De-emergence: Experimental Approaches to Deactivate Processes of Emergence

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Abstract: - The processes of self-organization and emergence have been intensively studied and modeled. The focus has been on their generative mechanisms and the need to preserve and sustain their continuously acquired coherence(s), for instance, in ecosystems and living systems. Rarely has the focus been on the reverse attitude, that is, to prevent and avoid their establishment or on approaches leading to their deactivation. This is probably because of their supposed fragility since they are considered easy to break down with perturbations. For instance, a flock may be destroyed by shooting inside it, or an ecosystem may be ruined by placing poisonous substances within it, such as the case of an anthill or weed killer onto a lawn. Here, we consider the occurrence of unwanted and dangerous cases of self-organization and emergence against which there are currently no effective approaches available and, thus, need to be appropriately modeled and implemented. For example, the establishment of tornadoes and hurricanes. The latter is known as Rayleigh-Bénard convection can easily be deactivated in laboratory conditions, but not once established in the atmosphere because of the power of the created forces, which generate destruction and devastation. We are interested both in the theoretical aspects of such eventual de-emergence approaches and in their actual technical implementability.

Key-Words: - Coherence; Deactivation; Decoherence; Emergence; Incompatibilities; Incompleteness; Prevention; Systemic Domain.

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1 Introduction

The purpose of this article is to focus on the unusual topic of de-emergence, which involves the deactivation of processes and properties of togetherness, such as emergence and self-organization. This is also in reference to the theme of reverse emergence, which is understood both as the effects of the emergence process on the phenomenon from which it emerges and as a study of its dismantling.

This article brings to attention the research topic of deactivation of processes that constitute togetherness in populations of elements and, possibly, their interactions. Examples of conditions and processes that constitution togetherness are covariance and correlation, (long-range) correlation, coherence, ergodicity, interactions, meta-structural properties, networking, power laws, remote synchronization, self-similarity, and synchronization between them. We consider the cases of self-organization and emergence for which deactivation becomes problematic when they assume forces and time scales that are difficult to deal with, such as tornadoes and hurricanes.

The relevant theoretical aspects and admissible, practical approaches are considered, to activate related lines of research. In Section 2, some ingredients for the togetherness of collective entities, generalized as multiple systems, such as covariance and correlation, are specified. In Section 2.1, we consider the introductory issue of Multiple Systems as given by clustering and synchronization. In Section 2.2, we elaborate on Multiple Systems as Collective Beings. In Section 2.3, the specific cases of self-organization and emergence are mentioned. In Section 3, we address the case of deactivation of togetherness. In Section 3.1, the case of decoherence is addressed in particular. We then mention related possible theoretical issues that need to be explored and extended. This is in reference to the theme of reverse emergence, understood both as the effects of the emergence process on the phenomenon from which it emerges and as a study of its dismantling.

In Section 3.2, related theoretical issues are mentioned. In Section 3.3, two real cases are considered: the Rayleigh–Bénard convection and social systems, together with some possible tentative approaches for their deactivations. This is to provide an idea of the admissibility of the problem and possible approaches. It is, therefore, a research project open to new approaches and modeling. In Section 3.3.1, possible experimental approaches for the deactivation of Rayleigh–Bénard convection, such as tornadoes and hurricanes, are mentioned. In Section 3.3.2, possible experimental methods for the deactivation of emergence and self-organization phenomena in social systems are considered. We conclude by mentioning the related open lines of research that could be introduced.

2 Some Ingredients for the Togetherness of Collective Entities

With the term "togetherness," we refer to the ability of generic entities to acquire specific properties having the effect of making them unified, for instance, when structured and interacting reciprocally, [1].

At the classic macroscopic level, the togetherness of material entities composed of elements, considered at different levels, is due to their generic structures, such as structured components of electronic and mechanical devices, molecular bonds, and attractive forces, such as magnetic and gravitational.

An introduced significant generalization, [2], relates to meta-structures, multiple, simultaneous structures, variable over time, and their sequences as in liquids and in the organization of domains within a ferromagnetic material, [3]. We mention a case relating to meta-structures, such as links among links of a network, establishing, in turn, multiple superimposed soft networks, [4]. Moreover, sequences of multiple structures over time are considered meta-structures of interest when coherence establishes multiple, partial systems, [5]. The large varieties of interactions (occurring when one's behavior affects another's behavior) involved are analytically intractable and impossible to represent in explicit ways. A previous approach was based on using mesoscopic variables [6] that are not related to microscopic properties but to equivalences, allowing for incompleteness and reasons for unpredictability.

A further generalization occurs when considering collective entities whose acquired togetherness is due to their continuous interaction, enabling levels of coherence. The interest here is in collective interacting entities of which the typical basic example is represented by the so-called Brownian motion, the irregular, disordered, random, and unpredictable motion of a speck of pollen on water due to collisions with single and multiple water molecules, interacting with one another because of thermal energy. Due to thermal interactions a number of particles subject to Brownian motion in a given medium, such as water, have not preferred directions for their random oscillations. Consequentially, over a period of time, the particles and molecules will tend to be spread evenly in the medium.

