Towards a General Theory of Change:
a cybernetic and philosophical understanding

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In memory of Eliano Pessa

Abstract

We consider possible cybernetic and systemic approaches to an interdisciplinary general theory of change as a philosophical and scientific project. The approaches considered are intended as necessary; however, they are not necessarily the only ones, probably, at least in some cases, non-sufficient. The aim of such a theory should be that of identifying levels of descriptions suitable to classify, describe, and forecast the consequences of changes, as well as of finding the conditions which allow to control them as introduced by Cybernetics. Historically the scientific contents relate to the theory of phase transitions, its variations, and quantum approaches. However, we consider processes whose dynamics of change may be represented by other approaches such as meta-structural properties, that is, of necessarily dynamic structures between variable clusters rather than between entities considered structurally invariable. Furthermore, we consider the dynamics of processes of emergence, the general process of changing, as dynamics of validity regimes, an approach inspired by considering fields rather than entities in physics. On the philosophical side of the interdisciplinary general theory, we consider how such a hypothetical general theory of change should consider the theoretical incompleteness of changing, based on equivalences and multiplicities, and the quasi-ness of phenomena when properties are continuously lost and recovered. When systems are not always systems, systems are not only systems, and a system is not always the same system. The quasi-ness of the interaction machinery supporting the interaction activity of emergence is given by the variable duration, different start and end instants, inhomogeneity, and the various composability of interactions themselves which, furthermore, interfere with each other. It relates to the keeping of the same identity by continuously changing systems such as emergent systems. A swarm is always a swarm, even if continuously different. Theoretical incompleteness and quasi-ness are philosophical aspects of the meta-structural, mesoscopic approach, suitable to give new philosophical meaning to Cybernetics and General System Theory in the field of complexity. Where ‘to regulate’ means the ability to induce and to orient complex phenomena (where the replacement substitutes the regulation) with the fundamental role of weak forces as constraints to dynamics, to be processed by systems and not only be formally respected.

Keywords: change, emergence, incompleteness, meta-structure, quasi-ness.

1. Introduction

The most important feature of the world of phenomena is the occurrence of changes and their ways to occur. Changes may occur in different ways depending on the time and space considered, e.g., their granularity in classic Newtonian time-space; in relativistic non-Galilean time-space; in multiple simultaneous ways in the quantum view such as multiple localizations for quasi-particles; depending on Uncertain Principle in physics when the measurement of homologous components, for instance, position and momentum – given by the product of the mass of an object and its speed – are limited by the fact that the increasing accuracy in knowing the value of one variable correspondingly involves reduction in knowing the value of the other variable; and depending on the Complementarity Principle for which, for instance, the corpuscular and wave aspects of a physical phenomenon never exhibit simultaneously.

In simple cases of classic time-space, changes are intended as due to the stable structures among variables, allowing approaches such as in classic first-order Cybernetics and as replacement of the structure with a new one such as in second-order Cybernetics where the *replacement substitutes for regulation*.

Others occur in time and for configurational variables leading to deep structural changes in the systems under study. This case is usually dealt with the so-called *theory of phase transitions* (Sole´, 2011).

When the change is not reducible to observable direct actions of the environment, these latter are qualified as process of complexity such as *self-organization* and *emergence* where:

- Self-organization is intended as quasi regular sequence of properties acquired in a phase-transition-like manner, e.g., tornados and whirlpools (Minati, 2018).
- Emergence is a generalization of self-organization, occurring when the sequence of properties acquired in a phase-transition-like manner is *coherent*, e.g., flocks and swarms (Minati & Pessa, 2018, pp. 65-86; pp. 255-260; Minati, 2019a), when coherence, in short, is intended as long-range correlation. Emergence may be intended as even a kind of Cybernetics of the n^{th} order where the observer is active part of the phenomenon.

