The concept of emergence is playing an increasingly critical role in the quickly expanding field of complexity theory. In a previous article in the inaugural issue of this journal (Goldstein, 1999), I discussed the history and development of the construct of emergence from its origin in the movement called Emergent Evolutionism (see Alexander, 1966; Broad, 1925; Morgan, 1923; and Wheeler, 1926) through its current employment in complexity theory. Although emergence may be an intriguing, even revolutionary, notion, the more one tries to get a clear grasp on the concept, the more it can prove to be elusive and murky. The controversy surrounding the concept did not end with Emergent Evolutionism, but continues to ignite debates concerning the implications of emergence for causality, determinism, predictability, the ontological status of emergent phenomena, and so on.

It appears that emergence is not a concept that comes alone but, rather, tends to carry considerable metaphysical freight. This can be seen in remarks from two leading complexity scientists. First, chaos physicist Doyne Farmer (quoted in Waldrop, 1992: 297) places emergence in a grand evolutionary scheme:

The key is that there would be a sequence of evolutionary events structuring the matter in the universe in the Spencerian sense, in which each emergence sets the stage and makes it easier for the emergence of the next level.

Second, in similar vein, complexity researcher Stuart Kauffman (Kauffman, 1995: 23) declares:

A theory of emergence would account for the creation of the stunning order out our window as a natural express of some underlying laws. It would tell us if we are at home in the universe, expected in it, rather than present despite overwhelming odds.

Emergence may indeed go on to reveal matters of cosmic significance, yet this same proclivity for speculation can also set up sundry conceptual snares for the unwary in their appeal to emergence for either descriptive or explanatory purposes. In this article I want to discuss these snares in relation to eight broad issues encountered on the route to adopting the idea of emergence:

- causality
- spontaneity
- predictability
- ontology
- prevalence
- levels
- coherence
- outcome.
CAUSALITY

DOES EMERGENCE VIOLATE CAUSALITY?

The study of complexity is challenging many established assumptions about the dynamics of systems, including the role of causal explanations in complex systems. Some complexity theorists have gone so far as to propose that complex systems may violate the linkage of cause and effect. For example, Ralph Stacey (1996: 187), a pioneer in applying complexity theory to strategic planning and organizational creativity, has charged:

>Causal links between specific actions and specific organisational outcomes over the long term disappear in the complexity of the interaction between people in an organisation, and between them and people in other organisations that constitute the environment.

Stacey, no doubt, is not averring that complex systems are acausal. So, what exactly is he getting at?

There are indeed features of emergence that do seem to make it a good candidate for causality violation, since emergent patterns, structures, and properties are characterized by a radical novelty in comparison to the properties and patterns of the components out of which emergence arises (for more on the role of causality in emergent systems, see Goldstein, 1996). According to chaos/complexity physicist James Crutchfield (1994:1), emergent structure is:

>not directly described by the defining constraints and instantaneous force that control a system ... not directly specified by the equations of motion ... [and] cannot be explicitly represented in the initial and boundary conditions.

Consequently, the radical novelty of emergent phenomena can appear quite enigmatic.

These recent notions of the implications of emergence for causality were foreshadowed in the philosophical discussions accompanying Emergent Evolutionism, which recognized the novelty of emergents as challenging inherited ideas of causality. For instance, animal behaviorist C. Lloyd Morgan (1923) believed that emergent novelty necessitated a distinction between causality and causation: “causality” would refer to the causal nexus of natural processes; whereas “causation” would allude to a breach in natural processes afforded by emergent novelty—which, in turn, would allow a place for the inclusion of divinity in the natural world. For sure, Morgan’s distinction is not particularly enlightening, but this cannot be blamed solely on his theological preoccupations, since they are not all that dissimilar from current-day speculations on the cosmic, evolutionary significance of emergence, as seen in our quotes in the introduction. However murky Morgan’s distinction appears, it does point to how emergence pushes us up against traditional notions of causality.

To understand more about the impact of the radical novelty of emergents on the causal nexus of a complex system, it can be helpful to take a look at the phenomenon of chaos, another system dynamic that has been challenging conventional understanding of causality. Philosopher David Newman (1996) has made a case for understanding strange attractors in chaotic systems as instantiations of emergence. Specifically, Newman claims that being in the basin of a strange attractor is an emergent property of a nonlinear dynamical system, since it is a property neither deducible from, predictable from, nor reducible to antecedent conditions or factors. Thus chaos, like emergence, challenges conventional notions of causal connection.