This situation is particularly generalized considering multiple systems established, for example, by the multiple roles of their interacting components such as in the case of multiple interactions, [7]. Their structure is constituted by the dynamic occurrence of multiple and variable interactions involving the same elements, as in ecosystems and the internet, and multiple networks where the same nodes simultaneously belong to different networks (such as energy and telecommunications networks); keeping, however, dynamic levels of predominant coherences or replaceable temporary incoherences corresponding to the established systems. This is the dynamics, i.e., the mechanisms, of processes of emergence of complex systems, [8].

As is well-known, the classic model of non-multiple systems may be considered as being given by systems of ordinary differential equations such as:

$$\begin{cases} dM_1/dt = f_1\,(M_1, M_2, \ldots, M_n) \\ dM_2/dt = f_2\,(M_1, M_2, \ldots, M_n) \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ dM_n/dt = f_n\,(M_1, M_2, \ldots, M_n), \end{cases} \tag{1}$$

where:

- the considered system is intended as constituted by n elements p_i ($i = 1, 2, \ldots, n$), assumed invariable in number and properties (i.e., a very unrealistic assumption);
- there exist measures M_i ($i = 1, 2, \ldots, n$) for each n element pi ($i = 1, 2, \ldots, n$);
- the n elements p_i ($i = 1, 2, \ldots, n$) interact between them through fixed rules of interaction f_n.

As a consequence, the change of any measure M_i is, therefore, a function of all other M_s. The change of any M implies a change for all the other measures, making the system a single, totally interconnected whole. The instantaneous values of $M_1, M_2, \ldots$, and M_n specify the state of the system at each instant.

Examples include systems such as electronic devices consisting of

- components p_i ($i = 1, 2, \ldots, n$) such as, for example, capacitors, diodes, inductors, micro-

CPUs, micro integrated cards, oscillators, relays, resistors, and transistors;
- having properties (M_n) such as measurements of their electrical state, thermal state, dissipation level, and the result of microprocessing of input signals;
- interacting with each other via multiple circuitry (f_n) when powered, involving for example multiplying or reducing the input signal or their combinations, approximating the maximum or minimum value of the input signal or their combinations, combining multiple signals, sending signals conditioned by the state of others.

The acquired systemic property is *functioning* (the device becomes a computer, robot, smartphone, television) that decays when the f_n interactions cease, for example when the power supply ceases.

Other examples include the solar system, and the hydraulic and electricity systems.

Examples of generic systemic properties are a) allostasis -when keeping stability through structural changes-, b) resilience -when adapting and self-repairing in the face of disruptive perturbations-, and c) autopoiesis -when having the ability to regenerate recursively-.

Temporal sequences of the system (1) specify the behavior of the system, the assumed constituted fixed and invariable elements, and the rules of interactions.

Instead, the simultaneous validity of different versions of the system (1) may be intended to analytically represent the concept of multiple systems, when f_n changes in $f_{n,t}$ and the expressions in the system (1) become time-dependent, i.e.:

$$\begin{cases} dM_1/dt = f_{1,t}(M_1, M_2, \dots M_n) \\ dM_2/dt = f_{2,t}(M_1, M_2, \dots M_n) \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ dM_n/dt = f_{n,t}(M_1, M_2, \dots M_n) \end{cases} \quad (2)$$

Realistically, it is possible to have a different number of variations per instant, and the number of variations may be different, even if limited per instant. It is then possible to consider the level of multiplicity by considering the number of variations over time and the properties of its trend over time, identifying levels of multiplicity.

Examples include systems such as audience, baseball teams, company staff, customers of a shop, passengers on trains or planes, and school classes where:
- components p_i ($i = 1, 2, \dots, n$) as agents, for example, players of teams, company staff, passengers on trains or planes, boids of flocks, swarm insects, molecules of biological entities;
- having properties (M_n) such as measurements of their state, for instance, 3D spatial position, velocity, direction, temperature, and mass;
- interacting with each other via the application of global and local variable, context-dependent (compositions of) rules ($f_{n,t}$) such as for collision avoidance based on some feedback mechanisms and compliance with minimum permissible distance values; compliance with maximum permissible distance values to avoid disintegration; adoption of a kind of dependent behavior such as analogous imitation of that of the adjacent neighbors; and self-regulatory, adaptive behavior through some learning mechanism.

The acquired, emergent systemic property is the *behavior* and its consistence, ability to restore temporary losses of coherence, and tolerate temporary inconsistencies (for instance of baseball teams, company staff, and communities keeping their identity in the face of variations in the number of components and in the interaction rules $f_{n,t}$ applied).

2.1 Multiple Systems as Clustering and Synchronization

We mention the possibility of considering Multiple Systems as dynamic clusters having synchronization as the source of their coherence, [9].

For example we may consider the case of populations of *interacting clocks*, whose internal cyclic dynamics are given by

$$\Phi = \omega \quad (3)$$

where:
- Φ is the phase;
- ω is the frequency. (2)

A simple case is given by large populations of fireflies which, when synchronized, generate large amplitude periodic signals. The equation of the *Synchronization Function* between them can be found, see, for instance, [9].

