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The Complexity of Self-reference
A Critical Evaluation of Luhmann's Theory of Social Systems

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DIPARTIMENTO DI SOCIOLOGIA E RICERCA SOCIALE

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1. Introduction

During the past fifty years, the idea has been frequently advanced of connections linking wholes and their parts, generating loops that tie together parts and wholes in such a way that the fragmentation of the whole always implies loss of information. To mention only some authors, Bateson, Capra, Hofstadter, Luhmann, Maturana, Rosen and Varela are advocates of this idea. These parts-whole connections form what we shall call 'hierarchical loops'. When parts pertaining to a hierarchical loop are separated from their whole, they behave differently (and *may* have a different nature) from the way in which those same parts behave within their whole.

Hierarchical loops must be carefully distinguished from horizontal loops. The latter are well-represented by feedback and autocatalytic cycles, where elements of the same kind interact with each other. Non-linear phenomena mostly rely on horizontal loops.

Unfortunately, the above-mentioned scholars – with the remarkable exception of Rosen – do not usually distinguish as sharply as necessary between horizontal and hierarchical loops. This unfortunate state of affairs – quite typical, however, of newborn, still unfolding ideas – has contributed to obscuring the scientific importance of hierarchical loops.

The present *Quaderno* focuses on Luhmann's contribution to the theory of hierarchical loops, and the wholes to be analyzed are *social systems*.

Before at least some of the details are presented, a preliminary outline of the underlying main problem addressed by Luhmann will be useful. The shortest answer to this problem – "How is a society at all possible?" – while correct, is nevertheless too short to be helpful. To give some exploitable benefit, this answer must be 'unpacked' to some extent. The following two pieces of information are helpful.

First, Luhmann constantly developed his theories from within a systemic perspective. The above question should therefore be reformulated as "How are *social systems* at all possible?" This reformulation makes Luhmann's basic question more determinate, because it explicitly refers to both the *general* categorical framework to be exploited to provide an answer, namely general systems theory, and the *specific* types of systems that are under analysis: *social* systems.

Second, while social systems raise many problems which warrant study, one of them is so central that its clarification is required if a reliable, robust theory of social systems is ever to be developed. This is the problem of the *reproduction* of a social system. 'Reproduction' here does not have the usual biological meaning of the generation of a new individual. Within the theory of social systems, reproduction should instead be understood as the capacity of the system to maintain its identity against the continuous flux of its members.

Luhmann is understood better as soon as his theory is seen as a step within one of the main strands in the evolution of sociological thought. Social systems are systems able to outlive their members – new individuals are born, others die off, yet others move from one social system to another. All these modifications notwithstanding, social systems show some kind of *stability* which, for the most part, is independent of the continuous transformation of the underlying set of their members. As said, this problem is called the 'reproduction' of a social system.

The most obvious answer to the problem of the reproduction of social systems has been provided by Pareto: the reproduction of a social system (its temporal continuity) is brought about by the reproduction of the individuals that happen to make up the system. As obvious as this answer appears, it nevertheless raises a problem. In fact, it was Parsons who realized that the reproduction of individuals cannot be assumed as a properly sociological category. While the reproduction of individuals can be seen as a *socially conditioned* problem as one wishes, it nevertheless remains an essentially biological affair. In order to avoid reducing social problems to biological problems, and in order to answer the question of the reproduction of a *social* system satisfactorily, one must find an authentically *social* type of reproduction. Parsons' answer was that the reproduction of a social system is provided by the reproduction of its (social) roles, i.e. by the reproduction of the patterns of action that are typical of that system. The reproduction of a social system is therefore the higher-order outcome of the reproduction of roles (patterns of action). This answer gives a much firmer basis to social theory. This is not the end of the story, however. Luhmann later came to realize that roles or patterns of action are themselves in need of a firm basis, because roles are implementations of perspective points, interests, values, and – more generally – of meanings. In its turn, the reproduction of roles implies the reproduction of their meanings. In short, the reproduction of a social system is grounded in the reproduction of meaning.

The following points may clarify the discussion thus far:

- The Pareto-Parsons-Luhmann series clearly shows an increasing transition towards higher levels of abstraction. In order to find better answers to earlier proposals, sociologists have had to delve into deeper and deeper waters.
- The process of reproduction does not imply lack of variation. On the contrary, reproduction is precisely the process that allows the generation of bounded (and therefore, possibly viable) variations.
- Parsons and Luhmann have detached the reproduction of social systems from their *material* bases. Both roles and meanings, indeed, are far from being material entities.

The last remark requires a further comment: what these scholars have shown is that the reproduction of social systems is not governed by the reproduction of their underlying material bases. Needless to say, "not being governed" does not imply "being existentially independent". Put otherwise, social systems do need a supporting material basis. However, the important result is that, once such a basis is somehow given, the reproduction of the higher system does follow its own relational laws. While neither Parsons nor Luhmann were able to deal with this major ontological problem, which can be properly articulated only within the framework provided by the theory of levels of reality [Poli 2001; 2007], they nevertheless had the merit of both raising the problem and disentangling some of its intricacies.

The *units* of meaning used by a social system for its reproduction are communications [Luhmann 1986]. Building on [Bühler 1934], Luhmann sees communication as essentially based on information, utterance and understanding. Information is the selection of what has to be communicated; utterance is the 'how' of the communication; understanding refers to what the *receiver* grasps from the previous two aspects of a communication. In more traditional terms, the first two components of communication can be read as its content and form. The real novelty comes with the third component: the understanding, which implies that "not the speaker but the listener decides on the meaning of a message" [Baecker 2001, 66]. For Luhmann, none of the three components *on its own* is a communication. Only the three components together form a communication. From this it follows that a communication can never be attributed to any one individual [Seidl 2005, 29]. Communications – as Luhmann defines them – are from the very beginning social acts. Moreover, communications can be accepted or rejected. This further aspect, however, is already part of the next communication. Communications generate further communications, which generate still further ones. For Luhmann, a social system is the autopoietic system of communication, where communication is the *unit of reproduction* of a social system.

The paper is organized as follows: Sections 2 and 3 sketch the evolution of systems theory and provide the basics of autopoiesis. Sections 4-7 present the aspects of Luhmann's theory of social systems that are relevant to our discussion. Section 8 introduces Rosen's (M,R)-systems. Sections 9-11 develop the theory of anticipatory systems and Section 12 briefly applies the theory to the problem of conflicts. Section 13 presents the idea of higher-order complexity. Finally, Section 14 calls attention to some of the underlying philosophical problems, and Section 15 concludes with a structural comparison between Luhmann and Rosen.

2. The Evolution of Systems Theory

The evolution of systems theory can be read in different ways. Here I shall adopt a structural viewpoint according to which the evolution of systems theory exhibits three main phases of development. The first phase in the evolution of the theory of systems depends heavily upon ideas developed within organic chemistry. Homeostasis in particular is the guiding idea: A system is a dynamic whole able to maintain its working conditions. In order to define a system, one needs (1) components*,* (2) mutual interactions; (3) the environment in which the system is situated, (4) a boundary distinguishing the system from its environment.