It is crucial to note that chaos is technically termed “deterministic chaos” because, although the outcome is aperiodic and random-like, it can be produced, i.e., “determined,” by simple rules. (Here I am leaving out “stochastic chaos,” which results not only from deterministic rules but from the admixture of stochastic events in the resulting chaos.) Mathematician Ralph Abraham, a mentor of many of today’s leading chaos and complexity scientists, made a very telling observation about chaos that is also pertinent to the causal nexus of emergence:

>An attractor functions as a symbol when it is viewed through an output projection map [map of a system by concentration of some variable into a finite dimension state space] by a slow observer. If the dynamic along the attractor is too fast to be recorded by the slow-reading observer, he may then recognize the attractor only by its averaged attributes, fractal dimension, power spectrum, and so on, but fail to recognize the trajectory along the attractor as a deterministic system. (Abraham, 1987: 606; his emphasis)

The failure to discern determinism in such a system is thus not because it is indeterminate, but instead is due to limitations of observers, i.e., their “slowness” compared to the much more rapid unfolding of the system’s dynamics. The observer is in an
Emergence: Complexity and Organization

Emergence is unpredictable. Indeed, the early emergentists placed unpredictability high on their list of attributes for emergence, along with both of the claims that emergence violates causality and is totally spontaneous. Along with both of these claims, there is the often-heard insistence that IS EMERGENCE UNPREDICTABLE?

Emergence in complex systems is envisioned to arise from self-organization, in contrast to the external or hierarchical imposition of new order on to a system. But another conceptual snare lies in wait here: an overemphasis on the spontaneity associated with the idea of self-organization can lead to a discounting of the conditions that are necessary for these spontaneous processes to occur.

One particularly influential source of this overaccentuation on spontaneity can be found in Stuart Kauffman’s (1995: 25) concept of order for free:

Most of the beautiful order seen in ontogeny is spontaneous, a natural expression of the stunning self-organization that abounds in very complex regulatory networks … Order, vast and generative, arises naturally.

Kauffman’s way of conceptualizing “order for free” is at the basis of his cosmic meditations on emergence of which we saw examples above. “Order for free,” in fact, is not that different than the old idea of spontaneous generation or other candidates for spontaneous processes in nature (discussed more fully in Goldstein, forthcoming).

On a more prosaic level, the phrase “order for free” does seem to be a decent way of rendering how emergent patterns and structures arise out of the dynamics of the systems itself and, therefore, don’t derive from the intrusion of order represented, for example, in how a cookie cutter makes a shape in dough. However, the phrase also has the unfortunate connotation that there is no cost involved in emergence, which can then lead to neglect of some of the very important determining conditions of emergence.

This kind of “order for free” perspective shows up in allegations on the part of organizational enthusiasts of self-organization that all that is required for self-organization and emergence is simply to interrupt the normal hierarchical command-and-control practices of management. Certainly, there are times when such a strategy can confer tremendous benefits on an organization, but there are other times when this can be a strategy for disaster, a subject to which we will return later. Moreover, this kind of neo-laissez faire attitude ignores the fact that one of the sources of the order found in emergent patterns is the containment field or boundaries within which self-organization takes place (see Goldstein, 1999). We can say that emergence is a “qualified” spontaneity, but this qualification points to various and sundry “costs” attached to the bringing about of emergence.

SPONTANEITY

IS EMERGENT ORDER FOR FREE?

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PREDICTABILITY

IS EMERGENCE UNPREDICTABLE?

Along with both of the claims that emergence violates causality and is totally spontaneous is the often-heard insistence that emergence is unpredictable. Indeed, the early emergentists placed unpredictability high on their list of attributes for emergence, along with nondeducibility from and irreducibility to antecedent conditions. Morgan (1923) thought that the same novelty that
Emergence: Complexity and Organization

Complexity science also has its share in the issue of subjectivity versus ontological reality. In my previous article in this journal, I discussed how an observer is supposed to affect the collapse of the wave function. The insular ontological status of what is being observed is a common theme, particularly in certain interpretations of quantum mechanics. For example, observing the object of study can influence the results. A particularly egregious case is that of certain interpretations of quantum mechanics, for example, where the presence of two emergent patterns called t-tetraminos can lead to unexpected results.

