Chapter 4
From Collective Beings to Quasi-systems

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This chapter is dedicated to explore among different post-GOFS systemic properties of different *nature* like ones considered above and based on the concepts of *quasi* already used in different disciplines since long time. The concept of quasi relates here to quasi-systems, quasi-dynamic coherence and the passage from Multiple Systems-Collective Beings to Quasi-Multiple Systems-Quasi-Collective Beings. The simplified idea assumed by GOFS to deal with systems *or* nonsystems is unsuitable and having reductionist aspects when dealing with complex systems and multiple phenomena of emergence, having structural dynamics and levels of coherence where DYSAM-like approaches are more appropriated.

We will elaborate the concepts of pre-properties, quasi-systems and related pre-properties, quasi properties, system propagation as environmental or field property and dynamic coherence for quasi-systems. We will consider the case of the cytoskeleton as typical example of quasi-system.

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Such quasiness asks for appropriated approaches such as network based and meta-structural.

4.1 Pre-properties

With the concept of pre-property, we consider the process of *acquisition* and eventually emergence of properties. There are several aspects that may be considered in such processes of establishment of properties when, for instance, *previous phases* or *states* are compatible, convertible, necessary, converging and of regular-irregular increasing strength.

Conceptually we may also consider correspondent *post-properties* in *degenerative* processes and the occurrence of incompatibility, inconvertibility, no necessity, instability and decreasing strength.

The concept of pre-property may relate both to properties to be *continuously acquired* through processes of emergence like coherence or eventually gradually *possessed* and to the *nature of the property* rather than the process of acquisition.

Our interest focuses here on the first case related to acquisition.

Differently from the concept of quasi-property introduced later and considered later as *structurally partially* possessed by a quasi-system in an eventual inhomogeneous and instable ways, a pre-property is to be considered as *implicit*, potential or *step* of an eventual process of acquisition.

For instance, *pre-openness* may manifest in quantum and classical ways (Schaller, 2014), through *irregular converging episodes* and *levels* of openness interesting a variety of specific properties of *different nature* like related to energy, matter, information, behaviour, cognition and adaptation, considered *less important* than ones determining the *status of system* like being anticipatory or its periodicity. Irregular episodes of openness may relate to properties assumed *irrelevant* for specific statuses of system like openness to light, thermal energy and vibrations, when their eventual openness is considered, for instance, given by environmental influences. Let consider, for instance, a *device* whose peculiar systemic property is its ability to *function*. Its functional systemic openness is its ability, for instance, to process in *fixed* ways external inputs, supply and having some capacity of self-regulation as context sensitivity. However the device may have some other pre-openness aspects such as related to the design and material used. The design, for instance, may allow the possibility for the *functioning* device to *materialize* previous *implicit* aspects of openness different from the ones related to the functioning like *structurally* adapt to external perturbations, e.g. thermal or mechanical, the possibility to be converted into another one allowing different *compatible* usage (s) and the possibility to set a different system of which the device is part. They can all be preceded by ways of functioning *compatible* with *reuse*. The subject of reuse is at focus in different ways like in architecture (Baum & Christiaanse, 2014) and connected with recycle (Morgan, 2009).

In the same way, *pre-synchronization* (see, for instance, for synchronisation Acebrón, Bonilla, Vicente, Ritort, & Spigler, 2005; Boccaletti, 2008; Pikovsky, Rosenblum, & Kurths, 2001; for pre- and post-synchronisation in information transfer see Szmoski, Ferrari, Pinto, Baptista, & Viana, 2013; for partial synchronization see Pogromsky, Santoboni, & Nijmeijer, 2002; Wagg, 2002; Yu & Parlitz, 2008) may manifest through irregular converging episodes and levels. For instance, the process of synchronization of fireflies is crucial for their collective coherent flashing being other variables, like orientation and topological aspects, irrelevant. On the contrary these aspects are crucial for spatial collective coherent motions.

The concept of pre-property may be intended even as *meta* (Pan, Staab, & Aßmann, 2012), since eventually *representing* sets of properties visited or acquired by the system over time by keeping *levels of coherence* (for instance, by considering per instant the quantity of coherent elements, the number of different simultaneous coherences and their relations interesting different and same elements, temporal durations of local or temporary coherences and possible properties of levels) while assuming *definitive* convergence to one specifically. The system may *converge* to a way, e.g. periodic, or *jump* from a property to another one in a region of a suitable theoretical *space of properties* eventually equivalent (see Sect. 7.2). However, at this point the system must select to explicitly acquire *one* of these properties. *We may say that pre-properties are differently convergent eventually to a specific property*.

This is conceptually different from quasi-openness as at the paragraph 4.3.

The concept of quasi-property, introduced later, relates to the nature and the structure of the property rather than the way of acquisition. A quasi-property is ***stable in its incompleteness*** (Minati, 2016). *A quasi-property is permanently, structurally quasi-property.* ***However an instant of a pre-property may coincide with an instant of a quasi-property***.

There is a large variety of possibilities to consider pre-properties such as when dealing with clues and multiple nonhomogeneously and noncoherently superimposed different properties assuming slow and irregular convergence to the dominance of a single one like for order parameters (Sethna, 2006). An example is given when considering the *hopping* itinerancy of neural activities between attractors as in (Marro, Torres, & Cortés, 2007). A very well-studied example is given by the so-called *self-organized criticality* (SOC) when dynamical systems have a critical point as an attractor (see, for instance, Pruessner, 2012; Turcotte, 1999).

Similar concepts may correspond to *degenerative* cases when *post-properties* are precedents to the disappearing of properties like in the case of *missing* of robustness, stability and fuzziness and acquiring malfunctioning.

Pre- may be intended as related to situations where several balances and coherences are possible. Metaphorically speaking, we may consider a continuous *drafting* when keeping the status of pre-property or when collapsing or converging consists of the acquisition of a property like for *unstable phase transitions* (Keskin & Ekiz, 2000; Lei & Leng, 2010).

As we will consider at Sects. '4.6 System propagation' and '5.4.1 Non-invasiveness', eventual abilities to act on pre-phases may be effective to act on processes of acquisitions of properties like acting on initial, boundary conditions, attractors and topologies of networks.

Cases of interest occur (Falkenburg & Morrison, 2014) when *areas* of pre-properties are equivalent or nonequivalent, and approaches DYSAM-like are necessary to deal with their occurrences when the system displays linearity and non-linearity, classical and quantum properties and simultaneous roles like for Multiple Systems (see Sect. 4.5.1).

This multiplicity[1] is at the core of the systemic nature of pre-properties.

The prefix pre- does not mean that the property is expected to necessarily convert into an explicit form, i.e. materializing into something possessing and representing it.

The pre- should be understood to take place when interacting or noninteracting configurations of entities and systems acquire a meaning or role independently from their current properties and the status of pre- is kept.

Examples related to a particular case by which we may represent pre- are given by ***statuses of dissipative systems*** *keeping far from equilibrium even if the equilibrium is the final status and converging in very different,* ***unique****, several ways. The subject relates to the possibility to act on, and usages of, the multiple pre-converging statuses or eventual* ***temporary*** *properties.*

We may have classical pre-properties and nonclassical pre-properties outlining a future, for instance, of classical *or* quantum properties, e.g. different superconductor materials at different temperatures, even double regimes like during some complicated transient dynamics between phases taking place when classical and quantum aspects mix (Parisi, 1998; Sewell, 2002) and structural regimes of validity as at paragraphs 3.8.5 and 7.1.2 occur.

However the case of our interest here concerns processes of pre-self-organization and pre-emergence differentiated as considering dynamics of self-organization and emergence at the paragraph 3.2.3.

Indeed, we may consider pre-properties compatible or incompatible with processes of self-organization and emergence. In case of compatibility, for instance, scale invariance and power laws are clues, compatible and even pre-properties.

The interest relates to the possibility to act on compatible pre-properties to facilitate or even avoid acquisition of self-organization and emergence.

We consider a similar case for ergodicity in Collective Beings at Sect. 4.5. We may also consider, for instance, pre-network, pre-meta-structural and pre-chaotic properties relating to aspects suitable to *converge* and even *diffuse* and *contaminate* the nature of other aspects and properties.

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[1] We like to recall here how some of the conceptual keywords we are considering here for a post-GOFS were introduced in literature by Italo Calvino in the book Calvino, I., 1988, *Six Memos for the Next Millennium.* Harvard University Press, Cambridge, MA, in this order: Lightness, Quickness, Exactitude, Visibility, Multiplicity, Consistency.

We specify that pre-properties may be not *necessary* for the establishment of properties or quasi-properties, since we cannot postulate any necessary convergence, continuity or homogeneity, while examples of *non-continuity* are given by phase transitions.

Configurations of properties occurring for any reason, like due to environment and occurrence of *defects* due, for instance, to aging, may establish a single or sequences of eventual pre-properties like *symptoms*. They may transform into *properties* or *quasi-properties* if becoming emergent or related to some structures like stabilized malfunctioning.

It seems like a situation where the system *explores possibilities* to be eventually assumed as points of trajectories of its *chaotic version* around attractors. The case may be considered for combinations of evolution and self-organization studied, for instance, by *Stuart A. Kauffman* (Kauffman, 1993). Instabilities of attractors act as *sources* for creating pre-properties to be eventually consolidated. ***It is a kind of creative processes for systems*** (see, for instance, in the case of Neural Networks, Thaler, 2012, 2014).

Lightness[2] *and non-invasivity introduced at* Sect. 2.2 *relate to the need to respect and facilitate this kind of creative process for complex systems respecting their implicit form.*

Pre-properties may be eventually *recognized* by using suitable approaches.

Pre-properties may be understood occurring at the early stage of establishment of processes of emergence. There is increasing research interest on levels of processes of emergence and on the transience between levels; see Chap. 7. We relate to the starting and final transience of a process of emergence when:

- Arising from pre-properties to subsequently become acquired emergent properties.
- Degenerating, i.e. partially loosing coherence and stability becoming firstly quasi-property and then past quasi-property, meaning that the direction of the process is towards degeneration. In this view an illness may be considered as *failed*, i.e. degenerated, recovery process and healing may be considered as degenerated process of falling ill.