The main intuition behind this first understanding of dynamic systems is well expressed by the following passage:

> The most general and fundamental property of a system is the interdependence of parts or variables. Interdependence consists in the existence of determinate relationships among the parts or variables as contrasted with randomness of variability. In other words, interdependence is *order* in the relationship among the components which enter into a system. This order must have a tendency to self-maintenance, which is very generally expressed in the concept of equilibrium. It need not, however, be a static self-maintenance or a stable equilibrium. It may be an ordered process of change – a process following a determinate pattern rather than random variability relative to the starting point. This is called a moving equilibrium and is well exemplified by growth [Parsons 1951, 107].

The main result achieved by the first phase of development of system theory has been the proof that the system as a whole is defined by properties *not pertaining to any of its parts* – a patently *non-reductionist* view. Global equilibrium, say, is a property of the whole system, not of its parts.

The definition of a system as the whole resulting from the interactions among its components, however, contains a number of hidden assumptions. Subsequent developments of system theory have sought to address and understand these hidden assumptions. There follow the main assumptions hidden within the initial definition of a system:

- The first assumption is that all the system's components are given in advance, before its constitution. The underlying idea is that the system collects and organizes elements that are already there. We shall discuss this problem under the heading of the system's constitution.

- The second assumption places all changes on the side of the environment. What about systems able to learn and to develop new strategies with which to cope better with survival or other problems they may encounter? Systems endowed with this property will be called adaptive.
- The third assumption becomes explicit as soon as the problem of the historical continuity of the system through time is addressed. What happens when a new component enters the system or is generated internally? What happens when a component is no longer part of the system, or dies out? As we have already seen, this group of questions can be summarized as the problem of the reproduction of the system.

The overall outcome of constitution, adaptation and reproduction is complexity, although this of a type rather different from any of the mainstream conceptualizations of complexity [Poli 2009].

The first two assumptions have produced an extensive body of literature, whose main results can be summarized by distinguishing two different types of both constitution and adaptation. The two forms of constitution are the *bottom-up* type of constitution from components of the system (that are already available), and the *top-down* constitution from (a previous stage of) the system into its components. This latter form of constitution again assumes two guises: as constraints on initial conditions and the phase space of the system components, and as the development of a new organizational layer of the system.

In their turn, organizational layers are a structural condition needed by developing adaptive systems. In fact, an adaptive system needs both (1) rules governing the system's interactions with its environment and with other systems, and (2) a higher-order layer that can change such rules of interaction. These changes may be purely random, or they may follow pre-established, or acquired, patterns. In this regard, a hypothesis can be advanced which claims that the main difference between non-living natural systems on the one hand, and living natural systems, psychological systems and social systems on the other, is that the former have only one single organizational layer of interactions; the latter, more complex, systems have at least two layers of organization: the one governing interactions and the one capable of modifying the rules of interaction.

Furthermore, the persistence over time of living systems is made possible by *multi-stability* – a form of dynamic stability to perturbations that prevents the destabilization and rapid disappearance of such systems.

The third of the three above-mentioned assumptions is the most important one. Indeed, the unfolding of the third hidden assumption – the problem of the system's reproduction over time – has dramatically modified the entire landscape of system theory. The theory of autopoietic systems is possibly the best-known result connected with the problem of systems' reproduction. In this regard, it is worth considering that the theory of autopoietic systems is itself in need of further generalizations. The simplest generalization of these is well represented by Niklas Luhmann's theory of social systems. The second possibility is well represented by Robert Rosen, who some twenty years before the birth of the theory of autopoietic systems proposed what he called (M,R)-systems (from Metabolism and Repair), which subsequently developed into the theory of anticipatory systems [Rosen 1985]. As it results, Rosen's theory is both more general and more precise than the theory of autopoietic systems. In what follows, after a short description of autopoietic systems, I shall first sketch some aspects of Luhmann's theory of social systems and then present Rosen's proposal.

3. Autopoietic Systems

Autopoiesis is the capacity of a system to reproduce the components of which it is composed. A multicellular organism thus generates and regenerates the very cells of which it is composed; a unicellular organism generates and regenerates the components of the cell [Maturana & Varela 1980], [Maturana 1981].

Autopoiesis dramatically modifies systems theory. An autopoietic system does not start from pre-given elements, neither does it assemble them. Furthermore, autopoiesis does not come in degrees: either a system is autopoietic or it is not (in due time we will see why this is so). For an autopoietic system, the classic distinctions between system and environment and between closed and open systems acquire a new valence. Autopoietic systems are *self-referential* systems, meaning that the system's relational self-production governs the system's capacity to have contacts with its environment. Put otherwise, the system's connection with its environment is no longer a kind of immediate and direct relation between the system and its environment but becomes a reflexive relation, mediated by the self-referential loops that constitute the system itself.

As far as autopoietic or self-referential systems are concerned, the guiding relation is no longer the "system ↔ environment" duality, but the "system ↔ system" intra-relations, or automorphisms. For autopoietic systems, the classic difference between open and closed systems – where open means that the system's boundary is porous and lets both the system and its environment exchange matter and energy – acquires a new and different meaning: while *openness* maintains the previous meaning of exchange with the environment, *closure* now means the generation of structure, understood as the set of constraints governing the system's internal processes. Closure (or structure), then, organizes the system as a *holon*, or integral whole. The guiding connection changes from the system-environment connection to that between the system and its own complexity, understood as the system's capacity to adjust its own functional organization and internal structure.

4. Luhmann's Theory of Social Systems

Luhmann generalizes the theory of autopoietic systems to psychological and social systems. According to Luhmann, both psychological and social systems are autopoietic systems, i.e. both are dynamic, autonomous, self-referential systems able to produce their own elements. To tell the truth, Luhmann says very little about psychological systems and focuses almost all his efforts on the understanding of social systems.

We have already seen that Luhmann is better understood as contributing to an already ongoing strand of sociological thought. Taken at its face value, the Pareto-Parsons-Luhmann connection shows the evolution, internal to sociological theory, of the problem of the reproduction of social systems. To repeat: according to Pareto the temporal continuity of a social system (its reproduction) is based on the (biological) reproduction of the individuals that make up the system; Parsons moved to a properly social kind of reproduction and claimed that the reproduction of a social system is provided by the reproduction of its (social) roles (patterns of action); finally, Luhmann noted that the reproduction of the roles that structure a social system requires the reproduction or reconstitution of the meanings attached to those roles.

Apart from the evident increase of the level of abstraction shown by the three theories, quite a few substantial consequences derive from them. Here are some of the most apparent.