In the last years, these two topics have been the subject of an intense debate between reductionist scientists asserting that they are nothing but a special kind of phase transitions, and on the other side anti-reductionist scientists and philosophers asserting that they cannot be described by the available physical theories of phase transitions leaving aside the active theoretical role, and not just as source of relativism, of the observer.

However, we point out ow as a number of features understandable as typical of emergent phenomena, depend indeed on the adopted observational time scale. Let us contrast, for instance,

- the sudden occurrence of a ferromagnetic state at Curie temperature is an example of emergent phenomenon;

and

- the evolution of reptiles in million years, intended as non- emergent phenomenon.

We notice how by adopting a time scale whose unit is some dozens of million years, the time trend of reptile evolution mimics the one of residual magnetization close to Curie point (Pessa, 2009).

In this article we shortly review some approaches (meta-structures, validity regimes, waves of complexity) suitable to effectively represent and model processes of emergence not reduced to changes of scale, but as autonomous process having specific properties. Such approaches may be intended as conceptual extensions of approaches for Cybernetics of the n^{th} order, with their philosophical meanings suitable as approaches to a General Theory of Change (Minati, Abram & Pessa, 2012).

In particular the theoretical incompleteness (in short, a presumed completability would be incompatible as considered by Gödel's theorems in mathematics and non-reducibility to procedures, algorithms of complex phenomena such as emergent collective motions) and quasi-ness (in short, properties non-homogeneously, irregularly applying in a context of equivalences and of variable predominance) of the approaches considered are suitable to give new (philosophical) meanings to Cybernetics of the n^{th} order (related to the recursive application of cybernetics to itself) in the field of complexity when ‘to regulate’ means ability to induce and to orient complex phenomena with the fundamental role, e.g., in the deterministic chaos, of weak forces, to be processed by systems as constraints to their structural dynamics and not only to be prescribed, imposed and applied as substitutive.

As the search for a General Theory of Change appears of utmost importance for the development of Systemics and of a *general theory of emergence*, we remark that the problems to be solved appear to be of conceptual nature. Rather than related to the observational scale only, researchers should consider new conceptual frameworks having significant philosophical

meanings and consequences, such as based on Multiplicity, Logical Openness, Theoretical Incompleteness, and Quasi-ness (see Section 3).
Traditional systemic approaches neglecting such features may be intended to adopt a sort of *restricted systemic view* unsuitable to outline a General Theory of Change. We need, rather, a *generalized systemic view* suitable for a General Theory of Change and to achieve the generality only set by the so-called Bertalanffy's '*General* System Theory' (Bertalanffy, 1968).

2. Two Cases of Generalized Systemic Understanding of Theoretical Change

We mention two cases as examples of some levels of representations that have no contents of relativism, such as depending on the scale considered when adjusting the focus used for the microscope and the time intervals considered. The level of representation considered is rather context-dependent; it dynamically changes depending on the phenomenon under study since dimensionless and self-established such as when considering automatic clustering processes and emergent self-established networks in social systems with multiple roles the same nodes.

2.1 Meta-structures

In particular, we consider processes of change as represented by the dynamics of properties of clusters of elements and by their intra-clusters properties (Minati & Licata, 2012). The focus is on clustering rather than on assumed separable entities. We consider a mesoscopic level of description rather than a microscopic or mesoscopic one (Minati & Licata, 2015). *We deal with a world of clusters*.

A cluster is an aggregation of elements that share a similar measured value for the same property, i.e., the measured values are within a threshold value *k*. Suppose the difference between the two measurements is less than a certain *k* value, they are considered as belonging to the same cluster, *considered as equal since equivalent, interchangeable within the cluster*.
We point out that *k* is not pre-established but contextually self-detected, instant per instant, to optimize the clustering. For example, in a population of interacting elements, such as birds of a flock, at the mesoscopic level, we consider aggregations, clusters of elements that have the same value at a given time:

1) Altitude;
2) Direction;
3) The maximum distance between them;

4) The minimum distance between them;
5) Distance(s) from the nearest neighbour.
6) Speed;
7) Topological position (as at the edges and in the center). Where 'the same' means within a maximum and minimum value.