However the dynamics may be much more complex than reduced to consolidative transitions *towards* properties or degenerative transitions turning away from properties. How do we eventually recognize and distinguish between the establishing of pre-emergent properties and pre-properties in general? A research approach is given by considering, for instance, their eventual network, meta-structural and ergodic *nature* as mentioned above.

Pre-properties can be explored by the system through assumption of configurations and roles. *Detection of pre-properties seems as detection of unvoiced potentialities or collapsing potentialities.*

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[2] See note [1] above.

An interesting case combining the two features of pre- and emergent properties is given when considering *collective intelligence* (Bostrom, 2014).

In this case the process of emergence is assumed to take place and be in progress by an *established collective behaviour*. The collective behaviour comes *first* being collective intelligence *implicit* potentiality within it, when modalities of collective coherent behaving may be intended as pre-properties of collective intelligence. Such pre-property may be activated, made emergent and collapsed by an external event like the detection of a predator for a flock or swarm. However, collective intelligence may be understood as an implicit pre-property, *potentially* given by multiple coherent structures. Actuation of potentialities is often given by fluctuations and perturbations as for *noise-induced phase transitions* (Horsthemke & Lefever, 2006). As a matter of fact, it has been observed how suitable noise intensities can give rise to *noise-induced phase transitions*, that is, phase transitions towards more ordered states which would be *impossible* in the absence of noisy fluctuations (see Carrillo, Ibañes, García-Ojalvo, Casademunt, & Sancho, 2003; San Miguel & Toral, 2000). It is interesting to note that the formalism used to deal with the effects of noise in spatially extended systems is very similar to that used in QFT (see Fogedby, 1998; Fogedby & Brandenburg, 1999; Mikhailov & Loskutov, 2012; Minati & Pessa, 2006, Chap. 5 and Chap. 6 of this volume).

Another example is given when the system *oscillates* among properties like symmetry, stability and dissipation. Many cases pertain pre-order related to assumptions, for instance, of symmetry.

Another case relates to *pre-disorder* when systems may oscillate between two types of disorder (see, for instance, Blavatska, 2013; Patel & Fredrickson, 2003):

- The *quenched* disorder, in which the parameters of the system are randomly distributed, but this distribution does not evolve with time.
- The *annealed* disorder, in which the parameters of the system are random variables which evolve however in function of the values of the state variables.

Pre-order is related to pre-phase transitions, pre-self-organization and when order or new orders can be acquired.

The *status* of pre-property relates also to *compatibility*.

First of all we may consider the scale, the *granularity*, e.g. temporal, at which we consider a process of emergence. Temporal sequences of a process of emergence at a suitable scale are coherent. However hypothetically there are no *prescriptions* for properties of the process occurring *between* (see Chap. 2, Sect. 7.1) two subsequent sequences when considered at lower scale, i.e. decreasing the microscopic level. The request of compatibility relates to *temporal extremes* where the process can start to lose and then reacquire the original coherence. In this case the process of *reacquisition* of the original emergence at the upper scale could be given by increasing compatibility with the original coherence when such increasing compatibility should be understood as pre-property at the lower scale. A conceptual example is given by considering frames of a movie as a collective behaviour. *Coherent continuity* may occur at a suitable temporal scale, while continuity and/or coherence may not occur at lower temporal or dimensional scale.

All this is an example of the conceptual world of the post-GOFS. Reductionism and GOFS both assume a ***world of skeletons*** *and that everything will be reducible to this level assumed* ***complete and explicit****.*

4.2 Quasi

We are going to use in the following the prefix *quasi*- already considered in a varieties of cases in different disciplines.

We will not present in details the several meanings and usages by limiting ourselves to consider the general *transversal* disciplinary meaning useful to consider in the following a real new generation of systems, i.e. quasi-systems.

It is interesting to consider that in the common language, the meaning of quasi is generally understandable as related to *non-completely* or *not yet* and *in the process of*.

4.2.1 Analogy and Metaphor

We consider in this section some aspects important to be clarified before to deal with the issue of *quasi*, i.e. logical inferences, like deduction, induction and abduction, and the concepts of analogy and metaphor. The process to make *analogies* is not properly a *logical inference*, like deduction, induction and abduction are. The process of *making inferences* may be understood as *generating conclusions* from premises (Pearl, 2000).

4.2.1.1 Deduction

Deduction is a kind of *inference* starting from necessary premises. Premises contain everything necessary to reach conclusions. Therefore, in a valid deduction, the conclusion cannot be false if all premises are true.

In the case of deduction, the most widely used rule is the so-called *modus ponens*.

A very simple example is:

- All the pieces in this box are black – rule (R).
- Those pieces come from this box – case (C).
- Therefore those pieces are black – result (Res).

4.2.1.2 Induction

Induction (Holland, Holyoak, Nisbett, & Thagard, 1986) is an inference, which from a finite number of particular cases leads to another case or to a general conclusion. Because of that, induction has probabilistic nature.

A very simple example is:

- Those pieces come from this box – case (C).
- Those pieces are red – result (Res).
- All the pieces in this box are red – rule (R).

4.2.1.3 Abduction

In the case of abduction a reasoning of this kind is adopted:

- The starting point is a collection of data D.
- The hypothesis H, if true, could explain D.
- No other hypothesis can explain D better than H.
- Then H is probably true.

There is a *hypothesis inventing process* that may be even viewed as a *selection* among the most suitable ones for explaining D.

With abduction, a process of *clustering* is carried out, grouping together variables that are most probably related (or, more precisely, that it is suitable to think they are): *Because B is true probably A is also true, since if A were true the truth of B would be obvious*. *Charles S. Peirce* defines his concept of *abduction* in the following way: ‘Abduction is the process of forming an explanatory hypothesis. It is the only logical operation which introduces any new idea (Peirce, 1998)’.

4.2.1.4 Metaphor

In short there is a metaphor when descriptions of objects or processes are used to describe another different one and one is described in terms of the other (Kovecses, 2010). The metaphor aims to introduce *hypothetical* representative identities.

It is matter to represent *something* not well known in terms of something else better known. The equals, ideals and hypothetical representations introduced by a metaphor can also be very misleading. For example, consider, as it really happened, the electric current as *flow*, the *flow* of time, the *flying* of thought and the *life* of a company. Neither the physical properties of fluid dynamics related to the flows of matter, nor of the flying, nor of the biological properties of living matter are applicable.

The metaphor does not suggest in fact *extensions of the same approach*.

4.2.1.5 Analogy

The process to make analogies may be intended rather as a kind of *incomplete induction* being, for instance, not *only probabilistic* but also related to variable clusters of properties for which to consider probability (Bartha, 2010; Gentner, Holyoak, & Kokinov, 2001).

When considering two entities A and B, an analogy between them is established in the case, for example, in which A possesses all the attributes a_n and B instead possesses attributes a_n, but not $\{a_k\}$, with $1 \leq k < C < n$, where C is the *level* of analogy. An analogy can then relate to the regularity of partial match or matches between properties of processes. It is a matter of using the partial representation of a process to represent another one. Afterwards a simple form of analogy is given by dynamics and shapes as keeping topological properties.

An analogy can then concern the partial correspondence or regularity of correspondences between properties of processes. For example, the dynamics of processes can be described by analytical representations having common properties such as growth, increasing growth and continuity as in the case of logistics.

This can then be detected not by the *whole* dynamics but only for special cases that recur with regularity, such as with periodicity. For eventual representations in phase space, it can instead be considered the *type* of attractors. It is a matter to use the partial representation used to represent a process to represent another one.

A form of simple analogy is then given by the *proportionality* between measures used for processes and shapes.

The *logical power* of analogy stays therefore in detecting partial matches.

We mention for completeness the concept of *analogue computer* operating with *directly measurable quantities* like electrical, pressure and motion, rather than symbolically (Saggio, 2014).

4.2.2 From Analogy to Quasi

The concept of quasi that we are considering here may be understood as considering *sequences* of analogies assumed related to the *same* entity or process. The quasi may be introduced also as *continuous analogy*. The concept of quasi intended as continuous analogy may be intended to occur when, in the definition introduced above, k is continuously changing both as value and with regard to properties.

The concept of quasi-property may be in some ways related to the huge category of fuzziness, i.e. *fuzzy sets, fuzzy logic and fuzzy systems* introduced by *Lofti Zadeh* (Klir & Yuan, 1995; Zadeh, Klir, & Yuan, 1996) where a fuzzy property may be understood to occur having different probabilities, levels of intensity or completeness.

We comment that the difference between *quasi* and *fuzzy* relates to the dynamical and ***structural incompleteness*** *of the first, real identity of the quasi, while the fuzzy relates to the well-defined, even probabilistic,* ***levels of belonging*** *along time*.

This structural incompleteness may be given by *inhomogeneities* of different natures well represented by quasi-properties considered at Sect. 4.4 and the case of Multiple Systems introduced at Sect. 4.5 when multiple belonging and multiple interacting are *variable*, i.e. irregularly interesting different clusters of elements along time and per instant.

The structural incompleteness does not relate to *converging* processes but to keeping such incompleteness as identity, as dynamics allowing, for instance, the changing of degrees of freedom between states as discussed above and sources of equivalences for processes of emergence; see Sects. 3.7 and 3.8.

We consider the *implicit* conceptual framework represented by the usage of the term *quasi* as suitable to apply and depict several of the new aspects of the *perspective* new, post-GOFS systemics considered in the previous chapters such as between dynamical coherence, non-explicit, systems identity, transient and uncertainty. Other aspects are, for instance, quasi-homogeneity, homology, iteration, openness, probabilistic, random, regularity and reversible. The list may include quasi-Turing machines, and we could explore *quasi-meta-structures*.

The concept may be extended, generalized by introducing one of the ***quasiness*** *intended as dynamical stability in possessing quasi-properties introduced later*.