The three mentioned theories are more and more dynamically flexible. Biological reproduction presents such an overtly slow pace of change that we can leave it aside. More interesting are the other two cases. The social reproduction of roles, in fact, exhibits a pace of change remarkably faster than the pace of the biological reproduction of individuals. Parsons notes that roles form a system of roles in which they interact with each other. What is reproduced, therefore, is the system of roles and their mutual dependencies. Luhmann notes that Parsons' reproduction of roles contains a hidden assumption, namely that the meanings of the roles remain the same. Provided that the roles' meanings remain constant, the system of roles and their dependences admits only limited variations. On the other hand, as soon as one accepts that meanings are themselves in need of being reproduced, the system acquires a further degree of flexibility. To provide an obvious exemplification, consider family roles over the past few decades. According to Parsons, there is only a limited number of ways in which family roles can constitute the viable, stable subsystem 'family', and in which this subsystem can interact in a viable way with other social subsystems. By adding the layer of roles' meanings, Luhmann makes explicit the fact that the specific meanings of, say, being a father or mother change and these changes add new variations to the way in which family roles make up the system 'family'.

The second important outcome arising from the series of the three theories we are considering is connected to the question of the basic units of a social system. The question is: Of what is a social system made? Or: What are the elements that make up a social system?

The question is much less trivial than appears. Pareto's answer is the less surprising one: A social system is composed of individual human beings. Agents are the system's units of reproduction.

Parsons' answer, instead, is that *roles* are the units of a social system, not agents. Luhmann continues along the path opened by Parsons by adding *meanings* as the units of reproduction of roles.

To avoid mixing up different treads, it is mandatory to distinguish 'society' from 'social system'. As Parsons explicitly says,

> a society is composed of human individuals, organisms; but a social system is not, and for a very important reason, namely, that the unit of a partial social system is a role and not the individual (from the discussion between Ruesch, Parsons and Rapoport, as reported by [Grinker 1956, 328].

Note the explicit link between 'society' and 'organisms', which implies that 'society' is understood more as a biological than a sociological term.

The proposals of Parsons and Luhmann represent substantial moves towards a dematerialization of social systems. According to both Parsons and Luhmann, social systems are non-material systems, they are *relational* systems *over* a material basis. Neither of them denies that an underlying material basis is needed. The real nature of a social system, however, is not conveyed by its material basis. There is no way to understand what distinguishes social systems from other kinds of systems by studying the biological entities that happen to bear them or the physical environment in which they happen to be embedded. This is not to deny that *some* information may derive from biology or physics. The thesis instead claims that what is *specifically social* of social systems does not derive from other types of systems, biological or physical. In other words, social systems are higher-order systems organized in such a way that their reproduction is governed by the reproduction of properly social units and not by the reproduction of the units that characterize their underlying material bases. The reproduction of a social system requires *authentically social* units of reproduction. To repeat, this does not imply that social systems are entirely independent from their underlying material basis. They need a supporting material basis. However, the important result is that, once such a basis has somehow been given, the reproduction of the higher system does follow its own relational laws. Without this theoretical move, sociology cannot be constituted as a science. In the end, it is fair to acknowledge that neither Parsons nor Luhmann were able to spell out the details of this major ontological problem, for which the theory of levels of reality is needed [Poli 2001; 2007]. Occasionally, Luhmann himself speaks as if he were aware of such a theory, as when he notes that "by proceeding in the way he did, Parsons avoided every sort of reduction to levels of reality that do not consist in actions, such as material substrates or ideas" [Luhmann 1982, 49]. The evidence, however, is scant, and runs counter to Luhmann's constant dismissal of what he calls the old ontological viewpoint. According to Luhmann, an ontological approach is based on a hierarchization of levels. Correct intuitions mix here with basic mistakes. That some ontological hierarchy is needed is not denied by Luhmann: a social system needs to be borne by some other kind of reality – surely by some biological kind of reality and perhaps even by some physical kind of reality. On the other hand, an ontological perspective does not have to claim that social systems must reproduce within themselves the same hierarchy that connects them to their bearers. As soon as the problem is reformulated in this way, its absurdity becomes apparent. Otherwise stated, there is no principled reason why a contemporary ontological framework could not accept both ontological hierarchies – such as the bearer/borne hierarchy between the material and the social levels of reality – and functional differentiation within a level of reality – such as the differentiation of the social level into its functional subsystems. I am perfectly aware that few contemporary proposals are sufficiently flexible to accept so articulated a framework (which may become even more articulated when the psychological level of reality is included). On the other hand, the ontological framework that I have been developing during the past fifteen years does so [Poli 2001; 2006a; 2007].

I distinguish three main strata of reality (material, psychological and social) in such a way that (1) each of them is characterized by a different group of ontological categories; (2) they are connected by relations of existential dependence organized in a manner such that (i) the material stratum is the bearer of both the psychological and the social strata of reality, (ii) the psychological and the social strata jointly co-evolve from their material bearer, and (iii) they depend reciprocally on each other (all this is explicitly Luhmannian); (3) each stratum of reality presents its own internal organization. Interestingly, the material stratum presents a mainly hierarchical internal organization (well represented by the physics-chemistry-biology series), while the social stratum – as we know it today – is based on an internal organization of a functional nature, and the psychological stratum presents a still different internal organization, somewhat intermediate between the hierarchical and functional organization of the other two strata of reality.

A general ontological framework such as the one just sketched can clarify some difficult problems. To provide an exemplification, while I fully endorse the thesis that "in the relationship of emergence there is not more or less reality, not diminishing reality" [Luhmann 1995a, 111], I have doubts concerning the correctness of the immediately following sentence, "but rather variably selective connectivity. This is a matter of re-establishing transparency despite opaque complexity, and that can only be attained as new levels of system formation emerge." Leaving aside Luhmann's understanding of complexity (on which see Section 8 below), what Luhmann says makes sense only *from the point of view* of social systems, that is, from the point of view of the strategies that a social system can implement to understand and eventually exploit its external environment (i.e. the levels of reality working as material bearers of the social system). On the other hand, the claim comes close to nonsense as far as the *ontological connection* between the social level and its material bearer is concerned.

Be that as it may, and with all the limitations we can ascribe to their theories, Parsons and Luhmann nevertheless had the merit – beyond their explicit intentions – of raising the problem of the ontological autonomy of the social level from its material basis.

5. Communication

The units of meaning used by a social system for its reproduction are communications [Luhmann 1986, 174]. From [Bühler 1934] Luhmann derives the idea that communications are three-sided phenomena based on information, utterance and understanding. Information is the selection of what has to be communicated, utterance is the how of the communication, understanding refers to what the *receiver* grasps from the previous two aspects of a communication. As Baecker says, "not the speaker but the listener decides on the meaning of a message" [Baecker 2001, 66]. None of the three components *on its own* is a communication. Only the three components together form a communication, which implies that a communication can never be attributed to any one individual [Seidl 2005, 29]. Communications – as Luhmann defines them – are from the very beginning social acts, for the simple reason that an act of communication requires both a speaker *and* a listener. Communications come in series, one after the other, and form systems of communication.

In Luhmann's words:

> we can speak of a 'social system' whenever the actions of several persons are meaningfully interrelated and are thus, in their very interconnectedness, marked off from an environment. As soon as any communication whatsoever takes place among individuals, social systems emerge [Luhmann 1982, 70].