We mention another approach [9] based on considering the dynamical law modeling the time evolution of a generic unit considered as a *logistic map* suitable to represent realistically population dynamics:

$$f(x)=1-\alpha x^2 \quad (4)$$

where:
- x is the number of elements;
- α is a suitable control parameter.

In reference to the concept of Multiple Systems it is possible to consider the system of N *globally coupled logistic maps* and study their possible mutual synchronizations during their interaction:

$$X_i(t+1) = (1-\varepsilon) f(x_i(t)) + \frac{\varepsilon}{N} \sum_{j=1}^{N} f(x_j(t)) \qquad (5)$$

where

- $i = 1,2, \ldots, N$ represents single logistic maps $f(x) = (1-ax^2)$;
- $f(x)$ is the equation $f(x)=1-\alpha x$;
- α is a control parameter for the logistic map. It shows chaotic-like behavior when $\alpha > 1.401\ldots$;
- ε is the coupling strength.

Coherently operating groups are intended as establishment of dynamic clustering. In this case the dynamic clustering is observed in the interval $0.32 > \varepsilon > 0.075$. Mutual synchronization, i.e., the coherent phase, of the entire ensemble manifests for $\varepsilon > 0.32$. When $\alpha = 1.8$, dynamical clustering occurs in the interval $0.37 > \varepsilon > 0.14$, and so on [9].

Furthermore, it is possible to consider approaches for clusters and synchronization in Dynamic Networks established by populations of interconnected elements having simple internal dynamics. We consider here the case when elements consist of N *identical logistic maps*: "The pattern of connections in the network is specified by a random graph with the adjacency matrix T_{ij} which is obtained by independently generating any possible connection with a fixed possibility υ.", [9].

The collective dynamics of the network are modelled by the following equation (6):

$$X_i(t+1) = 1-[\varepsilon/\upsilon(N-1)] \sum_{j=1}^{N} T_{ij} \; f(x_i(t)+\varepsilon/[\upsilon(N-1)] \sum_{j=1}^{N} T_{ij} \, f(x_i(t)) \qquad (6)$$

where symbols are as specified above. When $\upsilon = 1$ equation (6) coincides with (5) describing the collective dynamics of N *globally coupled logistic maps*.

Through numerical simulations [10] it has been shown "...that, when the coupling straight ε is gradually increased, these networks experience dynamical clustering and synchronization." [9, p. 250].

We stress, however, that the limited effectiveness of these models lies in the fact that they are mainly based on fixed interconnections allowing for the occurrence of the phenomena of emergence limited to clustering and synchronization.

2.2 Multiple Systems as Collective Beings

We now mention how multiple systems may reach levels of temporary stability and robustness and as well to constitute initial conditions such as multiple, partial, tentative, and failing conditions. These may possibly converge to the establishment of a collective system when the collective interaction acquires significant levels of coherence: long-range correlations as in processes of self-organization and emergence (Section 2.3).

Furthermore, when the elements are autonomous, i.e., provided with a cognitive system making them able to *decide* rather than *compute* (selecting among possible reactions or looking for optimizations) their behavior, multiple systems are called collective beings, [7] (Figure 1).

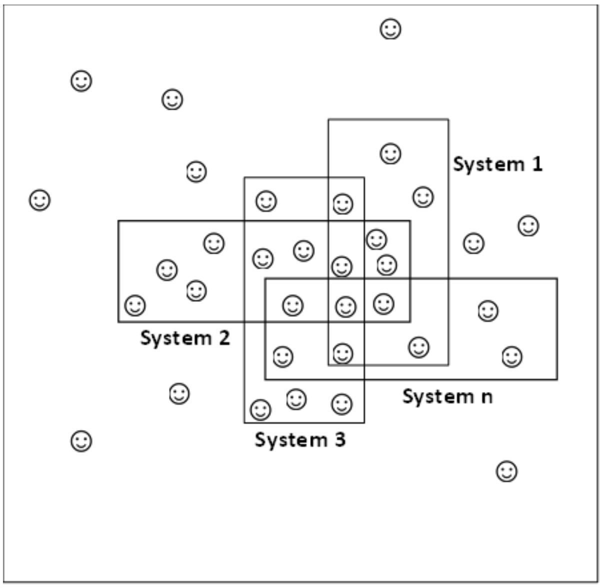


Fig. 1: An illustration of the concept of multiple systems as collective beings where same elements belong to more systems

The concept of collective being particularly applies to the collective behavior of agents assumed equipped with a cognitive system, having, furthermore, the ability to use different cognitive models depending on contextual situations, to memorize and learn, and emulative abilities, e.g., anthills, herds, schools of fish, swarms, and social systems such as Internet users, markets, football teams, players on the stock exchange, and traffic jams.

