposed to be adequate in relation to the above-named requirements exactness, fruitfulness and resemblance. When these requirements are substantiated for a particular concept, then one obtains conditions of adequacy; they are intermediate steps en route to adequate explications. The following postulates on the concept of emergence are therefore to be understood as conditions of adequacy for the explication of the concept of emergence.

Postulate 1

The concept should be specific in articulating the levels between which emergence is supposed to exist.

This specification presupposes a sufficiently precise characterization of the levels themselves. This is not trivial because emergentist theorists neither agree on the actual specification of levels nor on the identification of levels, between which emergence is supposed to occur. Clearly, the specification of the corresponding levels is necessary, so that we know what we are talking about. Postulate 1 thus formulates a condition of adequacy on the prerequisites for the concept of emergence concerning its definiteness.

Below we will describe the relevant levels as A and B, in which B is the 'upper' level, that shows emergence relatively to the 'lower' A level.

Postulate 2

The concept should be specific in articulating what in fact is emergent.

There are different candidates in history for the specification of what actually is emergent; emergent entities, properties, processes, laws, phenomena, constraints, or the occurrence of *downward causation* all belong to the area of historical candidates. Combinations of these possibilities can also occur, for example emergent phenomena, which obey certain emergent laws and remain stable due to some kind of emergent constraints. Postulate 2 also formulates a condition of adequacy on the prerequisites for the concept of emergence concerning its definiteness.

Postulate 3

The concept of emergence must not be empty, which means examples for emergence in the targeted sense must be given.

Postulate 3 is immediately evident. If there were absolutely no examples for emergence, the concept would become superfluous because it would not be positively applicable. Postulate 3 formulates a formal condition of adequacy on the concept of emergence.

Postulate 4

The concept of emergence must not be all-encompassing, i.e. there must be some counter examples to emergence.

Postulate 4 is also immediately evident. If there were absolutely no counterexamples for emergence, the concept would be empty, because it would not discriminate between cases of emergence and non-emergence. Therefore, it would be always applicable. Postulate 4 also formulates a formal condition of adequacy on the concept of emergence.

Postulate 5

Acknowledged cases of emergence and non-emergence must be expressed appropriately by the explicated concept of emergence.

Postulate 5 differs to postulate 3 and 4 as cases of emergence and non-emergence must not only exist but must also fulfill certain criteria. 'Acknowledged cases' of emergence as well as non-emergence must 'be expressed appropriately'; this means as cases of emergence they must also be classified as such by the concept. This postulate is also immediately evident, if also quite vague. The vagueness consists primarily in the fact, that there is no general consensus about 'acknowledged cases' of emergence.

However one can see with an easy example that postulate 5, despite its vagueness, is not pointless because some prevalent candidates for the concept of emergence can be rejected as inadequate by it. Take, for example, the case of 2 levels where elements from the upper level B are composed of elements from the lower level A. So, B comprises 'systems', which are composed of 'components' from level A. Now, let us further assume that we are talking about emergent properties, and 'novelty of properties' as a sufficient criterion for emergence. In other words, emergence exists when B-systems have (at least) one property, which components (from level A) lack. If A and B are physical components and systems, then a certain weight (W) of a B-system would be an emergent property according to the suggested criterion because none of the components of the system has weight (W). Hence, the certain weight of a system would be a novel and therefore emergent system property. Of course, this is not intended, as weight is traditionally one of the prime examples of a non-emergent but 'resultant' property. Moreover, this is also not intended by those emergentist theorists who would like to use 'novelty on the system level' as a criterion for emergence. However, in this case postulate 5 forces us to clarify what is actually meant by 'novelty' of properties on the system level.

Much trickier than the appropriate consideration of examples of non-emergent properties is the consideration of positive examples of emergence, because here there is no stable consensus: a concrete demonstration of emergence for some is a prime example of non-emergence for others.[2] As a consequence of this we have no pool of examples, which can serve as unproblematic touchstones for candidates of the concept of emergence. Rather it will also depend on the explication of the concept of emergence as to how these controversial cases will be assessed. Thus, we have to face an interplay of possible examples of emergence and the explication of the concept of emergence. In this situation the best course of action is presumably to understand postulate 5 as a requirement for a reflexive equilibrium between concrete possible examples of emergence and the attempt to give an explication of the concept of emergence (as far as achievable). It is clear in every case that an explicate of the concept, that has no contact to the acknowledged and the controversial examples of emergence, is useless. We will see how the confrontation of (controversial) examples of emergence and the candidates for explicates turns out to be in given cases.