The quasiness is a *generic* property, and eventual general approaches suitable to measure its degrees and compare its levels are difficult to be implemented and perhaps of doubtful effectiveness considering the dynamics that characterizes the property.

The ability to *formalize* is expected in a nonclassical way; see Chap. 5 – the quasiness is the challenge for the new systemics. It is not related to the becoming between states but to the *structural becoming*. Examples of structural becoming allowing quasiness are given by levels of emergence, properties as coherences and meta-structural properties and evolving multiple networks (see Chap. 7).

4.3 Quasi-properties

In this section, we will consider the concept of quasi-property and some cases.

The term is used in cases like *quasi*-classical, concave, ergodic, homogeneous, lattice, Newton methods, particle, periodic, quantum, species and zero.

A typical example is given by quasi-crystals (Janot, 2012; Varn & Crutchfield, 2015) possessing an ordered but not periodic structure. There is not translational symmetry as in crystals.

A non-emergent, i.e. established by functional and structured interactions, or emergent-acquired systemic property may be:

1. Stable and regular.

2. Unstable, having regularities, local and eventually partial.
3. Part of a stable or dynamical mix of stable and unstable properties.

Quasi-properties are intended to occur for cases 2 and 3.

Examples of *systemic* quasi-properties are given by:

- Quasi-openness, when the property is, for instance, temporally *unstable*; *partial*, i.e. dynamically relating to some aspects of the system like energetic, input processing; and *local* like relating to some subsystems or eventual structures only. In the same way, we may consider properties like quasi-order and quasi-autopoietic.
- Quasi-emergence, when there is, for instance, coexistence of emergence and organized systemic properties being the mix and the sequences of any kind. Examples are given by biological collective behaviours where living agents combine emergence and structures and collective behaviours *with leader* as for migrations (Guttal & Couzin, 2010). The same may be considered for quasi-self-organization. Other more generic examples are given by social systems like corporations, families, hospitals and schools continuously combining in different ways and time global structures and local emergences.
- Quasi-coherence, taking place when there is the occurring of multiple non-synchronous coherences and as properties of subsystems.
- Quasi-network, when links among components assumed to become *nodes* are not connecting all the components or links are unstable.
- Metastability where different stabilities are possible, see Sect. 4.4.1.

Besides with regard to the example of *pre-disorder* considered in 4.1, we may have *quasi-disorder* when the *quenched* and *annealed* disorder occur partially, in inhomogeneous way and relating to some aspects of the system only.

Furthermore quasi-scale invariance may relate to phenomena where scale invariance is not *global*, as in case of local scale invariance (LSI), see (Henkel, 2002) and multiple scale invariance in turbulences (Lesne & Laguës, 2011).

We mention that a different meaning occurs for *quasi-analytic class of functions* when if two functions of the class coincide *locally*, e.g. on an interval [*a, b*] on the real axis, then they are identical. *Local* coincidence means equality of the functions in the interior of entire interval (Beurling, 1989).

An instant of a quasi-property may coincide with an instant of a pre-property.

We may summarize as in Table 4.1.

4.4 Quasi-systems

We may first of all ask ourselves if the status of quasi-system is *coincident*, as necessary and sufficient condition, with the possession or acquisition of quasi-systemic properties. We may tentatively distinguish among some cases. For instance:

Table 4.1 Pre-properties and quasi-properties

Pre-properties	Analogue, compatible, converging, convertible, implicit, necessary, and of increasing strength. Related to space of properties having eventually properties. The concept of pre-property may be intended representing sets of properties visited or acquired by the system over time by keeping levels of coherence while assuming definitive *convergence* to one specifically.
Quasi-properties	Structurally partially possessed by a quasi-system in an eventual inhomogeneous and instable ways. Temporal, unstable, partial, i.e., relating to some aspects of the system, and local, i.e., relating to some subsystems only. Metastability. Structural incompleteness, real identity of the quasi.

An instant of a pre-property may coincide with an instant of a quasi-property and vice versa
They are different for their evolutionary paths: pre-properties are convergent, while quasi-properties are not

- A quasi-system may be given by a system when possessing dynamical structural aspects of instability due, for instance, to local or temporal *inhomogeneity* of its status of system. Correspondingly systemic properties will be local or temporal. For instance, a corporation may act as such, i.e. as a system, only during the working hours, and some departments may act as assembly lines, i.e. as structured sets instead than systems or just as sets depending on the tasks and environmental actions. An electronic system may be constituted of subsystems activated on request otherwise inactive structured sets of components.
- A quasi-system may be given by the *inhomogeneous* possession or emergent acquisition of systemic properties. For instance, an ecosystem may have different *levels of openness* depending on spatial location when some areas may be iced or shielded from light. A system may have openness related to different aspects like be open to energy but not to information and have such openness at different levels along time. A cognitively open system may have limited levels of openness such as ability to adapt but by using a limited selection of cognitive models. A biological system may have *dynamical interacting polipathologies*. A collective system may be able to acquire collective intelligence and assume intelligent behaviour only for specific events.

In the cases above, it is the ***nature of the system*** *making it to possess or acquire regular systemic properties as quasi-properties.*

We mention that forms of *degenerations* of Multiple Systems and Collective Beings may be considered examples of quasi-system when making reference to cases presented at Sect. 4.5.1:

(a) Agents may *simultaneously* belong to different systems.
(b) Agents may *dynamically* give arise to *subsequent* different systems.

The degeneration is intended to occur when agents do not belong anymore to *any* system, for instance, when in a flock a boid *becomes* isolated.

When considering quasi-properties, *it is the* ***nature of the properties*** *making the system as regular or quasi-system.*

Quasi systems ***convert*** *regular systemic properties into quasi-properties.*

Quasi-properties ***convert*** *a regular system into a quasi-system.*

In case of mix of regular and quasi-properties, (a) if possessed by a quasi-system, the quasi-nature of the system remains; (b) if possessed by a regular, i.e. non-quasi-system, its nature may vary depending on the mix.

It is possible to outline that future post-GOFS system research will concentrate on new issues and new concepts such as innovations in the concept of the system itself by considering, for instance:

- *Instable* systems, i.e. not being system all the time.
- *Partial* systemic properties such as local and eventually regularly or not regularly oscillating, when areas of the systems cease to have systemic properties for time periods or they lose their coherence, as because of drawbacks, perturbations and diseases in case of living systems.
- *Multiplicity* and its eventual related properties like varying along time, of systemic properties themselves.

It is matter of abandoning simplified dichotomous visions such as *systems* or *nonsystems*.

It is matter to apply also to systemics the concept of quasi not intended as *state* of incompleteness but as *structural* partiality, transience and multiplicity of properties that can be at different levels of diffusion and temporarily simultaneous or subsequent, similarly to the phase transitions of the first kind, like water ice vapour, where it is possible the coexistence of phases as opposed to those of the second kind such as paramagnetic-magnetic, where contemporary different phases are not possible. Other cases are given by multiple coherences, multiple emergences and dominions as at Chap. 7.

Even in these cases, the ability to detect *partiality* of properties, considerable as quasi, allows to detect the dynamics of properties and the possibility of directing them by identifying and facilitating evolutionary paths otherwise equivalent or identical.

Quasi-systems are understandable as systems ***in continuous structural becoming*** *eventually waiting for events to collapse, i.e. assume converging evolutionary paths and coherences when quasi-systems* ***transform*** *into systems. Conceptually it occurs when quasiness gives way for any reasons to structural stability and homogeneity of properties.*

When dealing with GOFS, the quasi is a limitation signal of incompleteness to be eventually fixed and *completed*. In GOFS the quasi is assumed as freedom where ‘request’ to *complete* in order to reach the expected single finality or equifinality may occur.

In the post-GOFS, the quasi is signal of complexity eventually in progress: it seems a kind of ***necessary condition*** *of continuous structural openness to acquire properties, i.e. complexity*. However, we may consider the quasiness even related to complexity itself in a sort of *levels of quasiness* like for *quasi-emergence*. These kinds of processes may be intended to take place from different points of view. For instance, it is possible to consider processes where a collective system *oscillates* between usual single-structured phases and phases characterized by different coherences not due to single structures. It may be understood as *keeping emergent the same coherence rather applying the same structure*. Quasi-emergence may be also understood to take place when there is simultaneity of structured interactions and self-organization like in institutions and corporations officially ruled by precise official regulations but occurring in reality by a huge variety of *modalitie*s often termed as *informal organization*. In such situations, it applies the term *quasi-emergent* since due to phenomena of different kinds.

Within a biological collective system under attached by a predator, a balance may occur between agents assuming behaviour maintained as collective and agents assuming individual escaping behaviour like for evacuation (see, for instance, Helbing, Farkás, Molnár, & Vicsek, 2002).

Other examples are given by the atmospheric system, ecosystems, social systems and economical systems of suitable dimensions and temporal scale having dynamical structures and properties.

4.4.1 Specific Forms of Quasiness

We list now some cases of kinds of systems having eventual *specific forms of quasiness*.

A first case considers systems far from the equilibrium such as *dissipative structures*. However, even if some analogies are possible between quasi-systems and dissipative structures, the property of quasiness is not necessarily due to dissipation and to keeping far from equilibrium but to structural reasons and dynamical coherences and may apply to a huge amount of properties other than thermodynamic. However, quasiness may be given by the fact that a system can be dissipative in different ways. Such ways and the related quasiness are represented by geometrical *irregularities* of trajectories around attractors and even by the nature of attractors (Mori & Kuramoto, 2011).

A second case relates to the so-called *disordered systems* (Klinger, 2013) where individuality is more important than general laws. Examples are given by (a) glasses where the composing elements are arranged randomly in space as opposed to ordered systems like crystals where the composing elements are arranged in stable patterns and (b) *spin glass*, magnet with so-called *frustrated interactions* displaying stochastic disorder when ferromagnetic and antiferromagnetic bonding is randomly distributed like in chemical glass. Accordingly, suitable approaches to model such systems are named *non-homogeneous*. The approach considered in this case is *non-homogenous* since elements are assumed distinguishable as opposed to the *homogeneous approach* when assuming single elements possessing identical features and then indistinguishable. In this case quasiness is represented by inhomogeneity.