In multiple systems and collective beings, the *coherence between elements replaces structures*. The coherence of collective beings is due to multiple, variable, differently necessary, and sufficient levels of properties, such as:

- Interchangeability among components, given by the ability to take on the same roles at different times or different roles at the same time as, for instance, in (quasi) ergodic behaviors. We mention that components of populations are assumed to assume ergodic behaviors in case they are related in such a way that, when, at any moment in time *x%* of the population is in a particular state, then each element of the population is assumed to spend *x%* of time in that state. Realistically, instead of this, it is more appropriate to consider levels of percentages of elements spending *x%* of time in that state, which allows to establish degrees of ergodicity.
- Multiple roles, e.g., the position and behavior of a single animal in multiple collective animal behavior, affect (interact with) those of other ones belonging to different systems, e.g., ecosystems, and, in networks, the same node has multiple interconnections with other nodes. We mention how, usually, the multiplicity of the role of a component is not due to its direct actions on the other ones, but to the different behavioral variations that the other ones assume depending on the position and behavior of the component in question.
- Multiple mediated flows of information having no direct, linear conveyance of information, such as when non-spatially close components in collective behaviors, e.g., boids of flocks, have a suitable topological distance [11] and in remote synchronization, [12], [13]. This is the case of generic collective animal behaviors:

"Correlation is the expression of an indirect information transfer mediated by the direct interaction between the individuals: Two animals that are outside their range of direct interaction (be it visual, acoustic, hydrodynamic, or any other) may still be correlated if information is transferred from one to another through the intermediate interacting animals", [14].

Multiple systems consider the weak micro-dynamics that are typically assumed to be irrelevant and ignored since it is presumed that they are overbeared by predominant macroscopic behavior. Significant and decisive for their establishment is the emergence of collective behavior. The macroscopic behavior of multiple systems is emergent, while it is supposed to be suitably approximated by the sum of micro-dynamics, it is non-summable because of their varied natures.

At this point, we may consider how the acquired togetherness of collective components may be considered as given, for instance, by the variable occurring of differently necessary and sufficient levels of (eventually combined) properties, such as their belonging to the basin of an attractor, be subject of covariance and correlation, (long-range) correlation, coherence, ergodicity, interactions, meta-structural properties, networking, power laws, remote synchronization, self-similarity, and synchronization between them. We may specify some approaches to determine covariance, correlation, measures, and generalizations as the cross-correlation function.

The concept of correlation is closely related to that of covariance since both measure the dependence between the variables under consideration. In particular, covariance determines how two variables covary.

It is possible to use correlation measures applying, for instance, linear approaches such as the so-called Bravais-Pearson coefficient, [15], [16]. The Bravais-Pearson coefficient measures the linear correlation between two sets of data such as between newborns' weight and length and a person's age and their corresponding income in a place.

The covariance [17] of two variables is divided, however, by the product of their standard deviations.

The covariance identifies how two random variables *X* and *Y* covary, that is, at what level both change in the same way. The Bravais–Pearson coefficient is essentially its normalized measurement between −1 and 1. We must stress that the Bravais–Pearson coefficient, as covariance itself, measures only linear correlations and ignores other types of relationships, [18], [19], [20].

Considering in a population a pair of random variables (*X*, *Y*), the Pearson's correlation coefficient ρ is given by:

$$\rho(X,\ Y) = \frac{Cov(X,Y)}{\sigma X \sigma Y} \tag{7}$$

where:
- Cov is the covariance,
- σX is the standard deviation of X,
- σY is the standard deviation of Y.

The covariance is given by the following:

$$Cov(X,Y) = \frac{\sum (x-\bar{x})(y-\bar{y})}{n} \tag{8}$$

where:
- $\bar{x}$ and $\bar{y}$ are the means of the data series,
- n is the size of the considered sample.

The Pearson's correlation coefficient ρ in the (7) may be expressed as r in the formula (9) where n is the number of observations:

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}} \tag{9}$$

However, the Bravais–Pearson approach can be generalized by other linear measures, such as the cross-correlation function. This applies to two time series of the same length N and where values are, respectively, denoted by x_n and y_n. Such values have been previously normalized, and have a zero mean, and a unitary variance. In this case, the cross-correlation function $C_{XY}(\tau)$ depends on time lag τ and varies within the range from $-(N-1)$ to $N-1$ according to the following expression:

$$C_{XY}(\tau) = \begin{cases} \dfrac{1}{N-\tau}\displaystyle\sum_{n=1}^{N-\tau} x_{n+\tau} y_n & if \quad \tau \geq 0 \\ C_{XY}(-\tau) & if \quad \tau < 0 \end{cases} . \tag{10}$$

The cross-correlation values can vary from 1 (maximal synchronization) to −1 (loss of correlation).

A successive, further generalizing level is given by the occurrence of processes of self-organization and emergence as sequences of covariances, correlations and, more generally, variable but predominant coherences, as considered in the following section.

In conclusion, let us consider how systems manifest themselves as a whole thanks to the *appropriate* interaction of their parts (different partitions are possible at different levels of description and scalarity, e.g., in a living system we can consider cells, neurons, organs, and tissues) when establishing significant levels of *cross-correlation* between them. Interacting alone is not sufficient as for the so-called Brownian motion mentioned above. They do not constitute a system, i.e. they are not cross-correlated and do not acquire systemic properties.

In multiple systems, there are phenomena of corresponding multiple cross-correlations albeit at different levels of intensity.

In the end we mention how *autocorrelation* is given by the degree of similarity between a given time series and its lagged version, considered over successive time intervals. Autocorrelation consists in measuring the relationship between a variable's current value and its past values.