Of these clusters, we consider the number of elements, the multiple simultaneous memberships of the same elements to various clusters, their changes over time, the distributions of elements within them (for example, how many are close to the maximum permissible value), and their possible interrelation properties (Minati & Pessa, 2018, pp. 113–114). Examples are clusters of molecules in a solution having similar thermal fluctuations; clusters of cars in traffic that cannot increase their speed (because they stop, slow down or travel at a constant speed because they are in a queue). We mention that we may consider *fuzzy memberships* stating the current level of membership not reduced to *0* or *1* (Chen, 2019; Miyamoto, Ichihashi & Honda, 2008; Salgado & Garrido, 2004).

By giving the rule of membership to a cluster, we identify aggregations that have their specific properties.

We stress that we have a single corresponding set of values per instant in cases 3, 4, and 7 listed above (there are only single max and min values and specific topological positions).

On the contrary, in cases 1,2,5,6 we may have more than one value at any instant when elements belong to multiple clusters related to the same parametrical values, that is, clusters of elements having the same speed-1, speed-2, …, speed-n, and so on for the altitudes, directions, and levels of closeness. The clustering is then on-going, dynamic, and context-dependent. Examples of the techniques used include processes of clustering, termed K-Means, K-median, and K-medoids (Aggarwal & Reddy, 2013; Boulis & Ostendorf, 2004; Everitt, Landau, Leese & Stahl, 2011).

This modelling approach considered in this section takes count of cluster and intra-cluster properties, termed *meta-structures*, 'meta' because of the clusters' incompleteness and variability, e.g., in number of components over time; in their non-regular, non-iterative occurrence; in number of shared elements belonging to them over time (Minati & Pessa, 2018, pp. 102–129; Minati & Licata, 2012; Minati, Licata & Pessa, 2013; Minati & Licata, 2013) as it is in collective behaviors (Minati & Pessa, 2006; Vicsek & Zafeiris, 2012); and in the non-regular occurrence of intra-clusters properties.

The approach has not the nature of relativism since it is self-tuning, i.e., based on the optimization of clustering.

2.2. Validity regimes, waves of complexity

The concepts of validity regimes and waves of complexity have been introduced (Minati & Pessa, 2018), pp. 127–128; pp. 265–266), based on inspiration from the concept of field in physics. While in physics, the discovery of electromagnetism introduced the opportunity to consider fields as *primary entities* rather than objects, we consider validity regimes (domains where interaction mechanisms apply) and their properties (domains where properties such as ergodicity and correlation apply) as *primary entities* of complex systems, rather than their phenomenologically interacting materiality (Minati, 2019a). *As we will see in the following, while in physics, the field specifies the admissible value at each point, the validity regime specifies multiple admissible behaviors as the validity of single interaction mechanisms and the validity of properties*.

The concept of validity regime may be intended to conceptually originate from the concept of domain (Minati, 2019a). When considering a single material entity, its domain may be intended as given by the space of admissible values that its degrees of freedom can assume in subsequent configurations. This view applies to the mechanical behavior of clock-like configurations of entities, e.g., engines, and, more generally, to *behaviors as selections* among equivalent states such as equivalent positions in a queue, in a crowd, and for fishes caught in a fishing net. Otherwise, the domain may specify multiple evolutionary equivalents and non-equivalent options available such as for a crumbling pile of sand and boids in a swarm. *The domain specifies at each point multiple admissible selectable options, states*.

The concept of the domain is intended tout-court, as a validity regime when no longer dealing with the admissible, possibly interconnected, selectable changes, status options, values, but to modalities and properties of changing. *The validity regimes specify at each point multiple, admissible, composable, selectable options of quasi-interaction machinery together with possible modalities and properties of changing, e.g., ergodic and chaotic*.