A third case considers *metastability* (see, for instance, Slowik, 2012). The concept of quasi-systems is well represented by metastable systems having *local* *minima* called *metastable equilibrium states*. More properly, considering a system of non-linearly coupled non-linear oscillators metastability is intended as property of the system where there is the simultaneous tendency of components to function autonomously and a tendency to assume a coordinated activity. A classical nontrivial case occurs for phase transitions. For instance, in the *first-order phase transitions* at the onset of the transition, the new phase appears as very small nuclei (for instance, small crystals, fine liquid droplets, small vapour bubbles) which, as the transition advances, undergo a dynamical growth process. However, it could occur that, under suitable conditions (for instance, the absence of external disturbances, very slow heat liberation or absorption, absence of impurities), the phase transition cannot take place and the initial phase continues to survive, even after crossing the critical curve, in a situation which is no longer thermodynamically stable. This situation is named *metastable* when in the presence of suitable disturbances, the metastable initial phase disappears and suddenly a phase transition produces the new stable phase. A *metastable state* is represented by suitable stationary values, and metastable equilibrium states for dissipative structures are also called *far from equilibrium stationary states*. The quasi relates to the fact that the meta-stability is kept and not *solved* by selecting one of the possible phases. The quasi may relate to properties of eventual regular oscillations among metastable phases.

A fourth case relates to emergence when an emergent system is a quasi-system since being in reality considerable as *collection of compatible*, *equivalent*, as of acquired emergent properties, different quasi-systems. This relates to the fact that a specific process of emergence may occur in different ways, establishing a quasi-system acquiring the same emergent properties (and *identity* of the system like being a swarm, an industrial district or a network). As we will see later, this is the case for Quasi-Multiple Systems when coherence of collective behaviours is intended given by coherences among different equivalent emergent multiple systems rather than sequences of structurally fixed, i.e. non-emergent, systems.

4.4.2 Levels of Quasiness

It is possible to consider the level of quasiness of a system as the 'difference' of the system from its non-quasi *completed* version.

It is possible to consider *levels of quasiness* of quasi-systems by using some suitable quantitative approaches. It is possible, for instance, to consider the *percentage* per instant of composing elements (a) involved in specific systemic properties quasi-possessed or quasi-acquired, (b) following some structures and (c) interact in some specific ways. In this way it is possible to also delineate a kind of *history of the quasiness* of a quasi-system in analogy with the *history of usage* of degrees of freedom considered at Sect. 3.7 and as considered by using the mesoscopic general vector as at Sect. 3.8.3.7. The ways of changing of the quasiness of a quasi-system along time may be considered to represent processes of acquisition, starting and even degeneration of self-organization and emergence at suitable scale. The *level of quasiness* may signal and correspond to critical phases of processes of self-organisation and emergence allowing to prevent, for instance, degeneration and disintegration. The availability of suitable data and approaches allows, for instance, detection of *critical points* in collective behaviours by distinguishing *physiological* quasiness when some elements definitively or temporally abandon the collective behaviour and when a process of disintegration is ongoing. Quasiness may assume aspects related to its eventual network representation like for diseases (Ki et al., 2007).

We should ask ourselves which are the eventual *relationships between quasiness and identity* as introduced in Sect. 3.5. Which levels of quasiness are compatible with the keeping of the same identity, and which one can be considered the breaking level? The first cases that come to mind are related to fault-tolerant systems, resilience and *robustness* of processes of synchronizations. Robustness here should be understood as acceptable quasiness keeping identity of the system.

However, the interest here is to consider properties of the changing of *physiological* quasiness as related to the *nature* of the system rather than its robustness. History of the system's quasiness and its structural changing (for instance, from relating percentages of elements to percentages of rules of interaction used, and so on), it will tell about the *structural change of the system* and its coherences rather than about the *change of the same system* as for structural changing; see Chap. 3.

Quasiness relates to ***balances*** *between coherence and incoherence, while levels of quasiness relate to non-perturbing or perturbing effects on such balances.*

Typical examples of such quasi-systems are biological living systems and ecosystems where the non- or low-invasive, light co-management allows the support of systemic identities, like life and health of lakes (e.g. against eutrophication) and mountains. Other well-known examples are given by social systems, e.g. organized criminality, and emergent quasi-systems where the levels of quasiness have cultural, economical, energetic, environmental and political aspects.

We conclude by saying that considering non-quasi systems looks at this point as a matter of ***simplification****. The reason to introduce all the concepts above about the subject of quasiness is to allow systems scientists to better carry out approaches and tools to act on such systems by considering, for instance, lightness as non-invasiveness. In the conceptual framework of the GOFS, these kinds of systems are* ***invisible*** *or reduced to usual systems. This is source of unsuitable, reductionist approaches like in biology when not deal with complex multiplicity of diseases and health* (Cesario et al., 2014) *and social systems.*

4.5 From Collective Beings to Quasi-collective Beings

Instead of Multiple Systems, we may consider multiple quasi-systems when (a) systems in play are quasi-system, their coherence is not homogeneous and variable, and (b) multiple interactions occur irregularly, and some elements may be not involved in the processes of interaction along time.

4.5.1 Multiple Systems and Collective Systems

The concept of *Multiple System* has been introduced in Minati and Pessa (2006, pp. 110–137) as coherent set of systems having components belonging to more than a single system. Similar understanding is considered for multiple networks where same nodes may belong to different simultaneous networks (Nicosia, Bianconi, Latora, & Barthelemy, 2013).

Multiple belonging to different systems is considered given by the occurring of multiple dynamical and context-sensitive combinations of single rules of interactions as introduced in Chap. 3 *generating, in this case, corresponding Multiple Systems*. While in some cases Multiple Systems can be effectively identified, as in the examples below, they can be *supposed* as modelling approach when dealing with collective multiple interactions.

Multiple belonging to different systems is considered ***also*** *given by the occurring of multiple dynamical and* ***contextual multiple contextual roles***.

The roles, states and actions have simultaneous multiple different *significances*. We consider simultaneous systems or sequences of systems when the same components can correspondingly play, both simultaneously and at different times, several, eventually interchangeable, *unintended multiple* roles and give rise to the emergence of different systems. This is the case when different components may be simultaneously part of different systems when they play *different independent roles*. Examples are given when the reaction of an organ while, considered as component of a living system, may also be a source of information when using diagnostic and regulatory techniques; the output of an electronic subsystem or component may be also a source of information for networking, regulatory and security monitoring system. Another example is given by networked interacting computer systems performing cooperative and shared tasks such as for the Internet. It is also possible to consider the case of the *counterpoint* music in Baroque music (de la Motte, 1981; Howen, 1992) with particular reference to *Canons* and *Fugues*. We consider the *multiple* roles of the same themes. For instance, in a Canon, a theme is *opposed* to itself: each one of the several voices performs a copy of the theme. Furthermore, a theme forms the basis for a Canon, when *each of its notes can take on different roles*, by having more than one single musical meaning in the mind of the listener.

We stress that multiple ***belonging*** *and interchangeable roles are in this case* ***passive*** *for components, while it is* ***active*** *when multiple interacting is selected by components.*

Collective behaviours may be intended as coherent superimpositions of different systems when same elements may simultaneously interact, for instance, by considering their distances, speed and altitude (see Sect. 3.8.2).

An interesting aspect of Multiple Systems relates to take in count *interchangeability* between interacting elements allowing to consider coherence of the emergent behaviour, for instance, as ergodic (Petersen, 1989; Walters, 1982). However, we need to consider also that the *same* system can be *both* ergodic and non-ergodic depending upon the time scale of the observer, as in polymers (Kotelyanskii, Veytsman, & Kumar, 1998).

It is possible to consider the ergodic behaviour of Multiple Systems by referring, for instance, depending to the phenomena under study, to *classes* of distances, speeds, altitudes, directions and prices of interacting elements.

We focus a little below on ergodicity because of its ***clarity*** *on considering the problem rather than for its applicative possibility to real cases.*

Migration of elements in Multiple Systems from one class to another one and simultaneously belonging to more than one is not *active*, but a matter of *belonging*, i.e. interchangeability of roles intended as belonging to classes; see Sect. 3.8.4.2.

Interchangeability of roles within collective behaviours can be considered represented by its ergodicity.

This is, of course, an idealistic simplified situation. We should, rather, consider different more realistic situations.

We may consider cases of *multiple ergodicity* related to the ergodicity of the values adopted by different state variables, e.g. speed, direction and altitude, and by different clusters as stated in Sect. 3.8.4. The degree of ergodicity is given by:

$$E_\varphi = 1/\left[1 + \left(X_\varphi\% - Y_\varphi\%\right)^2\right]$$

where we may consider $Y_\varphi\%$ as the average percentage of time spent by a single element in state S and $X_\varphi\%$ *as* the average percentage of elements lying in the same state over a given observational time and considering a system composed by finite, constant over time number of elements. The state shows ergodicity when $X_\varphi\% = Y_\varphi\%$ and the degree E_φ adopts its maximum value of 1.

This is assumed to occur for the *entire* system and the entire observational time in the assumption of complete ergodicity, while it may occur *dynamically* and per zones for quasi-systems and when ergodicity is not the *primary responsible* for coherence. The approach can be extended by considering *weak ergodicity* (Coppersmith & Wu, 2008).

The *ergodic hypothesis* states that, given an infinite time duration, the trajectory of the point representing the entire system in the phase space will pass through every point (or as *close* as we want to every point in the *quasi-ergodic* hypothesis) lying on the energy hypersurface.

