A UNIFYING FRAMEWORK FOR SYNCHRONIC AND DIACHRONIC EMERGENCE

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Abstract‐ The traditional discourse on emergent relationship, developed especially in the context of weak and strong emergence, significantly shifted in the direction of making a distinction between synchronic and diachronic emergence. The synchronic concept of emergent entities means that these are irreducible to their parts, e.g. the properties that these entities exhibit are not the properties of the entities' parts and the relationships in which the entities plays a role are not relationships in which the parts of these entities could be found. On the other hand, the diachronic concept of emergence means that emergent entities appear in time; created as a truly new thing in the world. The diachronic conception emphasizes the emergence of new phenomena over time while the synchronic conception focuses on the coexistence of new "high-level" entities on a lower level. There is a general belief that these two concepts are different and that it is impossible to find a general unifying framework for them. It is the purpose of this paper to demonstrate that both concepts agree rather than diverge, and that creating an acceptable unifying framework for both terms of emergence is already possible.

Keywords - cellular automata; diachronic; emergence; emergent relation; supervenience; synchronic;

I. INTRODUCTION

The interpretation of reductive, emergent and supervenient relationships is a key issue in many areas of philosophical thought; ranging from the philosophy of science to the philosophy of mind, ethics and aesthetics. So-called non-reductive materialism, which is based on the assumption that the existence of entities (individuals, properties and relations) at higher levels may not necessarily be reducible to elementary entities in certain cases, offers a solution to the questions raised in this area. Such entities are then irreducible to their parts, the properties that these entities exhibit are not the properties of the entities' parts and the relationships in which the entities play a role are not relationships in which the parts of these entities could be found. In these cases, supervenience and emergence are used as conceptual tools that capture the specificity of relationships between entities of higher and lower levels. Specific examples of such entities include the relationship between life and physico-chemical processes, the relationship between mind and brain (mental states and neurophysiological states), the relationship between moral values and behaviour and the relationship between aesthetic values and a work of art.

At the beginning of the 21st century, the traditional discourse on emergent relationship, which developed especially in the context of weak and strong emergence (Bedau 1997, Chalmers 2002), significantly shifted in the direction of making a distinction between synchronic and diachronic emergence. Although it is a relatively new aspect in the current discourse on emergence, the prototype of such a concept was already present in the classical British emergentism. This is expressed explicitly primarily in the work of S. Lloyd Morgan Emergent Evolution (1923), where both aspects of emergence (synchronic and diachronic) are emphasized. An example of synchronic emergence would be that an emergent phenomenon at level of B cannot be explained with the help of knowledge of phenomena at level

A (life, for example, could not be explained even if one possessed complete knowledge of physical and chemical phenomena). In addition, Morgan emphasizes diachronic emergence as well; the discovery of something genuinely "new" in the world. This is meant to reflect Morgan's concept of emergent evolution.

The modern distinction between synchronic and diachronic emergence is also defined in a similar vein. The diachronic approach emphasizes the emergence of new phenomena over time, whereas the synchronic approach focuses on the coexistence of new "higher level" objects or properties of existing objects or properties on a lower level (Humphreys 2008, 431). It is commonly held that the two concepts are conceptually distinct and that a unifying framework that would allow for the unification of both concepts as emergence in some general sense cannot be found (Humphreys 2008, 431). It is my belief, and the purpose of this paper, to demonstrate that both concepts agree rather than diverge, and that it is already possible to create an acceptable unifying framework for both terms of emergence.

Let us look first at what some perceive to be the core issue between synchronic and diachronic concepts of emergence. It is clear from the conceptual differences mentioned above that we can understand the different understandings of emergent relationships described as horizontal and vertical. Horizontally-diachronic emergence would be linked to the passage of time; to the moments during which no emergent entities exist, and then to the moments, in which these entities already exist, persist for a while and disappear again. Vertically-synchronic emergence would then be linked to the hierarchy of levels (from micro to macro) in which the entities and their properties at a given level are dominated by the entities and properties of a higher levels. While the passage of time seems so crucial to the horizontally-diachronic emergence, it appears that the vertically-synchronic emergence can be analysed outside of time,

because the dominance of high-level entities and properties over the low-level entities and characteristics is performed at the same point, i.e. synchronically. Whether or not one of the concepts depends on the progress of time and the other does not may not prove to be detrimental if the time aspect is not an important decisive factor for the classification and identification of emergent phenomena.