Communications generate further communications, and from these a social system emerges. When all communications end, when all the communications are rejected, the connected social system vanishes. The social system *at large* is the collection of all the ongoing communications. This is an autopoietic system that maintains (reproduces) itself through the reproduction of units, namely communications.

Having established that communications are the basic units of reproduction of social systems, the next step is to distinguish specific, different types of communications. Different types of communications form different social subsystems within the overall, inclusive social system as a whole. Here Luhmann distinguishes two main cases. Face-to-face communications are the units for interactions, and decisions are those communications that operate as the units for organizations.

To avoid misunderstandings between the social system as the inclusive whole containing all the ongoing communications and subsystems based on particular types of communication, the expression 'societal system' will refer only to the system of all the communications, while the expression 'social system' will be used generically and will be understood as denoting three different types of systems, namely interactions, organizations and societal systems. "This triadic distinction corresponds to the most important centers of gravity in current sociological research: the theory of face-to-face behavior or symbolically mediated interaction, the theory of organizations, and (admittedly only feebly developed) approaches to a theory of society" [Luhmann 1982, 71].

Each type of social system has its own specific features. Interactions require the effective presence of the interacting agents, which should perceive each other. Only the agents that are present belong to the system of interactions. Interactions, furthermore, develop by focusing on one issue at a time. Participants may change focus, but they are nevertheless constrained to organize subjects of communication into a temporal series.

The requirements of actual presence and thematic focus are strong constraints and they impose severe limitations on capacities for interaction. More complex issues require other systems of communication. Actual presence is the obvious requirement to be dropped. Communication should be also possible with those that are not face-to-face present. Organizations and societal systems can do this.

Organizations are those systems based on membership conditions. Joining and leaving organizations are conditioned procedures. Societal systems, finally, are more than the mere sum of communications. Aggregates of communications do not have the structure required for them to be systems. According to Luhmann, societal systems are social systems, which implies that they are autopoietic systems and need appropriate forms of reproduction.

An important difference between interactions and organizations, on the one hand, and societal systems on the other is that interactions and organizations can always start and stop, begin and end, while societal systems – society – cannot stop. Society is the underlying, ongoing general social system within which all the other types of social system find their place.

This raises difficult problems, both substantive and methodological. While interactions and organizations can be studied against the background of societal systems, what is the background against which one can study societal systems themselves?

Before this problem is addressed, something more must be said about the internal organization of societies.

6. Functional Subsystems

Modern social systems are different from previous kinds of social system because they are *functionally* organized into subsystems (economy, policy, law, science, art, etc).

All systems – according to Luhmann – must possess the capacity to distinguish relevant from irrelevant communications. Apart from this basic capacity, functional subsystems are characterized by specific codes: legal subsystems organize communication along the legal/illegal opposition, political subsystems along the power/non-power opposition, scientific subsystem along the true/untrue opposition, etc.

Each subsystem sees the other subsystems as components of its environment. Subsystems are not supposed to 'understand' each other, i.e. to share the same constitutive codes, the same basic distinctions. Subsystems read whatever is deemed relevant of the whole social system *iuxta propria principia*, from their own viewpoint.

Interaction between subsystems and face-to-face interactions share the same basic format of what Parsons called 'double contingency'. I quote: "each actor is *both* acting agent and object *both* to himself and to others" and "as acting agent, he orients to himself and to others and, as object, has meaning to himself and to others, in *all* of the primary modes or aspects" [Parsons 1968, 436]. From the point of view of functional subsystems, say A and B, double contingency means that (1) A understands B from the point of view of its own code and B understands A from the point of view of its own code; (2) A knows that B reads the actions of A from the point of view of the code of B and B knows that A reads the actions of B from the point of view of the code of A; (3) A takes its decisions knowing what is relevant to both A and B, and B takes its decisions knowing what is relevant to both A and B; (4) B is meaningful to A and A is meaningful to B.

The first two components spell out the former part of the above quotation from Parsons; the last two components spell out *a fragment* of its latter part (I have not detailed the various components of the clause "*all* of the primary modes or aspects", which refers to Parsons' idea of action as a system of relations and not as an event).

Apart from major subsystems – such as the political and legal ones – the second part of Parsons quote – the one specified by (3) and (4) – loses some of its force as soon as the subsystems are multiplied. When several different functional subsystems work in parallel, each of them tends to lose contact with the codes and internal relevancies of the other subsystems. One can describe the phenomenon by noting that functional subsystems, once constituted, tend to develop and maintain their own identities and working conditions independently of the other subsystems. This *natural* dynamic evolution of functional subsystems towards progressive independence and autonomization helps explain several aspects of the current social situation.

7. Autopoietic Social Systems

Autopoietic social systems regulate the exchange with their environment. From the point of view of the theory of autopoietic systems, the environment is not itself a system. The environment does not send 'signals' or 'inputs' to the system; system and environment do not share a common code. What the environment can do is perturb the system. The environment may eventually "trigger internal processes, but cannot determine those processes" [Seidl 2005, 23]. The processes triggered by the environment follow their own *internal* dynamic laws and communicate only with other processes internal to the system. All communications take place within the system; there is no communicative exchange between the system and its environment.

The relation linking a system to its environment is called structural coupling. Different systems may be related to each other in the form of a structural coupling whereby one of the systems becomes the environment of the other system. Eventually both systems can become each other's environment.

Whenever different systems are structurally coupled, the exchanges that occur between them take the form of perturbations. In this sense, the brain perturbs the mind (nerve impulses are not thoughts), social systems perturb psychological systems, and vice versa (communications are not thoughts), functionally different social subsystems perturb one another.

As we have said, autopoietic systems do not communicate with their environment. What they can do is exploit the system/environment relation and reproduce the same distinction within the system. This re-entry of the system/environment distinction within the system is the source of the system's structure. According to Luhmann, the possibility itself for a system to apply to itself the distinction between the system and its environment requires that the system be capable of observing itself.

The observational re-entry that generates the structure of the system constitutes the second level (or cycle) of autopoietic reproduction.

The capacity of self observation can alternatively be described as the capacity to produce a description of oneself, or as the ability to follow a norm. An operational implementation of the last version could take the form of a regulatory mechanism able to restore the functioning of the system whenever it goes wrong.

The claim that autopoietic social systems observe themselves raises a major problem. In the case of interactions and organizations, we can detect their unfolding. In both cases, acts of communication and decisions follow one another and form usually identifiable series of acts. We can understand interactions and organizations because they unfold against the background of the social system that includes them. Furthermore, both interactions and organization are patently able to observe themselves, either through the actors' capacity to observe themselves and the ongoing communication or through the organization's sense of identity and decision style. On the other hand, when the object of analysis is given by the social system as a whole, we have neither a background against which to place the social system nor suitable acts, observational data or identity conditions to exploit. Whatever it is that lets social systems maintain their working conditions, it is not directly visible. Luhmann may possibly be right in claiming that self-observation, or something similar, is needed. On the other hand, the question is this: How can this claim be proved? How can we prove something that is not visibly detectable?