Postulate 6

Emergence must be based on (i.e. implies) ontological reducibility between the corresponding levels.

This postulate is an essential part of the intention for the introduction of the concept of emergence in the history of science and philosophy. In both main fields of application to which emergentism has been originally introduced, it was always to be understood as an

[2] See for example, Hoyningen-Huene 1985, pp. 282-284.

opposing position to substance dualism; this concerns the philosophy of biology as well as the philosophy of mind. In biology, the position of emergence was directed against vitalism, which postulated some kind of autonomous life-substance respectively some kind of independent vital principle or impetus. In the philosophy of mind the position of emergence was directed against the doctrine that postulated some form of autonomous soul substance. In this sense, the position of emergence is in its intention a 'naturalistic' position that adopts a monistic world view and does not allow any irreducible new substances or forces. On the other hand emergentism is opposed to certain types of reducibility, as you can see from the next postulate.

Postulate 7

(Strong) emergence must be based on (i.e. *implies*) a sensible kind of (non-ontological) irreducibility.

Terminologically, postulate 7 locates a concept of *strong* emergence. Concepts of *weak* emergence do without a form of the non-reducibility between the relevant levels. A detailed characterization of concepts of weak emergence is unnecessary here as historically the relevant positions of emergence both in the philosophy of biology and the philosophy of mind represent forms of strong emergence. These were directed explicitly against the relevant reductionist positions, namely against reductionist materialism and reductionist physicalism respectively. Postulate 6 and 7 identify the strategic position of emergentism between substance dualism on one side and rigorous reductionist programs on the other side. Emergentists reject substance dualism because it does not appear to be scientifically maintainable, and they reject reductionism because it does not appear to do justice to the relative autonomy or the specific characteristics of the (presumably emergent) 'upper' levels.

Postulate 7 is formulated very open-endedly as it is not specified what can be considered as a relevant form of non-reducibility. The reason for this is, that in the history of the discussion on emergence many different types of non-reducibility were taken into consideration as (necessary) criteria for emergence. With regard to these many possible types of non-reducibility it is only clear that they must not mean or imply *ontological* non-reducibility because this would cause a conflict with postulate 6. Major examples from the history of emergence are epistemological, explanatory, predictive, or causal irreducibility. The idea is that some kind of B-knowledge (e.g. B-concepts or B-laws) cannot be comprehended from level A, or that the explanations of certain B-phenomena cannot be achieved from level A, or that certain B-phenomena cannot be predicted from A, or that the behavior of A-entities is causally influenced in such ways through B, that it is not reducible to causal relationships between A-entities. Which type of non-reducibility is used for the characterization of emergence and how the corresponding type is defined, is crucial with regard to the extension of the concept of emergence. Herein lies the danger that one comes into conflict with postulate 5 with either too strong or too weak concepts of reduction. If one uses, for example, a very strong concept of epistemological reduction, many cases of non-reducibility are produced of which some could be artifacts. This means that clear cases of non-emergence would be classified as emergent. Thus, with the specification of the concept of reduction a preliminary decision is made, regarding what can, and what cannot, be emergent. According to our point of view, an appropriate concept of reduction should specify a concept of emergence, which fits acknowledged cases of emergence and non-emergence (postulate 5). Here is an example of how the diagnosis of emergence depends critically on the chosen concept of reduction:

In a widely received article Jerry Fodor claims that, for a successful epistemological reduction, natural kinds of level A and level B have to be identified via bi-conditional bridge laws (Fodor 1974). If there are no such identifications between the natural kinds, no epistemological reduction is possible. This rather strong requirement is not fulfilled in many cases of chemical explanations of biological phenomena. However, the explanations in question are indeed seen as successful reductions *by the involved scientists*.