Humphreys demonstrates these possible consequences on a narrow range of emergent phenomena which he explicitly limits to models because their structure is generally better understood than that of real phenomena (Humphreys 2008, 432). Despite the fact that in my opinion it would have been possible to demonstrate the creation of a unifying framework for the synchronic and diachronic approaches using specific cases of physical emergence (e.g. Rueger 2000; Kirchhoff 2013), I will confine myself in this case, for the sake of discussion consistency, to models examining cellular automaton, specifically to Conway's Game of Life (Gardner 1970). [For the purposes of this article I do not consider it important to go into too much detail regarding the implementation of the cellular automaton. The important part is the existence of a two-dimensional grid of cells which can take on two values -- full / empty, or in the context of the Game of Life -- alive / dead. A few simple elementary rules govern each sequential step in the automaton's evolution, resulting in a certain value for each cell, depending on the status of cells in the immediate vicinity. The cells' values are recalculated in each step, and hence the final shape of a given unit composed of the cells changes as well. Many illustrative implementations of cellular automaton can be found on the internet and the reader may find there the graphic examples needed to illustrate the discussed topics.] Despite this, Humphreys does not find such a solution for a unifying framework for the synchronic and diachronic emergence here. On the contrary, he assumes that a solution of this sort does not yet exist. Yet I believe that he himself suggests one such solution at one point. However, he does not develop it and fails to see in it a strong connection to the conception of synchronic and diachronic emergence. The above mentioned solution will therefore be derived from the model (i.e. analysis of the behaviour patterns in cellular automaton), but in my opinion could be applied more widely to emergence relationship in general.

II. SHAPE EMERGENCE

Humphreys uses the term "shape emergence" for all phenomena which involve the formation of new structures in a system during its development over time. He is mainly concerned with computational models based on actors and cellular automaton, which are taken as examples of emergent phenomena in complexity theory. In this regard, "shape emergence" is close to Bedau's definition of weak emergence (Bedau 1997, 2003). Humphreys, however, tries to create a certain difference between the possible resulting emerging patterns in cellular automata in general. This is his response to Bedau's objections to the definition of weak emergence (Imbert 2007) that contains no restrictions on the final states of the system that can emerge in the simulation. In other words, Bedau's definition of weak emergence considers all states that are uncompressible and can be inferred only from simulations as weakly emergent. Imbert in his criticism

points to the evident contrast between "deceptive" and "target" properties, i.e. to the difference between states which are merely random cellular automaton (chaos) and significantly arranged states -- shapes and patterns (order), which seem to be much more emergent than random. This is why Humphreys tries to define the conditions that are non-random and which, in his opinion, express another type of emergence. At the same time, Humphreys assumes that the non-randomness of the system's final states may be ensured in two ways. Firstly, if the final state of the system is as random as the initial state was, then we cannot talk about the emergence of "newness" in talking of such a shape. Such states therefore do not meet the criteria of novelty for emergent phenomena. In cases where a final random state arises from an original ordered state, we must also intuitively reject the definition of such a state as emergent because of the conditions for formation and development of the self-organizing systems. It is counter-intuitive to consider the development of less ordered states as emergent (Humphreys 2008, 436). The other way to distinguish shape emergence as a special form of weak emergence, according Humphreys, is by adding the following clause to the definition of weak emergence: "P is a non-random property of the system S that is distinct from any property possessed by the initial state of S." (Humphreys 2008, 437).