A simple example is a validity regime where single specific interaction mechanisms evenly apply, as is the case for the prevalent interaction machinery used for flock simulations (Reynolds, 1987). In this case, the interaction machinery consists of the application of three rules to the behavior of ‘bird-oid entities,’ i.e., bird-like (boids for short): *alignment rules* (the motion of individual boid points towards the average direction of locally adjacent components); *cohesion rules* (the motion of individual boid point towards the average position of locally adjacent components); and *separation rules* (individual boid control their motion to avoid collisions and crowding), as implemented in several simulators such as http://sourceforge.net/projects/msp3dfbsimulator/?source=directory accessed on May 2021.

We consider then properties of changing of an on-going validity regime when its dynamic configurations of validity and combinations evolve with properties, that is, they are properties of *any*, or more realistically, of *predominant* outcomes of quasi-interaction machineries.

Examples of such properties include the coexistence, variable predominance, and combinations of rules or topological-based interaction machineries and chaotic, correlated, ergodic, networked, polarized, remotely synchronized, and scale-invariant regimes

The validity regime specifies at each point the availability of a single or multiple interaction machinery and related properties.

We may consider in *n-dimensional* validity regimes the topological properties of their dynamics, such as of internal waves, as in (Kastberger, Weihmann & Hoetzl, 2010), (intended as dynamics of edges and property of accumulation areas) stating on-going changes, propagation, and processes of combination with other regimes of validity having the same or different dimensionality (reminiscent of the dynamics of multidimensional attractors). Validity regimes may be conceptually considered in correspondence with the phase space in physics.
The dynamics of complex, multiple, quasi-systems having multiple processes of emergence is intended to be represented by the dynamics of edges and transience between validity regimes. As an example, we mention ecosystems of entities when we do not consider the inferred multiple interaction machineries (Herbert-Read, Perna, Mann, Schaerf, Sumpter & Ward, 2011), but their distributed availability and compositional properties in the validity regime, their ways of occurring, topological distribution, and validities. We consider ecosystems of multiple, simultaneous, interacting transients among validity regimes inferring or representing their phenomenology.

This is a specific category of change. However, the same approach may be studied for suitable generalization to other non-interaction-based machineries, such as remote synchronizations (Gambuzza, Cardillo, Fiasconaro, Fortuna, Gómez-Gardenes & Frasca, 2013; Minati, 2015), behaviors belonging to the basins of attractors, long-range correlational and topological mechanisms, generating behaviors suitable to be specified by validity regimes. For instance, in restricted cases such as markets, areas of influence of advertising, epidemiological treatments, and defense.

On one side, the approach may have relativist aspects since the interaction machinery is inferred, and properties are detected, i.e., observer-dependent. However, this aspect is conceptually reduced by the theoretical availability of equivalent alternatives that are decided by the system that collapses from local validity regimes to another according to various reasons such as energetic, adjacency, and causality in phenomenological sequences of acquisition-loss-recovery of emergent properties, with variable predominance.

3. Philosophical Features: Multiplicity, Logical Openness, Theoretical Incompleteness, and Quasi-Ness

Since Newton's time, the world has been conceived and represented as constituted of matter intended as aggregations of elementary, i.e., unquestionably irreducible, distinguishable and separable, having fixed nature, – no mutations are allowed as, on the contrary, it is for phase transitions and for the duality of wave-particle – entities with *in addition* the interactions between them. It is a very simplified scenario, an elementary approach unsuitable for dealing with phenomena of complexity, complex systems in which multiple emergence phenomena take place down to and including quantum level (Blasone, Jizba & Vitiello, 2011; Sachdev, 2011).

We need to conceive, adopt and use in the daily language, such as in communication, control, decision making, design, education, envisaging, questioning, and reasoning new concepts, new philosophical understandings suitable to do not approximate, reduce complex issues. *This situation is going to generate a deep conceptual and philosophical separation between those who use advanced approaches in necessary homogeneity with the problems of their disciplines (how to do without them in physics, biology, cosmology, telecommunications?) and those who continue to use simplifications and reductions. Technocracies are expected to take the place of democracies in a highly manipulable context*.