Let us consider pheromones for illustrative reasons: pheromones are substances, which are a means of insect communication.[3] The chemical structure of many pheromones has been analyzed and its function of communication for the corresponding insects has been elucidated chemically. In the perspective of the involved scientists this is a successful reduction of biological facts to the chemical domain. But, according to Fodor´s concept of reduction, no reduction has taken place. The reason for this is that some pheromones turned out to be a mixture of different chemical compounds (in certain proportions). According to the biological perspective a pheromone is a natural kind, and according to the chemical perspective a pheromone is a mixture of different compounds, but not a natural kind. So, the identification of pheromones with a mixture of certain chemical

[3] Cf. with this example Hoyningen-Huene 1997.

compounds is not an identification of a natural kind of B with a *natural kind of A* and therefore, no reduction is existent in Fodor's sense. Thus, one could posit the existence of *(strong) emergence* for the biological domain on the basis of Fodor´s concept of reduction, although, in the understanding of the involved scientists, we face a clear case of *reduction*.

Our goal at this point is not to decide this controversy. We simply want so show how much the concept of emergence and, as a consequence, the diagnosis of emergence itself depends on the concept of reduction applied.

A corollary to postulate 6 and 7 is this: the existence of emergence implies some kind of non-ontological irreducibility, when vice versa the existence of non-reducibilty does not imply emergence (because the non-reducibility in the non-ontological sense might be due to substance dualism).

Postulate 8

Emergence must not be parasitic on avoidably deficient information about the lower level.

The reason for postulate 8 is the fact that emergence was always meant to be understood as an ontological concept: The concept of emergence is supposed to characterize a positive, specific relationship between level B and level A instead of a relationship that merely depends on our (insufficient) knowledge of level A.

With postulate 8 arguments of emergence will be rejected, which are based on insufficient specifications of a B-system on the A-level or insufficient theories about the lower level, which *appear* to generate a kind of epistemic irreducibility. Here is an example, which shows that the violation of postulate 8 may generate incorrect arguments for the existence of emergence:

Konrad Lorenz discusses electric circuits exhibiting oscillations, which are supposed to be an example of emergence (Lorenz calls it 'Fulguration').[4] As Lorenz correctly remarks, the capability of an electric circuit to exhibit oscillations does not occur until a certain combination of certain components is realized. Subsystems of these kinds of circuits or their components do not exhibit oscillations. In this respect Lorenz´ electric circuits actually show a new system property, which the subsystems and the

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[4] Lorenz 1973, pp. 48ff; and Lorenz 1978, pp. 35f.; cf. Hoyningen-Huene 1985, pp. 282ff.

components of the system lack. So the capability of an electric circuit to exhibit oscillations is not deducible from the behavior of the subsystems or the behavior of the components, as Lorenz correctly notes, and therefore it is an emergent system property for Lorenz.

However, Lorenz´ assumptions are misleading. Trivially, the capability of an electric circuit to exhibit oscillations cannot be deduced *only* from the behavior of its subsystems and components because, then, one does not have the information available on how the electric circuit is formed. Once the circuit diagram is known, the capability to exhibit oscillations can be deduced from it. The purported emergence is only apparent because we possess incomplete knowledge concerning the system in question, as the configuration of the components is not specified.

Postulate 8 shows that emergence should be an 'in-principle-claim' regarding the irreducibility of the upper level B to the lower level A (for the corresponding sense of irreducibility, see postulate 7): due to the nature of the two levels, the emergent phenomenon is not reducible to the lower level. Emergence can, therefore, not be eliminated through improving our knowledge and is to be understood as an ontological concept, as stated before.

Postulate 9

There should be no mystery about emergence, i.e. it should be intelligible why the emergent is irreducible (in the relevant sense, see postulate 7), in spite of its ontological reducibility.

Postulate 9 aims itself against the tendency of some emergentist theorists (in particular early theorists) to make do with the mere assertion of emergence, without clarifying how the ontological reducibility agrees with the relevant (non-ontological) irreducibility or how this irreducibility can emerge at all. In this way, emergence often has an aura of mystery, which has to be taken at face value. In contrast postulate 9 demands that the in-principle-irreducibility of the emergent phenomenon, in spite of its ontological reducibility, must be made intelligible. This requirement is not particularly precise, but we will see, with the following discussion on candidates for emergence, what role it can play.

II. Candidates for the Concept of Emergence

Below we will discuss some of the concepts of emergence that can be found in the relevant literature. These concepts are candidates for satisfying the requirements imposed by the 9 postulates discussed before. By this means we want to illustrate how concepts of emergence can be evaluated on the basis of the suggested postulates.

First, the simultaneous compliance to postulate 6 and 7 will emerge as a main problem: How is it possible to reconcile ontological reducibility with a non-ontological form of irreducibility? When this problem is solved, the question arises as to whether the suggested compatibility is intelligible (postulate 9). And finally the question: If this conceptual compatibility is intelligible, are there also conclusive positive examples for the suggested form of emergence (postulate 3)?