III.HISTORICAL DEVELOPMENT OF A PATTERN

Humphreys expresses the incompatibility of synchronic and diachronic approaches with emergence in his assertion that „the historical development of a pattern is essential to its status as an emergent entity." (Humphreys 2008, 434). With this assertion he seeks to emphasizes that shape emergence is essentially a historical phenomenon because it determines whether the instance of a pattern is emergent or not. Without taking into account the evolution process of a pattern it is thus impossible to determine whether it is an emergent pattern. The mere synchronic relation between the pattern and the spatial deployment of elements that creates the pattern cannot be a determining factor. Humphreys compares the resulting process model simulation after n steps only with the similar instances of an identical printed pattern. While the first is emergent through the process that generated it, the second is simply an instance of laid out dots. Humphreys is convinced that no synchronic concept of emergence based on a supervenient relationship during which an identical base can give rise to identical supervenient features, has the ability to distinguish between two different instances of the same pattern (Humphreys 2008, 435). For example, a "blinking pattern" and the same static pattern which can arise by printing the blinking pattern (compare Huneman 2008, 602). Therefore, the diachronic concept is based on shape emergence, on specific instances of forms (tokens), and not on types of shape (types). Unlike the diachronic approach, the synchronic approach is based on supervenient relationships, on types, properties and generalities and assumes that it is possible to determine whether a high-level feature emerges from lower levels, based on a certain instance of the system. There is a crucial difference between the two approaches, which has consequences for the classification of emergent phenomena. Humphreys (2008, 435) uses these concepts to challenge the common assumption made in many discussions on emergence; the assumption that if a property is emergent

in any of its instances, it is emergent in all its instances. It is apparent that emergence patterns do not act in this manner.

As we have already predicted, a weakness in Humphrey's argument is certainly that he bases his conclusions solely on model situations, which are allegedly better understood than real phenomena. My effort to undermine this kind of reasoning is led by an excessively simplified model of emergent phenomena in cell automata. I agree that the historical emergence development of pattern is correct, but in a cellular automaton it can be misleading. Does it decide on the pattern's emerging sequence n steps preceding this pattern, or is only one previous step enough? What about the above mentioned "blinking" pattern, which ends in an unchanging state; forever-repeating the alternation of two designs with different values in the cells, which are the source of the „flashing" illusion. The historical development of the system can be very complicated, depending on the initial conditions and the distribution of values in the cellular automaton before the system reaches such a blinking pattern, yet it does not seem to indicate that the entire decision history is a prerequisite for its emergence. The moment such a pattern is set, previous history is "forgotten" and the system ends in an infinite sequence of two states of the system (blinking) repeating itself endlessly. Previous history is therefore, as far as the repetitive state is concerned, not significant. If we want to further argue that such a pattern is emergent and that its history determines its emergence, we must admit that it is sufficient to look at only one step which precedes the resulting pattern in the automaton.

What's more, this step is either a step from one stage to the next from everlasting repetitive "blinking" values, or a step from the immediately preceding state to establishing of an everlasting repetitive sequence of two states of the automaton. What history thus determines the emergence of shape? Let's ask a more explicitly: Which of the shapes in the cellular automaton is emergent and based on what criteria do we make this assertion? Unexpectedness, the surprise factor, novelty and unpredictability are in this case illusory and overly subjective criteria. Elementarity and an accurate description of the inference of cellular automaton rules also require more precise criteria of emergence. Given the above analysis of the "blinking" pattern, we are forced to conclude that any state of the cellular automaton must be either emergent or, conversely, that no state in itself is emergent. We have come to conclusions similar to the discussion about modelling based on the actors is concerned (Huneman 2008; Epstein 1999):

1.   No state of cellular automaton is emergent, if we relate emergence to a single static pattern in the cell automaton without taking into account the history of its development.

2.   All states are emergent because each pattern that is established in the cell automaton has its own developmental history, even if this development consists of only a single step taken from the old state to the new state.

I therefore believe that reference to the history of pattern design in the environment of the cell automaton is not a decisive criterion for emergence. Diachronicity is important in terms of the distribution dynamics of the model in time

because in the majority of non-trivial patterns the matter we are concerned with is not the final distribution of values in the automaton's cells, but a certain persistence or recurrence of secondary processes that become part of more complex and complicated structures. We can say that during the diachronic development of a pattern several levels of structuring can be identified as distinguishable. On a basic level, it's always about points with a binary value (empty / occupied or dead / living cell). At a higher level, we can distinguish new basic entities that are usually created by grouping several points so such an entity could move in the automaton's "space" in an unchanged form. Thus is obtained a higher basic element, the smallest variable structure which allows the transfer of information in the space of a cellular automaton and participates in the creation of higher complicated structures that are formed by currents and interactions of these basic movable structures.
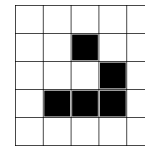
In the most famous case of a cellular automaton implementation, Conway's Game of Life, the basic and smallest floating structure is called a "glider".