2.3 Cases of Self-Organization and Emergence

We now mention two cases in which the collective interacting entities acquire forms of togetherness and robustness, i.e., the processes of self-organization and emergence (Table 1) to the point of constituting collective entities with their properties, different from those of the constituent elements. In systems science, the topic of emergence, a term originally coined in [21] and self-organization, introduced in [22] are found in an enormous amount of literature and research, [23], [24], [25], [26], [27], [28].

Table 1. Conceptual comparison between self-organization and emergence

Self-organization	Emergence
Synchronization Periodicity Self-similarity (at any scale a geometrical object is similar to a part of itself. Iteration.	Multiple variable synchronized synchronizations Multiple periodicities (5) Coherence is the property of collectively interacting elements to acquire and maintain emergent properties. Continuity.

Next, we examine how self-organization can be considered to consist of the (regular or quasi-regular, allowing tolerance for local and temporary deviations) recurrent acquisition of coherent sequences of variations of the *same* property. Examples of self-organization include self-organized properties of phenomena, such as the acquisition of whirlpooling in liquids and the repetitive flying of swarms, e.g., mosquitos around light. Furthermore, we mention the so-called Rayleigh-Bénard convection [29], in which liquids are evenly heated from below, which consists of the formation of convective patterns. While the occurrence of convective patterns may be predictable only in incomplete ways, other properties, such as the acquired patterns and their directions, are not predictable at all [30]. We also mention the so-called Belousov-Zhabostinski reaction, [31], [32], which consists of oscillating chemical reactions that acquire synchronized, periodic variations of striking color.

We now mention how emergence, [33], [34], [35], [36] can be considered to consist of the (regular or quasi-regular, allowing tolerance for local and temporary deviations) recurrent acquisition of coherent sequences of variations of structurally *different*, however admissible, compatible, and equivalent, properties. For instance, the change of position, speed, and direction of a boid in a flock, occurring at the time t_{n+1}, must be admissible and compatible with the physical constraints of the generic boids at the time t_n, e.g., a boid cannot instantaneously multiply its speed, [11], [27]. As in the processes of self-organization, composing elements of the established collective entity have several equivalent instantaneous changes available to choose from, where the selection occurs in several possible ways, such as due to energetic convenience, fluctuations, and cognitively-based living collective beings as flocks and herds, respectively, that is due, for instance, to atmospheric conditions and the shape of the territory.

Furthermore, changes must allow for the acquisition of coherent states or temporary incoherent recoverable incoherences [8], of which a basic understanding is the ability to keep different admissible, compatible, and equivalent versions of the *same* property, even if this understanding is observer-dependent. For example, the observer recognizes the *same* flock even moving through different shapes, densities, altitudes, and number of components (when is a flock no longer a flock?). This relates to the character of prevalent uniqueness and unrepeatability of self-organization and emergence processes. We may consider emergence as constituted of coherent sequences of multiple, local, and temporary self-organization-like collective entities and processes, [37].

3 Deactivating Togetherness

We now consider the following concepts, inspired by the so-called still, in progress, the idea of *reverse emergence*, [7], [38], [39].

The processes of self-organization and emergence have been intensively studied and modeled. The focus has been on their generative mechanisms and the need to preserve and sustain their continuously acquired coherence(s), for instance, in ecosystems and living systems. Rarely has the focus been on the reverse attitude, that is, to prevent and avoid their establishment or on approaches leading to their deactivation. This is probably because of their supposed fragility since they are considered easy to break down with perturbations. For instance, a flock may be destroyed by shooting inside it, or an ecosystem may be ruined by placing poisonous substances within it, such as the case of an anthill or weed killer onto a lawn.

We consider the occurrence of unwanted and dangerous cases of self-organization and emergence against which there are currently no effective approaches available and, thus, need to be appropriately modeled and implemented. For example, the establishment of tornadoes and hurricanes. The latter are known as Rayleigh-Bénard convection that can easily be deactivated in laboratory conditions, but not once established in the atmosphere because of the power of the forces that are created, which generate destruction and devastation. We are interested both in the theoretical aspects of such eventual de-emergence approaches and in their actual technical implementability.

3.1 Decoherence

We notice how we may consider self-organization and emergence as processes necessarily based on coherence, as given by synchronization and correlation. In this work, we consider decoherence as a loss of coherence and synchronization in the *classical* world (in quantum physics, decoherence has a very different meaning). The process of losing coherence is usually considered to have negative aspects, involving the loss of (systemic) properties acquired thanks to the establishment of coherences, e.g., degenerations of collective behaviors such as the dispersal of a flock into uncorrelated boids. The process of losing coherence is assumed to have a degenerative nature. Much attention has been paid to how to maintain or recover coherence, e.g., in dissipative structures and processes of emergence.

Here, on the contrary, the general purpose is related to approaches suitable to prevent and deactivate establishing or established processes of self-organization (recurrent acquisition of coherent sequences of variations of the same property) and emergence (recurrent acquisition of coherent sequences of variations of the same and different properties), networks, and systemic properties. In summary, the interest is in the processes of de-emergence.