What we see and can study are both the micro-systems provided by interactions and organizations and the macro-systems represented by the various functional subsystems. None of these, however, is anything like an entire social system.

These problems make explicit why theories of social systems are so scarce. Luhmann is possibly the scholar who has gone furthest along the route to an encompassing theory of social systems. I do not think it is unfair, however, to maintain that he has got no further than halfway.

It is worth noting that the lack of a general theory of its reference object does not afflict sociology alone. Biology is in the same situation. Notwithstanding all the astonishing results that support contemporary biology, it does not have a theory of organisms. And cognitive science likewise: Whatever exciting results mark its development, those working in the field do not have a shared theory about consciousness. The interesting fact is that biologists, cognitive scientists and sociologists are all collecting vast amounts of data and discovering many new truths literally without knowing what they are working on.

This situation requires attention. Something deep seems at work here. I am not bold enough to claim that I have the solution and can explain what is going on in these different situations. For the time being, what I suggest is that serious consideration should be made of *relational biology* and in particular the ideas of the late Robert Rosen, who was a mathematical biologist with a systemic orientation. In this sense, he worked within the same framework as adopted by Maturana, Varela, Parsons and Luhmann.

8. Rosen's (M,R)-systems

The starting point of Rosen's theory was relational biology, as developed by [Rashevsky 1954]. The main idea behind relational biology is that organisms are something more than their material basis. As Rashevsky was wont to say, in order to understand organisms one should "throw away the matter and keep the underlying organization". Matter, the physical basis of organisms, is simply immaterial to their nature as organisms. While neither Maturana nor Varela make reference to Rashevsky, autopoietic systems can be seen as possibly the *simplest* descriptive way to articulate relational biology. On the other hand, Robert Rosen's (M,R)-systems [Rosen 1958] are the simplest *mathematical* models mimicking autopoietic systems. In this regard, it is worth noting that Rosen's proposal antedates Maturana's by more than twenty years.

Some of the subtleties of (M,R)-systems are spelled out by [Rosen 1972]. For an introduction, see [Louie 2008] and [Nadin 2010a]. Deeper analyses have been conducted by [Louie & Kercel 2007] (still accessible) and [Louie 2006] (hard). The most systematic treatment of Rosen's systems is provided by [Louie 2009]. General discussion of Rosen's ideas is provided by the collections [Baianu 2006], [Mikulecky 2007] and the special issue [*What is Life?*, 2008].

Omitting all the mathematical details (which, however, are far from being irrelevant), the main outcome arising from Rosen's systems is that they provide a natural way to distinguish at least two main types of higher-order complexity. The guiding idea is that the main difference between mechanisms and organisms is that organisms, but not mechanisms, are closed to efficient causation. The claim of closure to efficient causation means that the processes are mutually entailed within a system more complex than a mechanism; they form hierarchical loops (also known as 'impredicatives' – on the logical coherence of impredicatives see [Devlin 1991, 155-159]. The obvious next step is to distinguish between systems in which at least *some* of their internal processes are mutually entailed, on the one hand, and those systems in which *all* their internal processes are mutually entailed, on the other.

To spell out these and related differences, I first distinguish between (1) systems based on some internal algorithmic machinery (simple and complex systems, including chaotic systems) and (2) systems based on internal dynamics comprising hierarchical loops. For obvious reasons, the latter systems cannot be based on algorithmic functions. I shall baptize them 'higher-order or super-complex systems'. In their turn, higher-order complex systems come in two forms, according to whether only *some* or *all* their internal functions are mutually entailed.

The distinction between complex and super-complex systems come close to von Foster's distinction between trivial and non-trivial machines [von Foster 1984] cited by Luhmann himself, e.g. in his [Luhmann 1997, 362].

To avoid misunderstandings, I use 'complexity' in whichever is the mainstream sense of the term, and I distinguish 'complexity' from 'higher-order complexity' according to whether maximal models of the former but not those of the latter are algorithmically implementable. Less cryptically, complex phenomena are fully codifiable by models based on some algorithmic machinery, while the claim is advanced that no models based on algorithmic machineries are in principle able to completely capture super or higher-order complex phenomena (for the mathematical details see [Louie 2009]). The present use of complexity (and higher-order complexity) is patently different from the concept of complexity used by Luhmann, who based it on the difference between system and environment (see e.g. [Luhmann 1995a], Chap. 5, Part II). From the point of view of Luhmann's understanding of complexity, the title of this paper makes no sense – an explicit way to call attention to the fact that a different interpretation of complexity is at work. While the use of the same term for different meanings is unfortunate, the differences are so marked that no confusion is likely to arise.

On the other hand, while the two theories of Luhmann and Rosen define complexity in remarkably different ways, they both share a major conclusion, namely that 'complex' systems irreducibly admit to different descriptions. From a Rosennean viewpoint, this conclusion is entailed by the lack of a maximal model for these systems (the validity of a maximal model implies that the model entirely captures the system – only machines ("trivial machines" as von Foster terms them) have maximal models). Luhmann's viewpoint is more convoluted, and occasionally makes reference to Logfren's idea of 'hypercomplexity', as in [Luhmann 1995b, 176]

Higher-order systems are not systems that are *slightly* more complex than ordinary complex systems. Complexity and super-complexity are entirely different types of complexity. As Rosen himself says, "Just as 'infinite' is not just 'big' finite, impredicatives are not just big (complicated) predicatives". In both cases there is no threshold to cross, in terms of how many repetitions of a rote operation such as 'add one' are required to carry one from one realm to the other, nor yet back again" [Rosen 2000, 44].

Living systems are such that all their internal functions are mutually entailed. This also means that hierarchical loops do not have leading centers: any member of a hierarchical loop is implied by other members of the loop.

This description of living systems fits well with Luhmann's analysis of social systems. To repeat, all the subsystems of a social system are mutually related in such a way that modern social systems do not have any leading subsystem.

The distinction introduced above between two kinds of higher-order complexity raises the problem of which of them is more appropriate to society (and mind, one is tempted to add). Taking for granted that the complexity of social system is certainly not the complexity of mechanisms, it remains to be seen whether society presents the *full* complexity of a living system or the intermediate complexity characterized by loops linking only some of the system's internal functions. The answer, however, appears straightforward: society as the overall system encompassing both all types of communication and all its functionally distinguished social subsystems cannot but include all its relational processes and their hierarchical loop. Sub-loops present themselves as natural candidates for specialized tasks, such as those performed by functional subsystems.

The analyses so far presented suggest a general conclusion, namely that none of the encompassing general systems in which we may be interested (organism, mind, society) appear to be understandable by exploiting customary scientific methodologies. None of them can be fully captured by analyzing the parts of which they are made. For all of them something like a logic of the whole is at work. Admittedly, these are cases where most of us are at a loss.