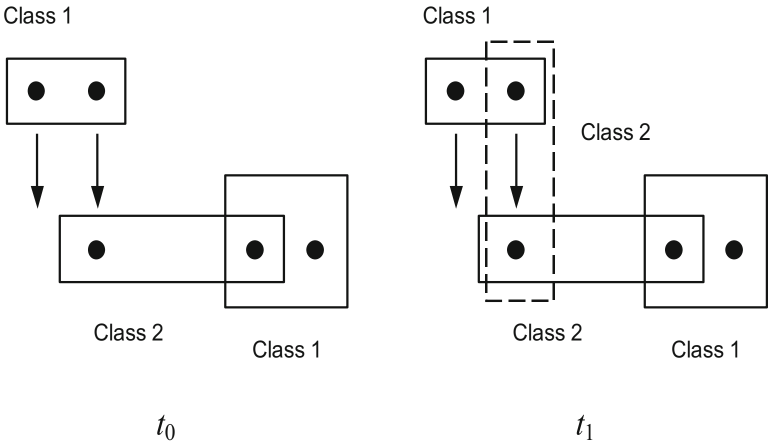

Fig. 4.1 By considering only two classes we have an example of multiple belonging from time t_0 to time t_1

Elements X_i may, for example, be represented as points in an n-dimensional space.

We consider a simplified situation which could occur in a two-dimensional space that could, for instance, be depicted as shown in Fig. 4.1 (Minati & Pessa, 2006, p. 304).

Multiple interactions are assumed to make elements to assume ergodic properties such as related, in this case, to distances. Ergodic is not the ***way*** *to interact but the effects of suitable multiple interactions.*

The *status* of Multiple System can be then considered both as *epiphenomenological* or related to the level of representation assumed by the observer.

Conversely, an *active interchangeability* becomes possible when interacting elements are *autonomous*, i.e. provided with a cognitive system possessing sufficient complexity to remember and respect *behavioural degrees of freedom*, and take decisions depending on the context and environmental conditions.

This is the case of *Collective Beings*, particular Multiple Systems established by agents possessing a (natural or artificial) cognitive system.

It is possible to identify almost two kinds of processes of *emergence of Collective Beings* from agents assumed possessing the *same cognitive system*, typically when belonging to the *same species* as for flocks and human beings:

- In one case agents interact by using the same cognitive model implying multiple roles, such as for collective behaviours.
- In other cases agents interact by simultaneously or dynamically using eventual different cognitive models.

The first case relates to contexts having *fixed behavioural rules* only admitting *parameterization*, while the second relates to contexts having *variables rules*.

Examples of the first case are given by flocks, swarms, herds and school fishes. Examples of the second systems are given by *human social systems* when:

(a) Agents may *simultaneously* belong to different systems (e.g. behave as components of families, working places, traffic system, buyers and mobile telephone networks). *Simultaneously* is related to the agents' behaviour, considering their simultaneous belonging, their roles in other systems. A buyer *while* buying also contributes to establish the system of buyers in the local store, performs a role for its family by selecting a product, performs a behavioural role within the facility and security system of the store and influences the local ecosystem.

(b) Agents may *dynamically* give arise to *subsequent* different systems, like temporal communities (e.g. attendance, lines and on a bus), in different times and without considering multiple belonging.

The collective interactions of Collective Beings allow them to collectively ***react****, i.e. cognitively and collectively make emergent their response behaviour.*

A scheme of Collective Beings is presented in Fig. 4.2 (from Minati & Pessa, 2006, p. 123).

We stress that Multiple Systems are both ***effective systems*** *as in the examples mentioned in the* Sect. 4.5.1 *and ecosystems, and* ***supposed as suitable modelling approach*** *since in several cases Multiple Systems considered above cannot be identified* ***analytically****, i.e. considering all the specific interactions used by agents per instant, because the problem is* ***intractable****, like for general collective behaviours.*

Another possible research approach to model in a more generalized way coherence of Multiple Systems and Collective Beings other than considering ergodicity and *level of ergodicity* is given when considering meta-structures and meta-structural properties as introduced above. However, as stated in Minati and Licata (2012), *any ergodic Multiple System possesses meta-structural properties* (see Sect. 3.7), while *any collective behaviour* may be intended to *possess meta-structural but not necessarily ergodic properties.*

Other representations and models not based on ergodicity are, of course, available. It is possible, for instance, considering scale invariance (Cavagna et al., 2010), network representations with related properties, models of artificial life (Bonabeau & Theraulaz, 1994), methods of theoretical physics in order to describe the emergence of collective behaviours as flocks (Darling, 1938), swarms (Bonabeau, Theraulaz, & Deneubourg, 1996; Lindauer, 1961; Millonas 1992, 1994), fish schools (Breder, 1954; Echelle & Kornfield, 1984), herds and ant colonies (Deneubourg & Goss, 1989; Deneubourg et al., 1991; Deneubourg, Aron, Goss, & Pasteels, 1990; Deneubourg, Goss, Franks, & Pasteels, 1989; Deneubourg, Goss, Pasteels, Fresneau, & Lachaud, 1987; Deneubourg, Pasteels, & Verhaeghe, 1983; Franks, Gomez, Goss, & Deneubourg, 1991; Goss, Beckers, Deneubourg, Aron, & Pasteels, 1990; Holldobler & Wilson, 1990; Millonas, 1992, 1994) and several other approaches like the ones based on partial differential equations. A general overview is available in Vicsek and Zafeiris (2012).

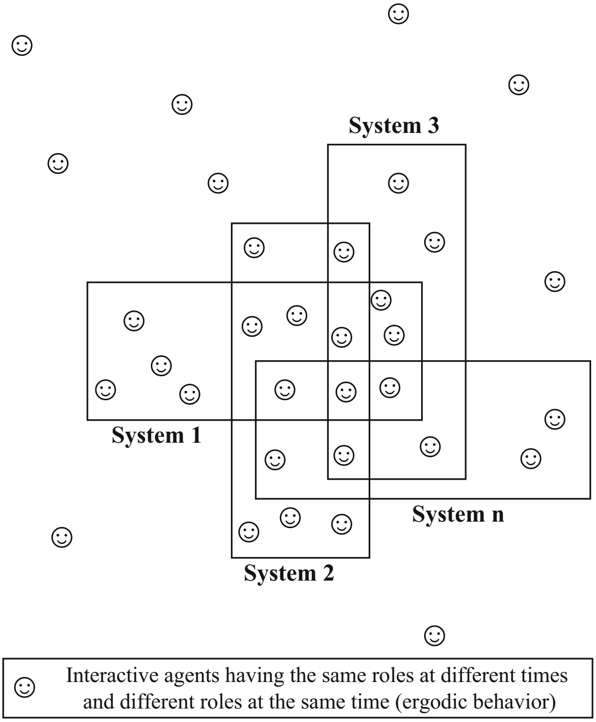

Fig. 4.2 Illustration of the concept of Collective Being

Several approaches are available to model and simulate collective behaviour like in (Bajec, Zimic, & Mraz, 2005, 2007; Couzin, 2009; Cucker & Smale, 2007; Cziròk, Barabasi, & Vicsek, 1999; Huepe & Aldana, 2011; Huth & Wissel, 1992; Quinn, Metoyer, & Hunter-Zaworski, 2003; Reynolds, 1987, 2006).

4.5.2 Interchangeability as Strategy

Dealing with the generic *defence* purpose, collective behaviour (see, for instance, Sumpter, 2010) can be understood as the implementation of the strategy of making roles and positions *equivalent* for the threat through interchangeability between interacting agents which take on the *same roles at different times and different roles at the same time* like in ergodic behaviour and for Multiple Systems and Collective Beings considered in the previous section.

Each component should be *equivalent* to each predator or external threat. The purpose is to divide the single probability of being the object of an attack or an external threat so that individuals have *minimized* the possibility to be involved (Krause & Ruxton, 2002; Pulliam, 1973).

Hypothetically, the larger the collective behaviour is, the minimum the probability for the individual to receive an external attack (for studies related to *density*, see, for instance, Ballarini et al., 2008).

On the other side, collective behaviours and their size increasing may *facilitate* the task to predators not interested in a single specific prey – the predator is not assumed to *select*. This is the case for *large* flocks.

Moreover, the larger is the flock, the more boids may detect the presence of threat. In the same way, when a group of boids is eating, the possibility to detect a threat compared to the one possible for a single-eating boid is higher (Anderson, 1980; Hemelrijk & Hildenbrandt, 2011; Pulliam & Caraco, 1984).

However, we must note that some competition may *noise* the group behaviour like competing for food or *polarizing*, i.e. degree of global ordering, when the flock detect food (see, for instance, Viscido, Parrish, & Grunbaum, 2004).

Collective behaviour may also allow assumption of *collective intelligent actions* allowing, for instance, the so-called *predator confusion* (Handegard et al., 2012; Jeschke & Tollrian, 2005, 2007; Krakauer, 1995; Olson, Hintze, Dyer, Knoesterm, & Adami, 2013; Tunstrøm et al., 2013; Vabo & Nottestad, 1997).

In case of collective behaviour, the possibility of *repeating* an *attacking* collective action, e.g. to sting or peck, or implement a *defence* collective strategy, e.g. herrings, reflect the light giving the predator the impression of being in front of a large being that is in reality collective. *High frequency of weak actions substitutes impossible strong single actions, moreover with the advantage of flexibility to adapt.*

Such flexibility is based on conceptual interchangeability.

4.5.3 Quasi-multiple Systems and Quasi-collective Beings

We mentioned in Sect. 4.5.1 how Multiple Systems relate to both effective systems and *supposed* as suitable modelling approach.

The concept of quasi allows more realistic modelling avoiding formal and rigid assumptions of general representations by using rule-based approach considered having general validity unless, eventually, context-dependent parameterizations.

The concept of quasi applies to Multiple System and Collective Beings when they are based on Quasi-Multiple Systems. Furthermore, multiple interactions may be quasi, i.e. occurring in partial, non-regular way when some of them may do not occur at all.

By considering the modelling based on ergodicity, we deal, for instance, with *multiple ergodicities* interesting different systems of the Multiple System or Collective Beings.