Humphreys proposes a more detailed typology of emerging patterns in the context of shape emergence. There are two basic types of non-random patterns. He calls the first a micro-stable pattern, because its constituents are fixed. The second type; the micro-dynamic pattern, remains unchanged only thanks to the continuous dynamic substitution of its constituents. This dynamics are important in terms of finding a general framework for emergence. Micro-dynamic patterns can further be divided into three subclasses -- recirculating autonomy, transient autonomy and equivalence class autonomy in view of the manner in which dynamics which are persistent patterns are kept (Humphreys 2008, 437). These details are not essential for further consideration. What is important are the dynamics and substitutions of which macroscopically stable patterns are created at higher levels. Although it is always possible to argue that an arbitrarily complex pattern is the result of a specific deployment of an individual cells' values in the cell automaton's space, it is possible to recognize the causal effect of these moving elementary structures at higher levels and possibly the higher structures that their motion creates. The essence of emergence pattern is therefore not the static distribution of the values of individual cells, and therefore not in the history of such a model's pattern, but rather in the dynamics of the overall variability of the model as such. In other words, the pattern basically does not exist outside of time and the example of "the blinking" pattern in this case too is a simplified a model to be able to capture the complex dynamics that we are now describing. In these cases, to maintain a stable pattern of movement involves the movement of many basic elements, which in their incessant movement establish a much larger and more complicated pattern. In view of these fundamental dynamic realities, it would indeed seem that the horizontally-diachronic concept

of emergence is significantly different to the vertically-synchronic concept. But it is not so.

IV. DIACHRONIC AND SYNCHRONIC CONCEPTS

We said that the diachronic approach to emergence infers the appearance (emergence) of new entities in time. In other words, we can determine the moments in time when such an entity did not yet exist and the time instants in which it already exists. This type of emergence is met in the case of micro-stable patterns that often arise after many steps of generating a pattern of initial conditions. The resulting pattern is determined in this case by the orderliness and stability due to the relatively random distribution of values in the cells of the automaton which shapes a new pattern. But what is it like in the second type of dynamic patterns? In this case, patterns persist only thanks to the micro-dynamics of the system. In the first case, states Humphreys (2008, 438), it is purely a concept of diachronic emergence, while the second exhibits an aspect of a persisting emergent pattern over time, which requires the attention of both diachronic and synchronic concepts. This is why Humphreys would not like to abandon the synchronic concept of emergence altogether, although he believes that it is insufficient and unnecessary for explaining the emergence of shape (Humphreys 2008, 437). I believe that it is this phenomenon of micro-dynamic patterns which not only leads us to feel that the synchronic approach is worth preserving in cases of shape emergence, but shows us clearly enough how closely together the synchronic and diachronic approaches are related to the concept of emergence.

From the perspective of the diachronic concept of emergence, the cellular automaton's succession in time is the result of individually generated conditions in which the status of the cells' changes are based on rules which cause the cells to jump between two values (full / empty; and, as interpreted by the Games of Life - alive / dead). From this micro-perspective, there is only the distribution of cell values in each state of the automaton, and the context of these status changes is determined by the distribution of changes caused in these individual steps in each given moment in time. Other than this organization in time, the orderliness of the individual states, there is only a static distribution of the cells' values, which prevents the possibility of comparing these conditions for the perspective new form of emergence. From this static micro-perspective, there is no way of distinguishing the distribution of any novelty in the random order of another cell's layout. We come once again to trivialize emergence. Either all distribution is "new", or no distribution is "new". We can speak of the novelty of shape or of organization and order from two perspectives only. These are the perspectives of macro-state and the perspective of the dynamic development of a system.