We focus on the coherence acquired by negative processes such as having a degenerative nature, the consolidation of pathological states, and acquired pernicious collective behaviors. The interest is, for instance, on the prevention and deactivation of incoming illnesses due to supposed processes of emergence, the emergence of economic problems - of which the so-called tulip crisis type-like (1637) was a typical example-, hurricanes, unwanted collective behaviors, e.g., traffic congestions, invasive, and dangerous ecosystems. We spotlight approaches that are suitable to prevent and deactivate processes of self-organization and emergence, [7], i.e., anti-self-organization and anti-emergence, and to prevent and deactivate the related establishment of logical openness [7] and theoretical incompleteness [7] based on unpredictable occurring of equivalences.

From a theoretical point of view, it is about eliminating the conditions necessary for the establishment of emergence phenomena such as logical openness and theoretical incompleteness. This is because logical closure and completeness are enemies of complexity, which they reduce to structures, like collective behaviors to marching platoons.

We mention how the concept of *logical openness* is an extension of thermo-dynamical openness (Table 2).

Table 2. Conceptual comparison between close systems and logical open systems

Logical Closed Systems	Logical Open Systems
Deterministic	Nondeterministic
Context insensitive	Context-sensitive
Nonlearning	Learning
Object-oriented	Process-oriented
Nonflexible	Flexible
Fixed rules, variable parameters	Changing rules
Contradiction avoiders	Using contradictions at a higher level of description
Mono or non-dynamic strategies	Multi-dynamic strategies
Ideal Modeling - Deterministic chaos equations - Equations of mechanics - Equations of thermodynamics - Ergodic systems - Field equations, such as those of Maxwell's electromagnetic field - Network science (ideal scale-free networks)	Non-Ideal Modeling - Agent-based models - Artificial life - Cellular automata - Dissipative structures - Neural networks - Properties of big data
Fixed structures	Variable structures, e.g., ecosystems
Nonadaptive	Adaptive

The *logical closure* of modeling relates to the evolution of closed systems, having no exchange of matter-energy with the environment, that can be represented with:

- Formal and *complete* analytical representations of the system's state variables and their intra-relationships, are assumed to all available;
- Complete analytical representations of interactions with the environment are assumed available.

The knowledge of the two points above allows us to *deduce* all possible states that the system can assume.

Conversely, the logically open modeling or logical openness [40] is given by the violation of one or both of the two points above. We may consider logical openness as the occurrence of an infinite number of degrees of freedom for the system. This requires the use of multiple, variable, equivalent, and non-equivalent models. These are violations of the two points above regarding logical closure. However, the unlimitedness of the degrees of freedom is a necessity for the constitution of emergence processes that would otherwise have fixed structures, substituting coherence.

The concept of *theoretical incompleteness*, [41], [42] relates to its non-completability in principle and it is related to logical openness since:

- a single model is assumed not sufficient to represent the phenomenon;
- the degrees of freedom, the system variables are continuously acquired and vary in number;
- the system continuously acquires equivalent and non-equivalent properties;
- the system can assume many equivalent and non-equivalent states, selected, for instance, by fluctuations. Examples include in quantum mechanics the uncertainty principle when accuracy in measuring one variable is at the expense of another); in theoretical physics the complementarity principle between wave and particle natures; and Gödel's incompleteness theorems, [43].

In sum the incompleteness of logical openness lies in the use of a variable number of non-equivalent models.

However, the typical conceptual context to which the concepts of logical openness and theoretical incompleteness are applied is that of complexity referring to phenomena in which emergence occurs, as previously considered in section 2.3; in chaotic systems highly sensitive to the initial conditions such as the double pendulum (Figure 2), smoke diffusion and weather, characterized by the morphologies and properties of the attractors established by their evolutionary lines in the phase space and their basins [44]; and in complex networks [45], [46], [47] acquiring properties such as the emergence of small words, clustering measured by the clustering coefficient, degree distribution, multiplicity and variability of the nodes and intra connectivity, power laws, scale invariance, and self-similarity.

In the cases of complexity, zipped, complete, and explicit models are conceptually not possible because of the logical openness and theoretical incompleteness, given by the varieties of interactions and structures involved.

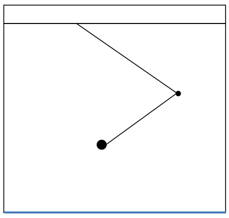


Fig. 2: An illustration of the double pendulum

In order to induce, obtain reduction up to loss of coherence, it is a matter of reducing more and more the degrees of freedom and the incompleteness, for example by slowing down interactions.

We may consider, for instance, to proceed via approaches such as environmental changes, introduction of perturbations, combinations of incompatibilities, delays, (environmental) inhomogeneities, desynchronizations, reducing equivalences, removal (invalidation) of necessary conditions, inverting local and global properties, and prevent remote synchronizations. Examples include the insertion in the process of desynchronized acoustic and electromagnetic waves, irregular vibrations, incoherent predominant entities, particles with irregular behaviors, irregular light variations, environmental inhomogeneities, environmental constraints, incompatible behaviors as inserting another antagonistic or dispersive collective behavior, in case artificial, and corrupt the established systemic domain. It is a matter of extinguishing or deactivating (cross-) correlations also through (irregular and inhomogeneous) environmental temporal and spatial deformations.