In these cases we deal with sequences of different *local* ergodicities changing over time and related, for instance, to specific interactions.

In this case *coherence among different ergodic multiple systems* may be modelled by using different approaches like considering synchronizations and networks.

A specific collective behaviour may be modelled as *resulting* from varieties of multiple, simultaneous *crossing* (*on* same agents) of multiple systems conceptually corresponding to the scenario depicted in Sect. 3.8.2.

A Quasi-Multiple System ***differs*** *from a specific Multiple System since it is composed by a variety of* **compatible possible multiple quasi-systems**. *This is the* ***light*** *version of the Multiple Systems.*

This is the case when systems establishing a multiple system are emergent (or eventual suitable dynamic combinations of equivalent, compatible, emergent and non-emergent systems) as at Sect. 4.4.1. In this case multiple interactions between same elements establish not only different systems as in the original definition of Multiple System but different emergent systems. In the latter case, *emergent systems are cases of a quasi-system* being in reality considerable as *collection of possible, compatible*, *equivalent* systems constituted by same elements.

Interchangeability, assumed for granted when considering ergodic models, is limited and *fuzzy* in these cases since equivalence relates to acquired emergent properties *only*.

Different *combinations* of such (emergent in this case) quasi-systems establishing Quasi-Multiple Systems may occur, *besides their coherence* considered later as given by properties of their single specific meta-structural or network properties, having the effect to optimise robustness, sensibility to environmental conditions and ability to reconfigure and to adapt.

We consider now *how to model such process of combination.*

We will consider in the following the level of quasiness of emergent systems, intended as Quasi-Systems for the reasons introduced above since they may emerge in a variety of equivalent ways, as given by their properties characterizing the varieties of equivalent different *ways* to emerge (coherent sequences of configurations of a flock are not unique, being different instantaneous configurations possible, compatible and equivalent for the global coherence).

Coefficients of scale invariance, network and meta-structural properties are considered to represent processes of emergence of collective behaviour. *Actually there are* ***different ways*** *and configurations by which* ***same property*** *of this kind may be respected.* Such different ways represent the quasiness of the emergent system, its being Quasi-System.

We may consider the conceptual correspondence with the approaches introduced in Sect. 3.8.4.

However the case under study here does not relate to the specific collective behaviour of a specific emergent system but to the collective behaviour of correspondent emergent systems, intended to *combine* in a Multiple System.

Approaches considered in Sect. 3.8.4 like the mesoscopic dynamics, see Sect. 3.8.4.7, and structural regimes of validity, see Sect. 3.8.5, are not considered here for *agents of the general collective behaviour* under study but for *single emergent systems having specific meta-structural or network properties*.

Because of that, the focus shifts here from mesoscopic properties of agents and meta-structural properties of mesoscopic variables to *properties of sets or sequences of meta-structural properties*. In conceptual analogy with the approaches introduced in Sects. 3.8.4 and 3.8.4.7, we consider here meta-structural properties rather than mesoscopic properties, *focusing on systems rather than on agents*.

At this regard it is possible to consider a collective behaviour as given by the behaviour and properties of a Quasi-Multiple System.

When considering the collective behaviour given by agents interacting in different ways as in Multiple Systems, we may apply the approaches introduced in Sect. 3.8.4 considering agents, mesoscopic properties and following meta-structural properties.

When considering the collective behaviour given by multiple single collective behaviours each establishing Quasi-Systems then combined in Quasi-Multiple System, we should consider the *properties of the single, emergent Quasi-Systems, like meta-structural and network intended as levels of quasiness. The reason by which we consider levels of quasiness of emergent systems as given by properties stating the coherence of the systems, e.g. coefficients of scale invariance, network and meta-structural properties, is that such properties may be respected by different, instantaneous systems playing equivalent, compatible roles in the process of emergence, which is quasiness.*

The general approach considered here focuses on ***levels of quasiness*** *and their properties, like periodicity, synchronization, correlation and properties of values assumed by the* ***meta-structural general vector*** *along time*:

$$\mathrm{MST}_{h,sn}(t_i) = \left[p_{h,1}(t_i), p_{h,2}(t_i), \ldots, p_{h,sn}(t_i)\right]$$

where

- h identifies one of the h meta-structural properties[3] possessed by the collective behaviour along the time of study.
- sn identifies one of the total number[4] of emergent quasi-systems established along the time of study.
- $p_{h,sn}$ takes the value 1 if the system sn possesses the meta-structural property h at time t_i or the value 0 if it does not.

The same concepts and approaches proposed above for Quasi-Multiple Systems applies when considering *Quasi-Collective Beings*, where Collective beings are

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[3] Same meta-structural property will be considered to give eventual rise to different meta-structural properties depending on different parametrical values.

[4] Since the multiplicity of emergent quasi-systems is here only *supposed* as approach and analytically unrecognisable in collective behaviours, their number should be also supposed as given by the number of meta-structural properties valid per instant and along time, however, considered *coincident* when differentiated only by parametrical values.

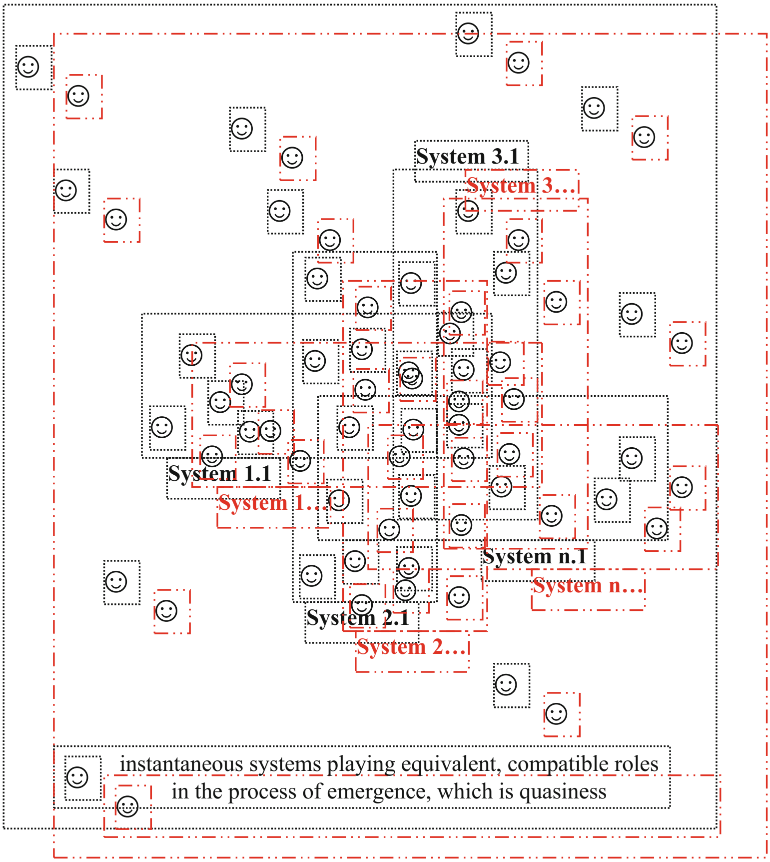

Fig. 4.3 Illustration of the concept of Quasi-collective Being

particular Multiple Systems established by agents possessing a (natural or artificial) cognitive system as introduced in Sect. 4.5.1.

We will not elaborate here the correspondence between the two cases. However we would like to mention how Quasi-Collective Beings are suitable to deal with collective and multiple behaviours of social systems.

Levels of quasiness, intended as properties that may be respected by different, instantaneous systems playing equivalent, compatible roles in the process of emergence, represent in quasi-analytical forms what is usually ***approximated*** *as statistical, probabilistic or generic freedom given by arbitrariness or relativity. This opens the possibility to use new approaches to orient and induce social emergence, with unfortunate possibility of* ***manipulation****, which in other forms there have always been, but also the possibility to* ***understand*** *them when in progress.* An illustration is available in Fig. 4.3.

The concepts introduced above should be considered typical of the post-GOFS as dealing with coherence, combinations (crossing and superimpositions), *compatibility, equivalence, emergence (as ubiquitous), lightness, multiplicity, non-causality, non-invasiveness, non-prescrivability, potentiality, quasiness and simultaneity.*

Suitable modelling should consider new approaches of formalization as in Chap. 5.

4.6 System Propagation

This is a daring tentative to conceptually introduce the hypothesis that the *status of systemic* intended as related to properties eventually of different levels possessed or acquired by any entity or *process* be not anymore considered as *only* and *mandatorily* given by active roles due, for instance, to *interactions* of any kind.

A first example is given by the establishment of *synchronicity* without explicit exchange of matter-energy like for remote synchronization (see p. 271), quantum phenomena and entanglement. Another example is given by network representations (see Chap. 8) where links represent relations among nodes that can be in their turn phenomena and systemic properties are represented by network properties like topologies, dynamics and emergence.

We are elaborating the suitability to consider the status of systemic as given, under suitable conditions, by properties, for instance, of the *hosting space* when a typical example is given by ecosystems.

The hosting space may in its turn have non-active and/or active properties as geometrical and as *environmental* and due to *fields* adding in active ways properties to *internal* elements, for instance, by supplying appropriated energy. We consider eventual properties of the hosting space such as geometrical and topological for networks.

The distinctions introduced above, i.e. between hosting space, environment and field, are a *simplification* introduced to fix the ideas, while real cases are given by different levels of their eventual dynamical combinations.

Propagation (Levis, Johnson, & Teixeira, 2010) and diffusion (Vrentas & Vrentas, 2013) are well-studied phenomena in different disciplines like physics, e.g. acoustic, electromagnetic, nanostructural, optical and seismic phenomena; chemistry, epidemics in medicine and sociology. Approaches to influence generic collective behaviours are allowed by the existence of *propagation rules* for propagating patterns of activities through the network of connections. This is possible by influencing the propagation of information, by modifying, confusing and applying *long-range interactions* (see, for instance, Barrè, Dauxois, & Ruffo, 2001).