Examples of concepts used in systems science and to be philosophically transformed, translated into the social culture are:

- Multiplicity contrasted with fixed, separable uniqueness, where uniqueness is replaced by variable, multiple, coherences (Minati & Pessa, 2018, pp.161–179).

- Logical Openness when, due to non-equivalent multiplicities, *modeling* may only consist of partial and redundant multiplicities rather than of *complete* models, and the strategy of being able to exhaust is ineffective (Minati & Pessa, 2018, pp. 47–51; Minati, Penna & Pessa, 1998; Minati, Penna & Pessa, 1996). Multiple non-equivalent models are required for the DYnamic uSAge of Models (DYSAM) (Minati & Pessa, 2018, pp. 201–204; Minati & Pessa, 2006, pp. 64–75; 2018, pp. 201–204; 30].

- Theoretical Incompleteness dealing with irreducible, analytically non-zippable, and non-completable incompleteness (Longo, 2011; 2019; Minati, Abram & Pessa, 2019; Minati, 2016) intended as phenomenological freedom of becoming (different from randomness) and quasi-ness of constitutive processes of emergence in complex systems.

- Quasi-ness of phenomena when properties are irregularly lost and recovered with variable predominance. When systems are not always systems, systems are not only systems, and a system is not always the same system (Minati, 2018; Minati & Pessa, 2018, pp. 151–160). Quasi-ness relates to different possible variants when, for instance, the interaction mechanisms non-homogeneously apply; it applies in different ways, with different parameters and at different times; different properties irregularly, but with predominant coherence, applies.

In such a conceptual framework, the cybernetic concepts such as control and regulation are generalized by considering incomplete, unstable, multiple, equivalent, and non-equivalent clusters of fields or regimes of validities, rather than single entities and of interactions in turn subject to the interactions of a higher order and are also understandable as interferences.

Philosophy has the task of generating new social imaginary, usable conceptualizations suitable for complexity. Classical paintings such as Michelangelo's Sistine Chapel in Rome; Dante Alighieri's Divine Comedy; literary classics such as Aristotle and Plato; book such as the Victor Hugo's Les misérables, Shakespeare's Hamlet, and thousands of other works have made us familiar with ways of thinking. This in the conceptual framework of a theory-less knowledge, theory-less Systemics (Minati, 2019b).

We need a new philosophy, new literature, new art, making us familiar with the thinking of complexity.

4. Conclusions

We considered the case of self-organization and emergence as a systemic context, to consider the conceptual, initial setting of a General Theory of Change. In this regard, we mentioned two possible approaches suitable for general and generic extensions to be considered: meta-structures and regimes of validity. Some generalizing crucial features are dealing with clusters rather than entities and regimes of validity as domains of properties related to the occurring of interaction machineries.

Such approaches require new understanding related to Multiplicity, Logical Openness, Theoretical Incompleteness, and Quasi-ness. Classic cybernetic features can be redefined in this context allowing new understanding and approaches. A General Theory of Change should necessarily have such properties rather than be disciplinary described (for instance, in physics *only*), be necessarily interdisciplinary multiple, logically open, theoretical incomplete and quasi. We may say a *general theory of interdisciplinary approaches* rather than a *theory of a general specific approach*, a new General System Theory (Minati, 2016; 2019c) as a General Theory of Change.

In this context, Cybernetics of the n^{th} order relates not only to the recursive application of cybernetics to itself but to different entities such as incomplete, quasi-clusters, and regimes of validity with a theoretical role of the observer.

Philosophy has the task of generating new social imaginary, new culture suitable to think in terms of complexity that cannot be relegated to technicalities and specializations.

Conflict of Interest

The author declares no conflict of interest.

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