Candidate 1

We begin with C.D. Broad´s concept of emergence, which he developed in his book *The Mind and its Place in Nature* on the basis of C. Lloyd Morgan´s (1852-1936) discussion of emergence. Broad indicated that properties of a certain whole typically, if at all, do not follow directly from the properties of its components. One rather requires laws of composition, which relate the properties of the components to the properties of the whole in question. Emergence exists if the relevant law of composition can only be obtained through the examination of that whole (Broad 1925, pp. 61-65). In Broad´s words:

> '[…] the characteristic behaviour of the whole *could* not even in theory, be deduced from the most complete knowledge of the behaviour of its components, taken separately or in other combinations, and of their proportions and arrangements in this whole' (Broad 1925, p. 59).

Broad's concept of emergence can best be illustrated by using one of his own examples; it concerns chemical reactions (Broad 1925, pp. 59, 62-63). With the envisaged chemical reactions two reactants X and Y react with each other and yield the chemical compound XY (for the sake of simplifying matters we are presuming that the reactants react in the ratio 1:1). This reaction is nomological, which means that it takes place reliably and predictably under certain circumstances[5]. As per the state of chemistry in Broad's time, 1925, the properties of the compound XY could, in principle, not be predicted from the

[5] As all classic emergentists Broad accepted the "microstructural supervenience of emergent properties" (Kim 2006, p.550), i.e. the idea that system properties are determined nomologically by its micro-structure.

knowledge of the properties of entities X and Y or the knowledge of other compounds of X and Y. Rather the law of composition, which describes the nomological connection between X and Y with XY, had to be empirically determined separately for every single reaction. The situation, which is illustrated by the example of chemistry (from 1925), actually produces a case of emergence, which complies with the given postulates. With regard to postulates 1 to 7 this is easy to see. Postulate 8 is fulfilled in accordance with Broad's assumptions; the laws of composition are supposed to be, in principle, not derivable from knowledge of the lower level. Broad assumes that knowledge about chemical compounds comprises of separate 'islands of knowledge': there is a law of composition for every compound, which is, however, isolated from all other laws of composition. Broad therefore assumes (in accordance with the contemporary state of knowledge of chemistry) that there are no comprehensive laws of chemistry, which systematically connect compounds and their reactants and in this way *explain* the properties of the compounds.[6] Postulate 9 is fulfilled as well since the fact that the properties of the whole are not deducible from knowledge about the components and their constellation results from the (assumed) epistemic disconnectedness of the corresponding laws of composition.

In reality, however, the fulfillment of postulate 3, which demands the existence of positive examples of emergence, is questionable. Shortly after the publication of Broad's book it emerged that his assumptions about the epistemic structure of chemistry were wrong. With quantum mechanics, developed in 1925, Walter Heitler and Fritz London succeeded in calculating properties of hydrogen molecules from properties of hydrogen atoms, which meant the beginning of (numerical) quantum chemistry[7]. However, there could be similar situations in other fields where:

– entities X and Y are combined to XY according to some law L, and
– L is epistemically disconnected, i.e. the only way to know L is trough empirical research.

[6] It is not beyond any doubt that postulate 8 is fulfilled, because the irreducibility of the B-system properties is due to insufficient knowledge about level A. *If* we knew the laws of composition the B-properties could be derived from knowledge of the lower level. Is Broad´s concept of emergence non-ontological and, thereby, in contrast to postulate 8? As a matter of fact we are inclined to interpret Broad´s concept of emergence as an ontological concept, as it refers to the condition of nature itself as the cause for the irreducibility of B-properties: the laws of composition are completely isolated from one another and have to be accepted as mere facts of nature, i.e. they have to be discovered separately through empirical research.

[7] See, e.g., Primas and Müller-Herold 1990.

Whether there are such situations appears to be an open question. For example, qualia could be associated with neuronal states in such a way that each quale would be unpredictable from the most complete knowledge of the neural basis. For each and every neural state it would be necessary to determine empirically which quale it produces (if any at all). The problem with this concept of emergence is to show the epistemic disconnectedness of L, as this means to provide an impossibility proof: it is impossible to unify the different laws of composition in a comprehensive theory, which would allow the prediction of such laws. Unfortunately, it is difficult to see how such proof could actually be provided.