The general idea is that forms of *status of being systemic*, like attitude to acquire systemic properties and assume a systemic behaviour, can *propagate*, could be *diffused* within the environment and hosting space, *emanated*, *induced* or even *transmitted* by systemic entities to other nonsystemic entities.

We consider the opportunity to introduce the subject by distinguishing between *propagation* of nonautonomous or autonomous systemic properties, i.e. possessed or acquired by systems provided or non-provided with cognitive system.

However, this eventual distinction is another simplification since processes of propagation, emanation, induction and transmission of forms of being systemic may overlap and simultaneously relate to different aspects of both nonautonomous and autonomous systems.

We will name, for short, the *status of being systemic* as *systemicity* having meaning different from the one of *being systematic*, i.e. methodical, repetitive and ordered.

We will try to tentatively consider structural properties of the hosting space as ***source or generator of systemicity*** (the conceptual inspiration is given by quantum entanglement) *when a* ***less*** *totalizing and invasive view is given by properties of the non-separable* ***environment****. We will consider the eventual* ***propagation*** *of systemicity.*

4.6.1 The Case of Nonautonomous Systems

A first example we mention is synchronicity. This relates, for instance, to dynamic clustering when synchronization is the source of their coherence (see, for instance, Boccaletti, 2008; Boccaletti, Kurths, Osipov, Valladares, & Zhouc, 2002; Ciszak, Euzzor, Geltrude, Arecchi, & Meucci, 2013; Mikhailov & Calenbuhr, 2002).

This may relate, for instance, to signals, energy availability and environment properties.

Another example occurs with order parameters as considered in Sect. 2.4 when dealing with the slaving principle used by synergetics.

The validity of a *network or meta-structural regime* is a further example of environmental-spatial systemic propagation when the *simple belonging*, e.g. *immersion into* and interaction within a systemic network or meta-structural environment-space, induces the acquisition of systemic behaviour transmitted through unavoidable interaction with entities previously possessing such network or meta-structural properties.

This is when elements of collective behaviours do not only interact but also propagate and diffuse in some ways properties of the interacting neighbour, i.e. by allowing forms of transitiveness.

When considering the collective behaviour established by nonautonomous elements, i.e. assumed not provided with cognitive system, we may take in count cases such as cellular automata, the climate system, protein chains and their folding, cell and bacterial colonies, objects on vibrating surfaces that tend to take consistent variations, autonomous lamps networks that tend to take consistent changes (Minati, de Candia, & Scarpetta, 2016) and the Internet (traffic signals).

As we mentioned above, geometrical properties such as symmetry and fractality may be responsible for acquisition of systemicity (Resconi & Licata, 2014) as well environmental with reference, for instance, to energy-light availability, information availability and possible distortion and noises.

Besides, another inspiring case, if not specifying the approach tout-court, is the vacuum curvature in QFT. As mentioned above and elaborated, Chap. 6 expressly dedicates to *theoretical systemics and quantum field theory*; thanks to the entanglement, no classical interactions are required to make entities interdependent. This relates to the unavoidable pervasiveness of the quantum vacuum or vacuums given by a variety of possible states of vacuum.

For instance, in the quantum vacuum, each perturbation causes the emergence of collective *long-range* excitations named Nambu-Goldstone bosons (NGBs) – see Chap. 6 – which coordinates the behaviour of individual components of the system, so as to keep *general coherence*.

Moreover the NGBs can interact between them, giving rise to the appearance of macroscopic entities (the so-called quantum objects), which in turn modify the behaviour of the entire system from which they originated.

4.6.2 The Case of Autonomous Systems

When considering the collective behaviour established by autonomous elements, i.e. assumed provided with *sufficiently complex* cognitive system, we may take in to account cases such as flocks, industrial clusters, industrial districts networks, markets and social systems such as cities, companies and families and individual living systems as human beings and animals.

At this regard in order to modify the behaviour of their possible collective behaviour and emergent acquired properties, it is possible to consider the approach based on *inserting* a collective behaviour *inside* the collective behaviour to be modified. We may call the inserted collective behaviour as perturbative collective behaviour (PCB) as introduced in Sect. 3.8.4. The PCB is not intended to *slave* (see Sect. 3.8.4.3) the previous one by looking to *substitute* its behaviour to the previous one. The purpose is to suitably influence in order to introduce emergence of a modified collective behaviour. Suitable strategies should be considered for such introduction. For instance, we may consider aspects such as:

- The (fixed or variable) number of agents establishing the PCB with regard to the number of agents establishing the collective behaviour to modify, i.e. which percentage?
- The *topology* and *distribution* (e.g. at borders, at the centre, regularly diluted, etc. and having suitable sequences and variations in time) of the PCB related to properties of the collective behaviour to modify.
- The difference between cases (a) when agents of the PCB are the *same* of the collective behaviour to modify and *mutating* their behaviour, i.e. their role and (b) when agents of the PCB are *new ones* emerging/materializing from the environment like fluctuations.

- The eventual *feedback* between the PCB and the collective behaviour to modify allowing the first one to change in number, topology and diffusion, allowing some kinds of *learning* when regulating depends on the expected modification to be induced.

The approach is even suitable for computational, simulated phenomena of emergence from nonautonomous systems and to be eventually considered for real cases. The approach can be considered when properties and effects of the PCB are not cognitively processed but reduced to suitable noises.

Furthermore we may then consider, *cognitive environments* settled by cultures, ideologies, religions, languages and cognitive models when hosting collective behaviours and phenomena of emergence established by agents, typically human beings possessing *same* cognitive system and *generating* cognitive models. The case does not apply to agents provided with *fixed*, nonevolutionary cognitive models like for simple animals having low cognitive abilities, e.g. learning, memory and representation.

Examples of the setting of *cognitive environments*, specifically related to *autonomous systems* when focusing on their cognitive processing, may be:

- The spreading out and usage of *analogies* – see Sect. 4.2 – and *metaphors* occurring when applying linguistic expressions proper to a phenomenon to other ones, e.g. the flux of time or the life of a company, in any kind of social interactions. When relating to systemic properties, this induces to practice cognitive correspondences helpful to assume levels of systems thinking.
- The usage of models based on requiring a specific property, like when a model of an artificial system *requires* a designer. If the same model is used, transposed to model natural systems, *then* the designer is required. An example is given by the solar system requiring *then* a designer (the solar systems is a system so it is assumed appropriate to ask *who* is the designer) unless one accepts the notion of self-organization.
- The *language* (Ellis & Larsen-Freeman, 2010) used. As considered in the literature, languages specify and limit our cognitive power and our designing space and represent and induce processes, contradictions and potentialities (Carroll, Levinson, & Lee, 2012; Sapir, 1929). It is possible to say that *we are our languages*. At this regard, *Lev Semyonovich Vygotskij* (1896–1934) wrote: ‘Thought is not merely expressed in words; it comes into existence through them’. (Vygotskij, 1986, p. 218). We need new words to establish a language able to *say* new concepts. Furthermore *Ludwig Josef Johann Wittgenstein* (1889–1951) wrote: ‘... to imagine a language means to imagine a form of life’ (Wittgenstein, 1953, Part 1, §19). However, it is not only a matter of words but rather of representation and of semantics by using modalities. *Systems thinking* is based on representing multiple correspondences, dynamics and coherences suitably represented by languages. For instance, *usage and focus* on linguistic expressions like control, decide, equilibrate, foresee, optimize, posses, regulate, separate, stabilize and solve will *facilitate* if not *induce* GOFS thinking. Other approaches are the ones inducing *familiarity* with ways of thinking, diffused by

huge varieties of cases like advertising; editorial products like newspapers, magazines and books; games and videogames; lifestyles; movies; tools, products and ways to use *propagating* concepts like 'the more is better'; and the concepts of functioning, planning and deciding, regulating and repairing and organizing and solving, assumed to apply to everything. This does not only open in general the doors to manipulation, but even worse it is a kind of *self-manipulation* limiting the cognitive evolutionary and emergent possibilities of social systems and forcing them to collapse into crystallized states than assuming new collective cognitive ability to make emergent *new social phases*, corresponding to new ways of thinking. At this regard we mention the following expression controversially attributed to Joseph Goebbels, Adolf Hitler's Propaganda Minister in Nazi Germany: 'If you tell a lie big enough and keep repeating it, people will eventually come to believe it'.

When considering social systems where autonomous agents are able to process information by using variable cognitive models, we may take in count the following examples.

The first example occurs when structural properties facilitate or even induce to act systemically, i.e. to interact in such ways suitable to establish systems. At this regard, it is possible to consider suitably *structured environments* able to induce systemic behaviour and acquisition of emergent properties by agents acting within and with such structures. With reference to human systems, it is the case for *architectural constraints* (see Chap. 10) able to induce acquisition of emergent properties by inhabitant agents. Any parent knows the influence of the decision to put their children to sleep in separate or single rooms. The subject concerning architectural constraints has different applicative significances regarding, for instance, the *induction* or *disrupt* of the coherence of behaviours related to a variety of kinds, like criminality, formation of traffic, hospitalization, safety at work, way to dwell and way to visit a location, as dealt with by a huge bibliography, like The Behavioural Design Lab, Alexander (1979), Eisenman and Lacan (2006), Fairweather and McConville (2000), Federal Facilities Council (2002), Geddes (1915), Hillier and Leaman (1974), Marshall (2009), Minati and Collen (2009), and Sundstrom, Bell, Busby, and Asmus (1996).

Another related interesting example takes place when interacting *within networks*; see, for instance, Motter and Albert (2012), Valente (2012).

A final example takes place when considering *virtual structures* given by the *way to respect* degrees of freedom as real structures. It relates, as introduced above, to modalities to respect and use degrees of freedom. While such ways and modalities are considered to establish *histories of usages* and related *profiles*, e.g. markets profiling users and buyers, it is a kind of virtual, *dual* structure. In this case the dual structure may be, for instance, physical, economical, juridical, linguistic and musical.