Patterns of emergent phenomena are not unique in involving the experimenter's perceptual perspective. The study of emergence is not unique in the involvement of the experimenter's perceptual perspective in the discernment of emergent phenomena. Another barrage against the ontological status of emergents concerns the role of subjectivity in the discernment of emergent phenomena. Does this mean that, as new and more sufficient theories come along, a similar conclusion should be reached about emergent phenomena in complex systems? Critics of Emergent Evolutionism argue that emergent phenomena are merely provisional, epistemological artifacts, lacking an ontological status. As I mentioned in my earlier article, the theory of quantum bonding was supposed to undermine traditional views of causality. However, it was at heart unpredictable. As I mentioned in my earlier article, the only thing really unpredictable about the stunning emergent patterns of the hexagonally shaped cells is the direction of their rotation—surely not the main feature of emergence in such systems. What is predictable, however, is that given the right container, and the right liquid, and the right process of heating, the remarkable Benard convection cells will emerge, and their pattern will be quite similar to those observed in previous experiments.

Moreover, as stated above, much of the order found in emergent phenomena derives from the order inherent in the containers of the self-organizing processes. Knowledge of the order of the containers, therefore, can help in predicting the type of order that will be found in the ensuing emergent processes. This, then, adds another measure of predictability to emergence. Furthermore, there is no reason to think that the predictability of emergent patterns in organizations will prove any less susceptible to increase as careful observation and scrutiny of these patterns deepen over time.

These constraints on the unpredictability of emergence are not meant to suggest that emergent phenomena will yield to total predictability. Instead, my point is that adopting a fatalistic attitude about the supposed total unpredictability of emergence is neither based in fact nor particularly useful in going ahead with studies of emergent phenomena.

**Ontology**

**Is Emergence Merely Provisional?**

If the more we learn about complex systems, the more predictable emergence becomes, does this imply that emergent phenomena are merely provisional, epistemological artifacts, lacking an ontological status? Critics of Emergent Evolutionism reached such a conclusion when the theory of quantum bonding came along in the 1930s and demonstrated that the emergent properties of compounds resulting from chemical reactions were deducible from knowledge of the components alone. This, then, adds another measure of predictability to emergence. Furthermore, there is no reason to think that the predictability of emergent patterns in organizations will prove any less susceptible to increase as careful observation and scrutiny of these patterns deepen over time.

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**Is Emergence Merely Subjective?**

Another barrage against the ontological status of emergents concerns the role of subjectivity in the discernment of emergent patterns. Of course, the study of emergence is not unique in the involvement of the experimenter's perceptual perspective in observing the object of study. A particularly egregious case is that of certain interpretations of quantum mechanics, for example, where an observer is supposed to affect the collapse of the wave function. The insular ontological status of what is being observed, then, becomes subject to doubt.

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Emergence: Complexity and Organization

Emergence: Complexity and Organization

Although computational capacity may not be directly relevant to all instances of emergence in complex systems, e.g., emergence in organizations, the core of what Crutchfield is alluding to still seems to be pertinent in general. This has to do with how emergent patterns, structures, and properties add some kind of potency in the form of greater adaptability than such systems would otherwise contain. If emergence can indeed bequeath this potency, then, from a purely pragmatic perspective, emergent phenomena must have considerable ontological status. Certainly, as the sciences of complex systems advance, better theories will be developed explaining more about how emergent phenomena are constituted out of lower-level components and processes. Crutchfield’s own “particle” theory of emergence is an example. Yet enough is being discovered about emergent levels with constructs commensurate with those levels, and micro explanations will not completely supplant their usefulness.

Moreover, one need not go as far as Crutchfield’s response, since the issue of subjective bias in studying emergence is not substantially different than that in any other scientifically informed discipline. That is why psychological researchers, for example, spend so much time worrying about inter-rater reliability. Identifying emergent phenomena demands a similar conscientiousness and a similar community of practice. Starting with subjectivity doesn’t entail us necessarily ending up there. Otherwise, we would all be condemned to a solipsistic existence. Hence, in my opinion, subjective bias does not ring the death knell for emergence any more than it does for other attempts to find patterns in our environments.

PREVALENCE

HOW UBQUITOUS IS EMERGENCE?