Luhmann had the merit of recognizing the problem and many of its subtleties. Rosen, however, did something more: he provided both (1) a deeper and clearer conceptual analysis of the intrinsic complexity of these systems and (2) a mathematical codification (which we have entirely skipped) for better delving into the intricacies of the arising, and often so awkward, problems.

To further test the fruitfulness of the framework I have sketched, I now discuss a couple of further issues, namely the problem of anticipation or of those systems endowed with the capacity to make anticipations, and the role of anticipations in the case of conflicts.

9. Anticipation

What is anticipation? The short answer is: Anticipation is future-based information acting in the present situation. The simplest way to understand anticipation is to think about the projects, plans and aims that persons may have. Occasionally some of these may even operate in an implicit way, i.e. below the threshold of consciousness. Social systems as well may comprise implicit forms of anticipation hidden in their internal loops.

The somewhat longer answer states that anticipation has two aspects: (1) the system has an idea or model of its future development, and (2) it uses the information related to that idea or model to take its decisions in the present. If, according to the values accepted by the system, the model projects a *positive* evolution of the system, the system tries to realize the projected development; on the other hand, if the model projects a *negative* evolution of the system, the system may try to modify its trajectory [Poli 2010a].

Many more details need to be added to this first outline if a reasonable picture is to be developed. For instance, the system may know that it is heading towards a negative outcome, but it may feel unable to change its behavior, or it may reject the very idea of changing behavior. Or the anticipatory model may be wrong and may take for positive outcomes ones that in reality are negative, or the other way round.

The first groundbreaking systematic study of anticipation has been [Rosen 1985]. After years of neglect, interest in his ideas is regaining momentum. For a survey, see [Poli 2010b] and the annotated bibliography [Nadin 2010b]. I shall focus only on the simplest aspects of anticipation, leaving further developments for other occasions.

Anticipation comes in different guises. The main distinction is between explicit and implicit types of anticipation. Explicit types of anticipation can be used synonymously with prediction and/or expectation, while implicit types of anticipation are properties of the system intrinsic to its functioning. In this regard, we may ask whether we are "consciously creating anticipations on basis of which we plan and make decisions, or are anticipations and decisions making made for us?" [Riegler 2003, 11].

Secondly to be considered is the distinction between anticipation as a simple looking into the future and anticipation as the capacity to take account of the consequences of that looking, i.e. its impact on current behavior. This second distinction may appear to be trivial, yet many conflicts spring from a kind of blindness to the consequences of the actions performed.

The most efficient way to learn how to foresee each other's reasons and actions is to devise forms of institutionalization of agents' expectations. Institutionalization lowers uncertainty, and less uncertainty augments confidence. "Instead of getting overwhelmed by the details of a new situation, humans seek to replace them with familiar activity and behavioral *patterns* that show a high degree of predictability to putatively gain control again, to be able to anticipate the outcome" [Riegler 2003, 12].

The problem with institutionalization, however, is that it generates forms of blindness towards whatever does not match its internal codes. Institutionalized behavior may not be able to detect what futurists call 'weak signals', namely early and usually minor behavioral differences that may eventually grow and become new behavioral patterns.

Furthermore, consideration should be made of the distinction between anticipation as a descriptive feature exhibited by some systems and the conditions that the system should possess in order to make anticipation possible (on the difference between anticipation as a descriptive feature and the conditions that make anticipation possible see [Poli 2010b]).

Moreover, no description is able entirely to capture an anticipatory system. Side effects are structural features of anticipatory systems. By default, when the system carries out a particular activity, it uses only some of its internal resources (technically speaking, only some of its degrees of freedom; or only some of its functional subsystems are entitled to assume such activity). Side effects are due to the tension between the fact that the system's dynamics characterize it as a whole (the equations of the system's motion link all the variables defining the system) whilst the system's functional activities require only some of its variables.

The variables not involved in any particular functional activity are therefore free to interact with other systems in a non-functional way, and even in a dysfunctional one (see the reconstruction in [Poli 2010a].

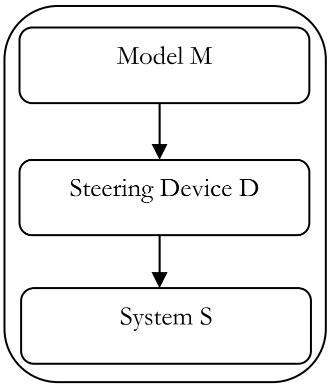
A major consequence is that activities will in general have effects on a system other than those which are planned. However, there are often typical ways in which a system can go wrong. It may therefore be possible to develop diagnostic tools and devise appropriate responses.

10. The Functional Structure of Anticipation

The simplest scheme of an anticipatory system is shown by Figure 1 below, where an anticipatory system is composed of three parts: a normal (i.e. not anticipatory) system S, a model M of S, and a steering device D able to steer S according to the outcomes of M.

The only internal condition is that the model should be able to run faster than the system itself. In this way the model can precalculate the evolution of the system S. Apparently, Luhmann's reference to "the utilization of time differences" has some connections with the situation under discussion see [Luhmann 1997, 364].

FIG 1. The internal configuration of an anticipatory system



Provided that the entire system has the capacity to distinguish positive from negative states, when the model detects that the system is running towards a negative state, it may order the steering device to modify the system's trajectory. If instead the system is running towards a positive state, the model tells the steering device to maintain the system's dynamic trajectory.

This description of an anticipatory system is simple, but it is nevertheless helpful because it enables us to distinguish some of the typical ways in which an anticipatory system may fail. For instance, it may fail because the model is inadequate and needs updating, or it may fail because the steering device is unable to steer the system [Rosen 1974; Poli 2010a, b].

Anticipation can be understood at two different levels of abstraction. The simplest approach is to ask which types of controllers make anticipation possible. On considering the problem of the regulatory structure that a system may have, Rosen was able to distinguish different types of controller. In order of complexity, the various cases are the following:

1. System with feedback controllers.
2. System with feed-forward controllers.
3. System with feedback controllers with memory.
4. System with feedforward controllers with memory.

Feedback controllers 'perceive' the system's environment. The most important characteristic of feedback controllers is that they are special-purpose systems: for them, only highly selected aspects of the environment are relevant. Given some selected value, feedback controllers steer the system in order to force it to maintain that value. This is achieved by error signals indicating the difference between some fixed value and the actual value of the selected environmental variable. Within limits, the controllers in this family neutralize environmental variations and are able to keep the system stable. Their main limitation is due to the delay between environmental change and system adjustment: if the changes in the environment happen too rapidly (the exact meaning of 'too rapidly' depends on the type and sensitivity of the controller) the controller ends up by tracking fluctuations and rapidly loses its capacity to steer the system.

Unlike feedback controllers, feedforward ones 'perceive' the controlled system, not the environment. The simplest way to imagine a feedforward controller is to think of a model of the system as in Figure 1 above. In other words, a material system with a feedforward controller is a system containing a material model of itself. In order to behave as a feedforward controller, the model should run at a velocity faster than the velocity of the system. In this way the model anticipates the possible future state of the system.