We will first consider the formation of the above-mentioned micro-stable patterns. Humphreys mentions them as an obvious example of historical emergence and distinguishes their character from that of micro-dynamic patterns that persist only thanks to the dynamic substitution of more elementary entities. I want to use this example to emphasize the fact that even in the case of micro-stable patterns, the resulting pattern of the system is not the result of a static distribution of values in the cells, but similarly, the result of a dynamic process which maintains the pattern. The inference algorithm for cell values is still running (essentially forever) and the micro-stable pattern is interesting in that the algorithm gives the same distribution of values in the cells for all the other states, and thus ensures the stability of the resulting arrangement of the pattern. The first finding is that micro-stable patterns should be seen not only from the perspective of their organization in time, the history of their development, i.e. diachronically, but also in terms of their persistence, i.e. synchronically. The emergence of micro-stable patterns is therefore not only a matter of taking a purely diachronic approach, but also synchronic one.

Let's move on to more dynamic structures, which manifest their stability and autonomy over time. The smallest moving elementary entity, which is capable of exhibiting stability (identity and autonomy), during its movement, is repeated in its preceding shape during the course of up to four generations. Four generations of the automaton's states are therefore necessary for the diagonal shift of this shape. It must be said again that, from a micro-perspective, the smallest moving elementary entity loses its identity and its significance. It makes sense to talk of such an entity and its diagonal shift only from a macro-perspective and after four steps of generation of system states. This does not just mean that we need a broader time scale to enable us to talk about the origin of the new, but rather, that it is a structure that is distributed in time (in this test case between the individual steps generated by the states of the automaton) and have no significance in isolated states. In addition to the aforementioned elementary moving entities, many other structures whose identity is spread over larger time scales are known. They are therefore full time structures, which cannot be spotted when looking at single static states of the automaton's development history. This also significantly changes the concept of a synchronic approach.

Glider Generator is a form which generates one or more gliders. The so-called Glider Guns is a structure that creates a new glider every 30 generations and thus manifests its identity in the 30 step generation.

Although Humphreys himself suggests a non-supervenient concept of emergence elsewhere (see. Humphreys 1997), here he derives the idea of the synchronic relation from the concept of emergence (e.g. van Cleve 1990; McLaughlin 1997), which assume there is a supervenient relation between low-level entities and high-level entities. Maybe there is no need to insist on a supervenient relation when discussing emergence, but this is not essential for further thoughts on the subject. Let's assume we can rely on the existence of a supervenient relation. In this case, it is true that for any given microstructure S (low level), there are necessary consequences D on the macrolevel (higher level) and should state S occur, then D must also necessarily occur.

The vertical-synchronic concept of emergence is understood to mean that there are higher-level entities (objects, properties, and relationships) alongside entities which exist on lower levels. The coexistence is understood to mean that the supervenient relation is valid in every moment in time. If the supervenience relation is valid in a vertical direction, i.e. between levels (e.g. between micro and macro levels), time becomes insignificant for this relation. It is not expected that a delay caused by the limited speed of information transfer, or relativistic effects, would occur between the micro levels and the supervenient macrolevels. The vertical relation between levels is timeless and binds supervenient states on their low-level basis. It is therefore predicted, from the point of view of synchronic links (e.g. Huneman 2008, Humphreys 2008), that specific instances of the automaton's state would be indiscernible (for example the "blinking" pattern, or the print of such a pattern). The cells' states are synchronized with a macroscopic pattern, whether they were generated by the automaton, or the pattern was photographed and printed. But this is only part of the truth. We cannot say that such a pattern is not synchronic in each state of the automaton with a specific deployment of values in individual cells--we have to admit that the pattern in each of the isolated states of the automaton is often nothing more than a deployment values in the individual cells. The claim states that the states of cells are synchronic with macroscopic pattern, which is therefore--if not exactly a mistake--problematic at the very least.

V. DYNAMIC SYNCHRONICITY

We have seen that the basic entities of higher levels in the particular case of the cellular automaton (not only Conwey's Game of Life, which we considered here), have no individual existence in each of the generated states of the automaton, because they have different "time extensions", i.e. a different number of steps is required of the automaton on a microlevel to produce them on a macrolevel. In other words, if we are to understand these patterns as (emergent) individualized entities with their own causal effects, then we must understand them as temporal and procedural entities with different time extensions. Thank to this understanding, our perception of the concept of synchronicity also changes. A horizontally-synchronic concept of emergence requires that the macroscopic pattern be synchronized with the states of the automaton's cells. In view of the different time extensions, this can only be accomplished by letting the states of the automaton's cells synchronize the macroscopic entity during the process of its formation, i.e. at least during its time extension. Synchronic emergence cannot therefore be understood from this perspective as static images of patterns, but at the very least as the sequence of a few patterns of different lengths that preserve the identity and autonomy of a macroscopic entities. It's a fully dynamic synchronicity which gives macroscopic entities meaning and it's the only legitimate way to speak of synchronization between the base levels of the automaton's cells and macroscopic entities.