Emergent Evolutionist C.L. Morgan (quoted in Tully, 1981: 35) once exclaimed, “it is beyond the wit of man to number the instances of emergence.” The reference was to all living creatures as instantiations of emergence. This pleroma of emergents has grown even larger with the recent additions of neo-emergentists. Thus, in the study of cellular automata, there are parameter values in which emergence is abundantly prevalent. Of course, it is precisely because of the fascinating systems behavior at these values that so much of the study of complex systems takes place at them. But, we must remember that these values are set by experimenters. So why should we expect the same prevalence outside the laboratory?

Computer scientist and pioneer of complexity theory John Holland (1998) warns about confusing authentically emergent phenomena with instances of “serendipitous novelty” that ubiquitously surround us, for example the play of light on waves. For Holland, if emergence is to be a meaningful construct, it must be more rare than all the multifarious combinations of patterns that we perceive in our environment. Holland’s criterion to distinguish emergence from other such concatenations of patterns is one often heard in complexity circles: “Emergence … occurs only when the activities of the parts do not simply sum to give activity of the whole” (1998: 14). In another article (Goldstein, 1999), I have described a certain arbitrariness incumbent in defining emergence as “more than the sum of the parts.”

What I want to call attention to here, in contrast to Holland, is how it may indeed be valid to refer to the play of light on waves as an authentic example of emergence, at least from the point of view of novelty, irreducibility, and so on. Emergence, after all, does include novelty, and it is serendipitous in the way that it takes advantage of the confluence of many factors, including random ones. So, operationally, it may be impossible to distinguish emergence from “serendipitous novelty.” However, I don’t think that this amounts to a significant issue, since the crux of the matter is not so much what counts or doesn’t count for emergence as how important the instance of emergence is to the agenda or intention on the part of observers of or participants in emergent phenomena. The play of light on waves may be unimportant for certain purposes or intentions of observers, but I can imagine where it could be quite important for others, such as for Claude Monet.

In terms of organizations, can it not be said that emergence is going on all over the place, since people are continually interacting? Working entirely alone is unquestionably rare. But interaction itself is not enough to lead to emergence. It must be interaction that ushers forth some novel pattern, structure, process, or pattern; moreover, a pattern that exhibits a type of coherence not found among the interactional agents alone. However, even such emergent patterns may be of negligible importance for organizational dynamics. An example might be several employees spontaneously meeting in a restaurant at lunchtime, sitting together, and as a result regularly meeting for Tuesday lunch. How important is such an emergent lunch pattern? It could be an authentically emergent pattern, but it is not immediately obvious how important it would be for organizational functioning (of course, it might prove to be extremely significant if these lunch meetings ended up generating creative ideas that were used back in the workplace).

It seems to me that for emergence to be a useful construct it must be neither rare nor everywhere. If it is too unusual it will have little to do with everyday organizational dynamics. If it is everywhere, then it loses any explanatory power. But once recognized,
the more important issue is what it adds to or detracts from the organization.

LEVELS

THE CONFLATION OF LEVELS

Inherent in the very definition of emergence is the notion of a level distinction between the preliminary components (the micro level) and the emergent patterns (the macro level). Thus, the early emergentists conceived of evolution as a series of discontinuous emergences of new qualitative levels of reality (see Blitz, 1992). A paralleling level distinction is made by contemporary complexity theorists. For example, Chris Langton (Lewin, 1992), when referring to a graphic illustration of emergence, points upward to a global, emergent level "up here" and downward to a component, interaction level "down here." And Bedau (1997) points to the level distinction when he characterizes emergent phenomena as being "autonomous" in respect to the underlying processes.

Some sort of hierarchical stratification seems a necessary component of any doctrine of emergence. In this vein, the dynamicist Diner (Diner, Fargue, and Lochak, 1986: 276) underscored that in the evolution of a dynamical system there is a required "explicit passage from one level to the other ... to disclose the appearance of these [emergent] properties."

This level distinction can be overlooked by organizational theorists in their fervor about the role that attractors may play in organizational dynamics. Thus, we are hearing about the leaders' visions as attractors or incentive and other reward systems as attractors. But attractors are a construct whose proper level is the emergent level, not the local interaction level, whereas leadership vision and corporate rewards are more appropriately understood as local, component-level phenomena.