The third class of controllers comprises feedback controllers with memory. If a feedback controller is able to leave a trace of the system's experience, this memory trace can be used to tune the system's behavior better. A system with this capacity is obviously able to learn from its past experience.

The next class of controllers consists of feedforward controllers with memory. As in the previous case, systems of this type can learn from their past experience. Rosen notes that systems of this type – "ironically", he says – must use feedback controllers of type 1 for their operations. In fact, they must be able to work on deviations from predicted states (i.e., they need error signals, exactly like type 1 controllers).

One may also consider the idea of general-purpose controllers. All the controllers discussed so far can be described as working on single types of 'perceptions' or variables. The obvious next step is to let systems behave in as articulated a way as possible (i.e., exploit as many variables as possible). The only constraints are given by the unavoidable need to use feedback controllers to modify the internal models of systems with this latter type of controllers [Rosen 1974; Poli 2010a].

On a higher level of abstraction, one forgets all the details concerning the nature of the controllers and considers only the functional connections internal to the system. What emerges in this case is that an anticipatory system presents hierarchical loops among the underlying system S, the model M and the steering device D. This implies that all the relevant information is generated internally to the system. The environment may eventually act on the system as a trigger for actions, not as a source of information [Luhmann 1995a]. Hierarchical loops (or impredicativities as they are called in logic) mean that the system generates its own meanings internally. An anticipatory system is a system able to generate its own behavioral codes, and the formal side of this capacity is provided by hierarchical loops.

Those systems that are capable of observing their own behavior can use this information to generate new structure. This is done by adding self-observations to the hierarchical S-M-D cycle. The observational re-entry that generates structure constitutes the second level (or cycle) of autopoietic reproduction of an anticipatory system [Poli 2009].

11. Do Anticipations Change?

A system's *schemata* determine how it looks at the environment. They are therefore anticipatory. Schemata construct anticipations of what to expect, and thus enable the system to *actually perceive* the expected information. Construction imposes anticipations and poses the question of how to construct.

Most anticipations work as acquired habits either through evolution (as in biological anticipation) or learning (as in most cases of psychological and social anticipation). Evolution-based anticipations are difficult to change, for obvious reasons. However, as difficult as they are to change, they may evolve, and this raises the question as to whether we can eventually bend evolution in some or other direction.

According to the theory of anticipation, behavior is almost always *goal-oriented* rather than being *stimulus-driven*. Anticipation runs contrary to the claim that psychic processes in general are determined by stimuli (i.e. it is at odds with both Behaviorism and most of current Cognitive Psychology) (for some data see [Poli 2010b]).

If behavior is indeed goal-oriented, this implies that changes in behavior are filtered by the system's identity (seen as the second entry in the system's autopoietic cycles). The reason for this is straightforward. Anticipation is based on feedforward controllers, i.e. on controllers that detect and control the system itself. Changes in the system's working (i.e. in its identity) are therefore projected by feedforward controllers into new anticipations. From this basic dynamic of the system it follows that the most productive strategy to change the anticipations that a system may have is to modify the system's dynamic identity.

Anticipation works at many different levels (and sublevels). The least we can assume is that there are biological anticipations, psychological anticipations and social anticipations. As far as conflicts are concerned, the most relevant types of anticipation are obviously the psychological and social ones.

From what we have seen, it is evident that most anticipations work silently: they constrain the system's behavior without the system being aware of them. Given the connection between anticipation and identity sketched above, this implies that the system knows only some fragments of its own identity.

The main problem with such an extensive family of anticipations is that the different types of anticipation may work together and synthetically produce the system's general anticipatory patterns, or they may conflict and eventually cancel each other out. Very little is known about these processes, and I am forced to leave their analysis for another occasion.

12. Conflicts

The connection between anticipation and conflicts has been well known since the early days of conflict studies. In fact, the difference between defensive and aggressive conflicts is often articulated in terms of anticipations, as shown by the way in which the basic types of conflicts are usually defined:

- *Defensive conflict* = when the initiating contendant tries to avoid an *anticipated* loss.
- *Aggressive conflict* = when the initiating contendant tries to acquire an *anticipated* gain.

Furthermore, it is often assumed that power is a scarce resource, i.e. that "what he loses, I gain". If power is indeed a scarce resource, the obvious consequence is that contendants will try anything to acquire more of it.

To date, conflict studies have taken it for granted that the idea of anticipation is sufficiently clear and does not require further analysis. We have seen, however, that anticipation is far from being properly understood and presents unsuspected complexities. Indeed, the theory of anticipation has many surprises in store. Conflicts, as based on anticipations, embody people's habits, dispositions, tendencies, and attitudes – and none of these are well understood, to say the least. Much more is involved, however, for systems which are able to anticipate behave in a much more sophisticated way than systems without such a capacity.

If it is true that anticipations essentially depend on hierarchical loops, no complete algorithmic model of anticipatory systems will ever be developed. What we may eventually be able to develop are sets of partial models addressing different aspects of a given anticipatory system.

While some of these models may represent observables and the procedures for dealing with them (e.g. conflict management procedures), other models should try to represent the system's latents. Since anticipations may be at work behind manifest behavior, we should find ways to map reality not as something entirely manifest but as a field of dispositions and powers, i.e. as a field of possibilities or latents.

The most general way to make latents visible is to change the system's boundaries. The simplest strategy is to embed the system within a larger context or system. In fact, most systems change their dynamic patterns when embedded within larger systems. Inducing new dynamic patterns via embeddings within larger systems is usually less difficult than trying to change the system's dynamics in a direct way.

When embedding into larger systems proves not to be a viable strategy, the opposite strategy of segmenting the original system into smaller systems can be tried.

For those cases in which none of the usual strategies work, one may try to induce (controlled) dynamic dissonances into the system. This is a potentially dangerous option, because it may definitively ruin the system. However, there may be cases in which the induction of dissonances is the only option available. The presence of internal dissonances forces the system to reconsider its dynamic identity and eventually change its guiding patterns, e.g. by reconfiguring what it considers to be good and bad.

13. Systems of Higher-order Complexity

Although widely incomplete, the theory of higher-order complexity paves the way for a new, deeply innovative, vision. Even if most details of this new vision are only starting to become dimly visible, some of its categorical requirements are nevertheless surfacing. In this section, I shall offer for discussion the idea that higher-order complexity requires at least four different categorical frameworks, namely those provided by the theories of levels of reality, chronotopoids, (generalized) interactions, and anticipation. Put briefly:

- The theory of levels of reality provides the basic ontological framework for articulating the relations of dependence and autonomy between entities. See [Poli 2001] for a first introduction to the theory.
- In its turn, the theory of levels paves the way for the claim that there may be *different* families of times and spaces, each with its own structure. The claim is that there are numerous types of real times and spaces endowed with structures that may differ greatly from each other. The qualifier 'real' is mandatory, since the problem is not the trivial one that different abstract theories of space and time can eventually be and have been constructed. I shall treat the general problem of space and time as a problem of *chronotopoids* (understood jointly, or separated into *chronoids* and *topoids*). The guiding intuition is that each stratum of reality comes equipped with its own family of chronotopoids (see [Poli 2007] for further details).
- The theory of levels of reality also provides the natural framework in which to develop a full-fledged theory of causal dependences (interactions). As in the case of chronotopoids, the theory of levels of reality supports the hypothesis that any level has its own form of causality/interaction (or family of forms of causality/interaction). Material, psychological and social forms of causality/interaction may therefore be distinguished (and compared) in a principled way. Besides the usual kinds of basic causality between phenomena of the same nature, the theory of levels enables us to distinguish upward

and downward forms of causality/interaction (from the lower level to the upper one and *vice versa*).