Another hypothetical approach would be to leave the processes unchanged but to reduce their intensity, making, for instance, the environment highly dense and sticky. This approach, at first glance, seems impractical when there are intense forces and very small metric and temporal scalarities are at play. Reversely, we mention how the know-how to deactivate emergencies and networks also involves knowledge regarding the ability to recognize deactivation processes in progress (in case they are fraudulent or malignant) and recovery capabilities.

3.2 Theoretical Issues

Here, we list some theoretical issues related to future possible models finalized to deactivate or extinguish various forms of togetherness. Those models should be identified, for instance, as:

- Anti-emergence factors, such as strategies and approaches, as follows:
  - reducing incompleteness, e.g., reducing equivalences,
  - operate with (forced) finite values,
  - reducing options,
  - approximate, converge unruled processes to ruled,
  - combine antagonistic, incompatible emergence processes,
  - transform and use, i.e., reduce, non-ideal model to ideal (zip in analytic representations).
- Anti-chaotic factors are achievable by reducing high sensitivity to initial conditions (by forcing, for instance, the usage of macro initial conditions made of indistinguishable micro initial conditions at a different scale).
- Deactivation of networks, identifying structural critical points or disruptive interventions aimed at deactivating network functions or its properties, e.g., identically connecting all the nodes, making, for instance, the environment conducive and inconsistent the small-scale worlds.
- Deactivation of systemic properties reduced to possessed properties.

Symptoms of the establishment of the processes of emergence or, in any case, processes compatible with it (quasi-emergence), such as the establishment of self-organization zones that can combine and amplify, extend themselves, converging on a single process of emergence, or expire out due to their insufficient compatibility or mutual incompatibility. See, for instance, the interactions between two adjacent convection rolls in turbulent Rayleigh–Bénard convection, [48]. Another example of symptom occurs when the corresponding acquired dynamic structures in processes of emergence may be understood as the occurrence of possibly multiple simultaneous sequences of processes of self-organization and are coherent, i.e., display the same property in spite of adopting multiple coherences. An example is given by the theory of “dual evolution” for adaptive systems, introduced in [49].

Finally, let us mention how the situation of togetherness, as of self-organization and emergence, is considered special in a context in which the natural prevalence of disaggregation, incoherence, and non-synchronization is taken for granted.

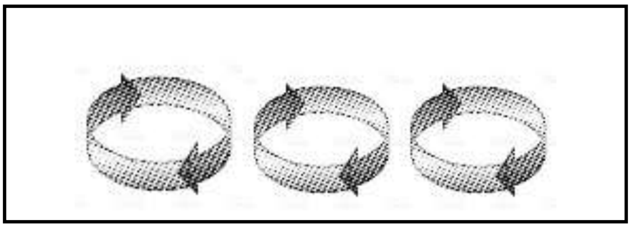
However, this situation could be considered not so obvious as natural, for example when disaggregation could be considered predominantly as *degenerated togetherness* and not just as a generic disorder where we consider the transition from disorder to order, [23]. In this perspective, disaggregation could have prevalent residues of previous togetherness that can be considered as, at least partially, recoverable, composable, and reactivated. In essence, can togetherness be considered as, albeit variably, predominant and detectable in its residues or is there an invariable predominance of disaggregation?

The question is of interest considering that the initial conditions for the establishment of the coherence of togetherness would not be null, the acquisition of togetherness would not start from zero. It would be a matter of detecting residues of previous, possibly remote, togetherness and exhuming them in new processes, or paying the cost of going against them.

3.3 Two Cases: Rayleigh–Bénard Convection and Social Systems

Rayleigh–Bénard convection is a type of natural phenomenon that occurs in a planar horizontal layer of fluid that is heated from [50], [51], Figure 3. Such convections are easily deactivated in the laboratory, introducing obstacles and perturbations, while not in the natural environment where enormous forces and quantities are involved that have highly unpredictable onset and behavior.

cold



hot

Fig. 3: Schematic example of Rayleigh–Bénard convection

Collective social systems are kinds of multiple, collective beings that can be deactivated on a small scale, like anthills and wasps' nests. Analogous is traffic in cities, crowds of people entering shops, and possibly small riots. At much larger scales, using the same approaches with greater intensity and force often does not work and may even be counterproductive about reinforcing effects. It should be mentioned how simplified togetherness of temporary social systems is established by the occurrence of positive and negative feedback, for example, in terms of communities of buyers and sellers in the stock exchanges. Deactivating actions that are usually assumed include temporary suspensions of negotiations.

3.3.1 Experimental Approaches to Deactivate Rayleigh–Bénard Convection

Large-scale Rayleigh-Bénard convection, which includes tornadoes and hurricanes that have highly unpredictable onset and behavior, is endowed with vast forces that involve enormous masses of liquid and atmosphere, develop at great speed, and have high levels of unpredictability. Any reproduction of laboratory approaches is, in fact, impractical. It is a question of considering the possible use of approaches of a completely different nature appropriate to the forces and times of the phenomenon.