Again, turning to dynamical systems theory can shed some light on what I am getting at concerning the emergent level of attractors. In the period-doubling route to chaos found in the logistic map (to calculate populations at discrete time intervals with a simple nonlinear difference equation), different attractors emerge as the control parameter increases (see Feigenbaum, 1983). When the dynamics become trapped at a fixed point attractor, the population gets stuck at a particular amount and does not change after that. If the parameter is raised, a period 2 attractor emerges, and this sequence of period doublings occurs all the way to chaos.

At what level are these attractors? Imagine that you are a little being traveling along the parabola. You come to a fixed-point attractor and it is like a wall you can't get beyond. This wall seems to be of the same nature as the parabolic road you are on, so it seems like the attractor is on the same ontological level as the road. But that is only because you are a onedimensional being. Actually, the attractor is a phenomenon that arises out of the dynamics of the system represented by the logistic equation. As such, attractors "deform" the possibility space of movement along the parabola from their higher-level vantage point: they come from above, so to speak, and constrain the behavior below. This, of course, doesn't make them miraculous—they arise out of the particular dynamics of these nonlinear interactions when certain parameter values become critical, i.e., at bifurcation. But they are a higher-level emergent construct.

Similarly, organizational attractors need to be understood as phenomena on the global or emergent level. How this emergent level emerges from organizational dynamics nevertheless needs to be further clarified. The question, then, is what are the underlying dynamics of complex systems that serve to shape the specific emergent phenomena that occur in organizations, and not how lower-level activities function as attractors.

THE INTERACTION OF LEVELS

Although the level distinction between emergents and components needs to be kept in mind to utilize the insights of complexity theory more adequately in organizational research, an opposite snare also lurks: believing that there is some inseparable barrier between the level of the components and the level of emergent patterns. These levels are both distinct and interactive at the same time. As Diner (Diner, Fargue, and Lochak, 1986: 277) pointed out, researchers will not only try to see how the whole is generated by the parts, but also how the parts are generated by the whole: "The local properties get a real meaning only through their relation to the global properties." This is one of the aspects of emergence highlighted by Chris Langton: a bottom-up, top-down feedback going on among the levels. Similarly, Ralph Abraham (1987) has described selforganization in terms of the output of the system influencing the control parameters. Here, we see what can be termed a transgression of levels. This transgression, however, is not a conflation but a maintenance of the level distinction while at the same time trespassing it. This makes the study of emergence in complex systems a much more messy affair, and in organizational applications there will be a great deal of opportunity to get confused about what is happening on what level. But this kind of confusion can be taken as a good sign that one is getting close to the real essence of emergence.
COHERENCE

One of the defining characteristics of emergent phenomena in complex systems is a coordination, correlation, or coherence that is not present in the antecedent conditions of the components alone. An example of this coherence can be seen in the various emergent structures of the Game of Life that travel across the cells of the array, enduring through time. The property of coherence is one of the meanings of the typification of emergents as supposedly being “more than the sum of the parts.”

Applied to organizations, it is often supposed that the coherence of emergent phenomena is a good thing because of its facilitative role, say, in high-performance teams. Certainly, coherence can be an important asset in organizational dynamics, as borne out by numerous studies of team functioning. Very recently, Michael Lissack and Johann Roos (1999: 16) have pointed out the crucial role that coherence must play in effective leadership: “Finding coherence, enabling coherence, and communicating coherence are the critical tasks of leadership.”

A question arises in this context, however, as to whether the type of coherence manifested in emergence in complex system research is necessarily the kind of coherence from which organizations might benefit. This doubt becomes especially troublesome in the light of emergent coherence’s conceptualization by certain pioneers of complexity theory. A particularly strident example can be found in the Synergetics school founded by one of the trailblazers of complexity theory, German physicist Hermann Haken (1981). According to Haken, emergence—for example laser light—represents collective processes that reinforce themselves and eventually gain:

> the upper hand over the other forms of motion and, in the technical jargon of synergetics, enslave them. These new processes of motion, also called modes, thus imprint a macrostructure on the system ... If several of these collective motions, which we also call order parameters, have the same rates of growth, they may in certain circumstances cooperate with each other and thus produce an entirely new structure ... a new order will occur. (1981: 236; my emphasis)

The obviously poor choice of word in “enslave” points to more than a semantic issue—is this the kind of picture of coherence that is needed in organizations? In fact, I think these connotations of overly rigid coherence also show up in the buzzword “consensus.” In my experience, what most people mean by consensus is premature conformity to some group norm—in which case we could honestly say that it “enslaves” them.