With regard to different well-known aspects of *diffusion* studied in physics like for substances, gases, reaction-diffusion systems and dissipation through diffusion, and in social science, we would like to consider here the concept of diffusion related to behaviour as a special form of process of acquisition of collective behaviour. We should take in count the *diffusion* or spread out of a specific behaviour through processes of *positive feedback* phenomena; like when in stock exchange, the more stakeholders sell, the more they sell.

However, we may refer to behaviours induced by specific suitable, in time and quantity, micro-behaviours like the *collective escaping* of birds from the ground when some of them escape and reach a critical point in quantity or synchronization. This is also the case of emergency for crowd, queues or collective escaping from context where the reason to escape is relegated in a reduced area like partial structural failure and partial flooding.

We conclude this section mentioning that the implicit propagation and diffusion discussed above should also be considered within a more theoretical framework allowing, for instance, to consider ***levels*** *of propagation and diffusion when* ***dynamics of levels*** *and their properties may constitute another hierarchically higher aspect like* ***ways to propagate*** *and* ***diffuse****. While the first level introduced above is not incompatible with GOFS, if not when dealing with collective, emergent aspects, the dealing with eventual further higher levels and long-range aspects is suitable for the post-GOFS.*

4.7 Quasi-dynamic Coherence

We already discussed the concept of *dynamical coherence* at Sect. 3.2.4.

While the case of dynamical coherence relates to multiple coherences, quasi-dynamic coherence, in correspondence with quasiness introduced above, relates to multiple *partial*, subsequent or even simultaneous different coherences.

Partiality may relate to local inhomogeneous assumption of coherences, temporal sequences of coherences, non-regular sequences of coherences and different *levels* of coherences.

The general property of quasi-dynamic coherence could be interesting during *transience* when *establishing and acquiring* coherences, losing coherences during processes of *degeneration* and when an unstable mix takes place setting a metastable situation as pre-property to be eventually suitably collapsed.

Quasi-dynamic coherence should be intended as the name of the *place* where the game of assuming coherences is open. It is the name of incomplete, irregular and potential coherences in progress waiting to be *confirmed*, i.e. to become convergent *pre-coherence*, in a space of eventual temporal equivalences.

Metaphorically we may say that *it is matter of analogies between analogies*.

The setting of quasi-dynamic coherence could be intended as a way to introduce *possible future properties of the becoming*.

This is the case when considering validity of multiple, partial network or meta-structural regimes.

Real applications seem suitable for non-yet collective behaviours, as for populations of elements collectively interacting but do not establishing a collective behaviour *yet*, e.g. the Brownian motion and crowd.

Processes of quasi-dynamic coherence establish the *place* where metastable interaction is open to a variety of possibilities, and we should have suitable approaches to orient and facilitate emergence of the desired behaviour.

Quasi-dynamic coherence may keep as such indefinitely or eventually turn into pre-coherence, i.e. when quasi-dynamic coherent configurations become ***convergent*** *to a specific, stable or instable, coherence.*

An important step should be the ability to transform an established coherence into quasi-coherence and then quasi-dynamic coherence (dismount an established coherence) in order to *reopen* the game and make the system to select new levels of coherences. This is crucial, for instance, for biological dynamics when *illnesses* could be interpreted as unwilled, pathological coherence or incoherencies, social systems and probably for cognitive processes.

Like first-order cybernetics was conceptually related to ***play a game****, i.e. apply a specific rule-based coherence; the second-order cybernetics was related to change coherence, i.e. invent a new game; here the point is to set* ***how*** *to play by setting new environmental scenarios and ways to use and invent new possible rules.*

We may say that quasi-dynamic coherence may break an establishing coherence keeping coherence as general framework and be ***incubator*** *where different coherences are attempted, metaphorically* ***proposed*** *and from where an emergent different coherence may emerge.*

4.8 The Cytoskeleton as Quasi-system

With reference to the active behaviour of the cytoskeleton (Jülicher, Kruse, Prost, & Joanny, 2007), theoretical aspects of the framework introduced in Sect. 3.3 and related to modelling, we consider the following other aspects useful to show the suitability to consider the cytoskeleton and the model considered as example of quasi-system.

Based on the research of on the quantum processes that take place in microtubules (see, for reviews, Craddock & Tuszynski, 2010; Tuszynski et al., 2005), the activity of each microtubule was described by a quantum Markov process constant over time (see on these processes Mülken & Blumen, 2011), governed by interactions with the output of microtubules spatially close but in which the output of the signal produced by the microtubule considered takes place in a time that depends on the length of the microtubule same. This length is considered to be variable, as it occurs in real microtubules, and described by laws of variation already identified in the literature (see Baulin, Marques, & Thalmann, 2007; Deymier, Yang, & Hoying, 2005).

In addition to these interactions, unlike other models, it is also added to the interaction between microtubules and the intracellular fluid in which they are immersed. Actually, the latter is responsible for the formation in the liquid of coherent domains that can act as ‘temporary memory’ of information conveyed by the microtubules. Because of this, the liquid is represented as a system of interacting spin (representing the electric dipoles contained therein), with interactions between the nearest neighbours. As they have not been taken into account, the molecules of tubulin remained in the cytoskeleton after the disintegration of a single microtubule, since that recent models (see Glade, 2012) have shown that this fact is of secondary importance for the dynamic evolution of the system of microtubules.

4.9 Further Remarks

We mention how the problems and approaches mentioned in this chapter may be considered relating to a classical conceptual framework, the one of *uncertainty*; see Sect. 1.3.9 and 2.5.

On one side it is assumed in the literature that the regularities in nature occur represented as *statistical trends*.

Moreover, the concepts elaborated in this chapter, like pre-properties, quasi, quasiness, quasi-dynamic coherence, quasi- properties, quasi-systems and system propagation are intended to *specify* uncertainty, to be *cases* of uncertainty when uncertainty relates to the multiplicity and levels of coherence of phenomena of collective interaction.

Uncertainty of coherence represents its *open valence*. Can we *generalize* the study of uncertainty when related to such phenomena of collective interaction?

Can the *structural* quasiness of Quasi-Collective Beings be the suitable place to study such eventual forms of generalization?

Can properties of levels of coherences of sequences of collective interactions be described by a single general theory able to deal, for instance, with super-coherences and super-analogies?

It looks as a chapter of the post-GOFS.

Box 4.1: Order Parameter

When complex systems undergo phase transitions, a special type of ordering occurs at the microscopic level. Instead of addressing each of very large number of atoms of a complex system, Haken (1988) has shown, mathematically, that it is possible to address their fundamental *modes* by means of *order parameters*. The very important mathematical result obtained by using this approach consists in drastically lowering the number of degrees of freedom to only a few parameters. Haken also showed how *order parameters* guide complex processes in self-organizing systems.

(continued)

Box 4.1 (continued)

When an *order parameter* guides a process, it is said to *slave* the other parameters, and this slaving principle is the key to understanding self-organizing systems. Complex systems organize and generate themselves at far-from-equilibrium conditions:

> 'In general just a few collective modes become unstable and serve as 'order parameters' which describe the macroscopic pattern. At the same time the macroscopic variables, i.e., the order parameters, govern the behaviour of the microscopic parts by the 'slaving principle'. In this way, the occurrence of order parameters and their ability to enslave allows the system to find its own structure' (Graham & Haken, 1969, p. 13).

> 'In general, the behaviour of the total system is governed by only a few order parameters that prescribe the newly evolving order of the system' (Haken, 1987), p. 425.

In Sects. 3.8.4.3, 3.8.4.5 and 5.3.3, we considered as order parameter a suitable Perturbative Collective Behaviour (PCB) to be inserted *within* another collective behaviour in order to *induce* desired changes.

Box 4.2: Ergodicity

The terms *ergodenhypothese* and *Ergode* appeared in papers published by Boltzmann in 1871 (Boltzmann, 1871) and 1884 (Boltzmann 1884a, 1884b).

The theory is behind classical statistical mechanics.

The *ergodic hypothesis* states that, given an infinite time duration, the trajectory of the point representing the entire system in the phase space will pass through every point (or as *close* as you want to every point, in the *quasi-ergodic* hypothesis) lying on the energy hypersurface. The relationship, or *trade-off*, between time and space comes from the fact that an average value, for the location of the point representing the system, determined by following its successive positions over time, will be the same when the average value is calculated over an ensemble of different points, representing different systems, at a single instant of time, provided they lie on the same energy hypersurface.

Sampling at a single time instant across an ensemble of different copies of the same system is equivalent to sampling through time for a single system: that is the notion contained in the ergodic hypothesis.

The *Gibbs Postulate* about *time evolution and ergodicity* introduced by the theoretical physicist J. W. Gibbs (1839–1903), states that, *in the phase space*,

(continued)

Box 4.2 (continued)

all states in the microcanonical ensemble are equivalent, in the sense that they have the same probability of occurrence.

The assumption behind the Gibbs postulate is that after a long time, every system will ‘forget’ its initial conditions. In other words, the *probability of each microstate does not depend upon initial conditions.*

Let us assume system monitoring involves a single, particular, behavioural feature F, which will be assumed to be associated with a finite number of different possible states F_i. For each of these states, let us assume that our monitoring (over a given observational time) of a system, containing a finite (and constant over time) number of elements, gave the average percentage of time spent by a single element in state F_i as $y\%_i$ and the average percentage of elements lying in the same state as $x\%_i$.

The state shows ergodicity when $x\%_i = y\%_i$.

Referring to population dynamics, it means the *if* ***x****% of the population is in a particular state* ***S*** *at* ***any*** *moment in time, and* ***all*** *subpopulations spend* ***y*** *% of time in that state, the system is ergodic when* $\mathbf{x\%} = \mathbf{y\%}$ (Cornfeld & Fomin 1982; Minati & Pessa, 2006)

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The Behavioural Design Lab-Combining behavioural science with design-thinking to help organizations tackle big social issues Available at the web site http://www.designcouncil.org.uk/our-work/insight/behavioural-design-lab/