In this manner, dynamic synchronicity lets us see many other, more complicated structures, consisting of streams and flows of many basic moving patterns in their own dynamic autonomy. Where there are more complicated structures, it is then evident that although each of the automaton's states are composed only by the cells' positioning and nothing more, the identity of these structures has been developed and maintained not only directly through states of individual cells, but rather by (the more elementary) basic patterns, the movement of which produces these higher structures. It thus demonstrates a hierarchical arrangement where the higher (more complex) structures are created by the more elementary ones and therefore the number of levels of structuring has no limitation in principle. But not even such patterns, which are maintained by the flow of other patterns, have a meaning outside their time extension. In this sense, one can find analogies in open physical systems that are nonequilibriated thermodynamically and which maintain their autonomy by means of energy flow, material and information consumed to maintain their dynamic structure. Other than such flows and their consumption for the maintenance of their structures, these systems cannot exist. It is similar in those model pattern-sustaining cases in cellular automata as well.

Even though we are analysing synchronic and diachronic emergence using the model case of a cellular automaton, I want to emphasize again that this does not disqualify these findings. The emergence of this elementary model case is not essentially distinguishable from the emergent phenomena in different areas, but the latter are not so elementary as to offer easy access to analysis. What does such a dynamic approach to synchronic and diachronic concepts of emergence mean? Does it allow for the creation of a unifying framework for both concepts in a more general sense of emergence? I believe it does. Because the synchronic concept has become dependent on time, although not in the vertical direction, just in time intervals that are based synchronous binding and which have to be taken into account due to the individuality of higher entities, a unifying framework for the general concept emergence has been created. Synchronicity cannot be understood as completely timeless given the fact that it dynamically establishes the real existence of entities on higher levels of complexity. Thanks to this, it tightly (and dynamically) bounds the synchronic and diachronic concepts of emergence. In a vertically-synchronic direction, the dynamic flow of elementary entities is established on higher levels entities, which appear in the history development of the given systems in a horizontal-diachronic direction. Such emergence is fully dynamic and effects both the creation of new entities, which are in certain periods non-existent, in others appear (emerge), so that for a while they would dynamically maintain their identity and possibly later disappeared again. It doesn't matter whether one is talking about model cases of cellular automata or entities of physical, chemical, biological, social or cultural reality.

VI. CONCLUSIONS

I assume that the possibility of emergence of "new" entities in a given time is a dynamic synchronicity of the basic levels in which higher level entities participate. Whether this relationship is supervenient or has a different character is not a crucial matter at this moment. I believe that these outlined perspectives generate a general framework for the unification of synchronic and diachronic conception of emergence. The argument objecting to the fact that the synchronic approach is not a synchronic concept in its own

right cannot be proven in my opinion. The Synchronic concept cannot be reduced to absolutely timeless fragments of the various stages the cellular automaton generates, neither to timeless fragments of real, existing structures. Models of development patterns in cell automata are also in this case a heuristic and illustrative example of how not to verify speculative thoughts on high-level entities, such as consciousness and mental states that, given the current state of knowledge, allow for a wide range of opinions and arguments, but are ultimately not as convincing as we would expect. I believe that it is elementary cases which allow for much more illustrative evidence and recognition of mechanisms that are responsible for the existence of emergent entities at various levels of current reality. The fact that really "new", previously unknown entities (objects, properties and relations), may be discovered at various levels of reality is conditioned by a dynamic synchronicity of a continuous establishment of those higher entities based on the existence of lower existing levels. However, regardless of the hierarchy of such levels of reality and of the entities inhabiting them, the responsibility for their existence is left to a single principle or mechanism of their establishment, and this is the universal principle of emergence.

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