Hypothetically, suitable approaches to deal with the extreme forces and temporal characteristics of such phenomena rely on the flexibility and adequate self-adaptive pointing of appropriate optical and radiant technologies, with sufficient local temporal persistence to have thermodynamic effects. For example, high-power laser radiations, according to methods and approaches to be studied, e.g., introducing desynchronizing local, sparse delays, phase shifts, as hypothetically represented in Figure 4 and identified with appropriate research activity.

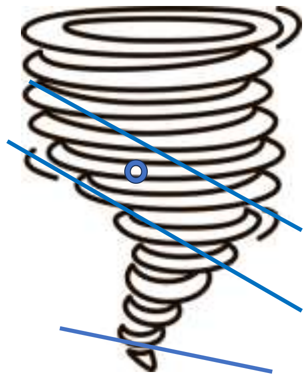


Fig. 4: Schematic example of laser desynchronizing local, sparse radiations

This would involve adapting, for example, military devices based on the use of lasers for such an application, [52], [53], [54], [55].

It would be a matter of moving beams of radiation along with maintaining the radiation adaptively constant for a sufficient time to break down the coherence of the convection in various parts by superimposing and inserting the adaptive radiation. Thermodynamic interventions aimed at producing effects are rather unlikely due to the limited time scale. Laser-based approaches can be studied in the laboratory at small scales. The adequacy of the radiation delivery requires great mobile flexibility of the stations equipped with the sources, providing that it takes advantage of the fact that it does not require improbable and impossible proximity to the phenomenon to be deactivated, but rapid capacity and adjustment of pointing. The use of drones seems unthinkable due to the limited time scale within which one must act.

Furthermore, it must be kept in mind that the radiation passing through the phenomenon to be perturbed must not impact sensitive entities that would be seriously damaged, such as ships or coasts. Other possible ideally considered approaches involve deactivating initial conditions by using the same laser-based technologies. However, such approaches seem practicable only through the detection of the relevant phenomena, for example, with satellite and aerial surveys.

3.3.2 Experimental Approaches to Deactivate Social Coherences

Traffic models, [56], [57], [58], show that traffic jams can occur spontaneously for homogeneous traffic flow when the density of vehicles exceeds a particular value. Traffic can be modeled as occurring in a number of states, such as free-flowing and traffic jams, with phase transitions occurring between the states. Changes in traffic properties, such as density, flow, and speed, can be induced by temporary changes in the width of road lanes, by signs, and the introduction of traffic police vehicles having the effect of order parameters.

Examples of general approaches used include disruption and perturbation of information exchange, e.g., information distortion (e.g., fake news) of the interaction processes, perturbances, invasive environmental changes, the introduction of entities with destabilizing behavior, and acting on the density.

Never before has it been so necessary to consider the unethical nature of such approaches, not only by avoiding them rhetorically with recommendations but by highlighting the non-strategic nature of unethical approaches that are only effective in the short term and by creating situations in which the unethical nature of such approaches is not convenient in the long term.

The interest in studying manipulative approaches to social systems lies in recognizing them and in implementing appropriately neutralizing approaches.

4 Conclusions

In this work, we introduced a focus on the unusual issue of de-emergence, intended as the deactivation of processes and properties of togetherness, such as emergence and self-organization. We mentioned related possible theoretical issues that should be explored and extended. This is about the theme of reverse emergence, which is understood both as the effects of the emergence process on the phenomenon from which it emerges and as a study of its dismantling. We considered two cases, i.e., the Rayleigh–Bénard convection and social systems, and some possible tentative approaches for their deactivations. This is to provide an idea of the admissibility of the problem and the possible approaches. It is, therefore, a research project open to new approaches and modeling.

However, the theoretical approach consists of progressively eliminating the conditions necessary for the establishment and maintenance of emergence processes (such as equivalences, high levels of degrees of freedom, and incompleteness mentioned above) or in any case correlation relations generating coherence. This is an approach with a conceptually different nature, not multiplicative, for example, from those considering an increase in propagation, diffusion, for example, epidemic, and positive feedback, admitting gradual and partial reductions.

Moreover, let us consider at this point the difference between first-order phase transitions that admit coexistence of phases (for example, the boiling of water in which the water does not instantly transform into vapor, but there is coexistence between the liquid and vapor phases) and second-order phase transitions that do not admit coexistence between phases (for example between ferromagnetic and non-ferromagnetic). *Since emergence is intended as constituted of coherent sequences of multiple, local, and temporary self-organization-like collective phenomena that admit coexistence, it may be intended to have a first-order phase transition-like nature*.

It could therefore be assumed that the nature of approaches used to deactivate first-order phase transitions may be appropriately considered for the deactivation of emergence processes. *However,* coexistence *in first-order phase transition processes should be considered replaced by* compatibility *and* coherence.

Furthermore, it is a matter of developing approaches capable of detecting the establishment, initial conditions for the establishment of collective phenomena of emergence, of coherence.

A different approach is based on acting on parametric values considering the availability of approaches for measuring, [59], [60], [61], levels of coherence and emergence also capable of detecting initial constitutive phases.

Memory note:
This paper is dedicated to the memory of Professor Hermann Haken.

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