Of course, coherence need not denote such rigid conformity. For example, coherence in the sense of boundaries or containment does seem a good idea, at least some of the time, at least when containment doesn’t simply reinforce nonadaptive organizational “silos.” What is needed is a paradoxically sounding nonconsensus coherence. This points to how much more work is needed in organizational applications of complexity to begin even to recognize and adequately describe the kinds of organizational phenomena on which complexity theory can shed some light.

OUTCOME

HOW BENEFICIAL IS EMERGENCE?

Amid all the hoopla surrounding self-organization and emergence, it is often assumed that they are necessarily a good thing, that systems exhibiting them are significantly better off, or, at least, that something problematic in these systems is markedly ameliorated. To be sure, the tendency to emphasize the beneficial nature of emergence seems to be a taken-for-granted attitude in complexity science. This can be seen in complexity theorist Luc Steele’s (1993, 1994) distinction between first- and secondorder emergence: first order is a property not explicitly programmed in; whereas second order is emergent behavior that confers additional functionality generating an “upward spiral of continuing evolution.” A similar bias toward the advantageous status of emergence can be seen in James Crutchfield’s point about intrinsic emergence being an additional computational capacity coming about from emergent patterns in a complex system.

However, this emphasis on the positive value of emergence derives mostly from the computational framework of much of complexity research. Within such a framework, the enhancement of computational capacity does seem to be a good thing and therefore the enthusiasm over it is warranted. What happens next, though, is that complexity theorists jump beyond the immediate computer simulations and speculate further about how such an increase in computational capacity would aid in the evolution of all complex systems. A similar bias for believing that selforganization and emergence are nothing but advantageous for a complex system can also be seen in organizational applications. I myself have given into this enthusiasm for the salving effect of self-organizational processes for evoking organizational creativity and motivation (see for example Goldstein, 1994, 1997a).

Strong caveats nevertheless seem to be in order here. First, consider the case of the former Yugoslavia. The central hierarchical control mechanism was dismantled and, consequently, the society self-organized, and became fraught with
emergent political structures. Unfortunately, a great deal of these emergent structures were formed around pre-existing fault lines of ethnic differentiation and hatred. Dismantling control mechanisms and thereby encouraging self-organization and emergence, therefore, doesn’t necessarily mean that you’re going to have a better state of affairs than existed before.

Self-organization and emergence are powerful forces that must be channeled appropriately. One of the challenges is how we can constructively create conditions so that they do indeed tend toward a better state of affairs. Here, there is a need for work on the “boundaries” that will contain anxiety and anarchic impulses (see Goldstein, 1994). These “boundaries” are akin to the earlier mentioned “containers” that shape the structure of emergent phenomena taking place within them. These boundaries can be psychological (e.g., a sense of safety), social (e.g., rules of interaction), cultural (e.g., rituals and stories), technological (e.g., computer networks), even physical (e.g., the actual physical attributes of the workplace). Working on the boundary dimension influences the turns that processes of emergence take. Experimenting with changing the boundaries, therefore, is a crucial step in learning how to guide emergence in constructive dimensions. Emergence can certainly be a very powerful advantage to a complex, human system, but much continuing ground work needs to be done to insure that it takes a constructive direction.

CONCLUSION

Charles Sanders Peirce (Taylor, in press) once wrote that in science and mathematics metaphysics leaks in at every joint. I have tried to point to where conceptual snares exhibiting a metaphysical tinge can leak in when it comes to using the construct of emergence. In the face of these snares, I am suggesting that those applying the idea of emergence tread cautiously and try to be aware of the assumptions underlying its application. Are these assumptions getting in the way of or aiding in the pragmatics of application?

Good physics doesn’t ensure good metaphysics. And at least one of the first steps toward constructive metaphysics is to recognize where it exists in hidden form, then to surface it, and then to consider if the particular flavor of metaphysics is in congruence with the aims of the applier of emergence. Emergence is a charged concept and as such can obfuscate as much as enlighten. It would be unfortunate if carelessness in using the construct of emergence contaminated future directions before they were even taken.

NOTE

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Emergence: Complexity and Organization