Candidate 2

With the following concept of emergence an element will be incorporated into the relationship of the levels, which leads to the genuine irreducibility of the upper level states. The basic notion is that the generation of B-phenomena via A-phenomena is lawful but involves deterministic chaos. 'Deterministic chaos' means that the phenomena of the upper level are determined by the phenomena of the lower level, but cannot be predicted from knowledge of the lower level because *the smallest* impreciseness in determining the A-phenomena makes the prediction of B-phenomena impossible. Due to the fact that an *absolutely* precise determination of the A-phenomena is simply impossible, this concept of emergence satisfies postulate 8. This kind of unpredictability is also not mysterious in any way and therefore fulfills postulate 9. Unfortunately, it is not clear whether such cases of emergence exist at all (postulate 3).

Candidate 3

The last candidate to discuss is particularly controversial. It involves a form of emergence, which is manifested through macro-determination (also referred to as: downward causation).[8] The basic notion is that in emergent systems of this type the usual causal, or determining, direction from level A to level B (micro-determination) is, at least partially, inverted. It is not the components of a system that determine the properties and behavior of the system, it is rather the system that determines, to some extent, the properties and behavior of the components. If in a system only micro-

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[8] For a clear description of this position (and criticism) see Klee 1984, pp. 56-62. Morgan already formulated the basic idea in the discussion of emergence in the 1920s: Morgan 1923, pp. 16-18, 20-21, 71, 78, 205-207.

determination governs, then the reductionist approach is quite plausible: One tries to understand the behavior of the system on the basis of its determining components. If a system exerts macro-determination, however, a reductionist approach appears to be foredoomed to failure because the components *do not* determine the system but the other way round, the system determines its components. In this respect it appears that macro-determination is a very promising candidate for emergence, which makes it comprehensible how the ontological reducibility (postulate 6) agrees with another form of non-reducibility of the upper onto the lower level (postulate 7). Correspondingly, macro-determination has been a very attractive candidate in the history of science, especially in the social sciences and the philosophy of mind.

However, there are very serious problems about the consistency of this position. To begin with, it is difficult to see how the upper level, in other words: a system, can develop its own form of causality, which cannot be traced back to the causality of its components. After all the system consists of nothing more than its components according to the accepted ontological reducibility. So, where does the additional causality come from (which then influences the components causally)? How then does the accepted macro-determination agree with the ontological reducibility? Assuming we could solve this problem and prove that there actually is such a causal influence upon the lower level, then, a new consistency problem arises. We must assume for physical, chemical and biological systems that the components of these systems are in a certain nomological relationship, which determines their dynamics. Now the irreducible downward causality emerges: it additionally influences the dynamics of the components. How does this additional causal factor agree with the nomological relationship, which already exists between the components? Does macro-determination, if it is really irreducible, not necessarily get in conflict with the nomological relationship between the components of the system? That would mean that the laws of nature, which otherwise apply for the components of the system, would be broken in systems with downward causality. This possible consequence is sometimes contested explicitly by representatives of macro-determination[9] and is sometimes kept open with quite vague or ambiguous statements.[10] In any case the break in the established laws of nature in systems with downward causality would be so dramatic that, without empirical support, it is unacceptable; but this empirical evidence is not

[9] E.g. Polanyi 1968, p. 1310; Sperry 1980, pp. 200-202; Sperry 1986, pp. 266-268.
[10] E.g. Sperry 1984, p.201; Sperry 1986, p.269.

available at present.[11] If one argues, on the other side, that downward causality should be *compatible* with the nomological relationship of the components of the system, then the question arises as to what this downward causality is actually supposed to be, because it has absolutely no effect on the lower level processes. Laws of nature leave no room for a substantial impact of additional determination factors; this also applies to the established probabilistic laws of nature.

Conclusion

It should have become clear that the concept of emergence is such a problematic concept that it requires a very thorough approach. We have tried to account for this situation through a number of conditions of adequacy for the concept of emergence. These conditions of adequacy allow a systematic validation of candidates for the concept of emergence. The discussion has shown on exactly which points of the respective concepts problems arise.

[11] The examples, which are typically invoked for downward causation, are unconvincing and unable to solve the addressed consistency problems, as shown elsewhere (Hoyningen-Huene 1994a, pp. 190-191; Hoyningen-Huene 1994b; Klee 1984, pp. 56-62.).

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