- An anticipatory system is a system such that the choice of the action to perform depends on the system's anticipations of the evolution of itself and/or the environment in which it is situated; reactive systems, on the contrary, are such that subsequent states depend entirely on preceding states. Whatever organisms, minds and societies may be, I take it for granted that they cannot be understood as purely reactive systems.

A couple of short addenda on anticipation are worth considering. First, given that anticipation requires only that the system contains a hierarchical loop including at least *some* of the system's functions, also non-living systems can be anticipatory. Second, organisms, minds and society require the capacity to coordinate the rhythm of the overall system with those of its parts. These general systems are all multi-strata systems composed of different types of components interacting at different functional levels and at different levels of organization. While most details of these highly complex systems are still unknown, the possibility should be considered that the anticipatory capacities of the system as a whole may diverge from those of its subsystems.

14. Latents and Other Philosophical Conundrums

The cursory reference to latents in Section 12 above requires brief explanation. The only aspect that I need to touch upon is that reality comprises not only what is actually given but also dispositions, habits, tendencies, and the forces generating them. These are collectively called latents.

Even if latents may not be actually detectable in any given situation, they may nevertheless be there. Latents may become actual if proper triggering conditions are in place, or they may be lost in the process. The simplest case of latents is given by dispositions, which can be described under the label "what would happen if" (what would happen if sugar were added to a liquid, or if the country went to war). Occasionally, latents can be perceived even when they are not exercised. They form a kind of halo around persons and situations. Individual and group decisions can actually be based on the perception of latents. The lack of a general theory of latents, however, makes it difficult both to organize systematically the psychological and social data already available and to guide research towards a better understanding of the less known aspects of the systemic perception of latents. Be that as it may, a major difference between the behavior of people and the behavior of institutions is that the latter seem remarkably less able to perceive latents. This raises an interesting side to the problem of institutionalization, namely the passage from more flexible, generic structures to more constrained and more specialized ones. I am forced, however, to leave discussion of this issue to another occasion.

The most relevant latents of interest here are provided by the hierarchical loops governing the general encompassing types of system – organism, mind and society. As we have seen, all them seem to be governed by normally undetectable hierarchical loops, which implies that they depend on the working presence of suitable latents.

Some other comments on philosophical matters are needed. One of the main problems with Luhmann – but not with Rosen – is his rather idiosyncratic understanding of ontology. Apparently, Luhmann believes that ontology starts from a pre-given set of elements, and it studies the combination of those elements. As he repeatedly says, the unity of the system's elements is not something that is ontologically given (e.g. [Luhmann 1995a] and elsewhere). I for one have no problem in accepting his claim. I think it is also important to note that, whilst *some* ontologists have indeed defended atomistic ontologies, almost all the great figures in ontology have defended much more sophisticated ontological frameworks. Indeed, the idea itself of focusing the analysis of the ontological import of the theory on the status of the system's elements alone is patently too restrictive. The real issue, in fact, is not the ontological status of elements but the ontological status of the systems themselves, and in particular the ontological status of autopoietic systems. Provided that the theories partially discussed in this paper are correct, the conclusion is straightforward: biological, psychological and social realities have the nature of autopoietic systems (eventually of generalized autopoietic systems). This is a major ontological claim, which gives us important insights into at least one of the major differences between physical and chemical systems, on the one hand, and biological, psychological and social systems on the other. Luhmann occasionally shows that he has some understanding of the problems that lie behind all these questions, for instance when he asserts that "autopoietic systems … do not create a material world of their own. They presuppose others levels of reality" [Luhmann 1986]. Even if this quotation is not entirely correct, because biological entities *are* material entities, it nevertheless moves in the right direction, namely the thesis that autopoietic systems are *relational* systems which can be realized by material systems. To repeat Rashevsky's vivid dictum in a slightly modified version: in order to understand autopoietic systems, "throw away the matter and keep the underlying organization". Clarifying the ontological nature of autopoieisis is one of the problems on the agenda of contemporary ontologists.

The second problem to be mentioned is that there is no reason to identify the system's composing elements with its units of reproduction. Many interesting wholes present both a *material* and a *functional* kinds of composition.

The third problem is the connection between latents see [Poli 2006b; 2009] and autopoietic systems. The shortest answer is that, from the point of view of elements (again!), many aspects of the systems of which they are parts are latent: systems constrain the behaviour of the elements without obviously being part of them. The fact that (at least some) elements may have been generated by the system makes the system's latency even more interesting. It has been recently suggested that one of the consequences of the downward causation exerted by the system on its elements is non-locality: "The causation is seemingly everywhere in the process and not localizable at any specific place". A further consequence is the "inability to tease the causal links apart" [Kercel 2004, 15], a consequence explicitly discussed by [Rosen 1985].

Lastly, what is the complexity of self-reference? Needless to say, self-referential systems cannot be entirely based on rote, algorithmic frameworks. Even if any of their states can obviously be simulated, self-referential systems, almost by definition, escape the possibilities of rote iteration. This argument only shows that the complexity of a self-referential system extends well beyond mainstream complexity theory. For this reason, the idea of systems of higher-order complexity has been introduced. As we have seen, these types of systems come in at least two forms: self-referential (or impredicative) systems, and living systems. Anticipation is but one of the many intriguing features of self-referential systems. Living systems are those self-referential systems in which all internal functional relations are entangled within one overall hierarchical loop. The really surprising outcome is that self-referentiality does not necessarily require life. Also non-living systems can be self-referential systems. However surprising, this conclusion is nevertheless most welcome because it shows that reality still has many surprises in store.

15. From Luhmann to Rosen and Back

Only the most general aspects of Luhmann and Rosen's theories have been considered by this paper. Even at such an ethereal level of abstraction, however, it is apparent that their theories are closer to each other than one might think.

I shall restrict my remarks only to the following two aspects. Luhmann states that "autopoiesis, as a concept, has no empirical explanatory value. Its potential lies rather in the fact that forces other concepts into adaptation" [Luhmann, "Organization und Entscheidung", 2000], quoted by [Seidl & Becker 2005, 11]. As a matter of fact, Luhmann's claim is overstated: almost all innovative frameworks require what may be a long period of maturation before they are ready for application. Be that as it may, both Luhmann and Rosen's theories have been used to model real, empirical situations. From the point of view of Rosen, Luhmann's lack of "empirical, explanatory value" assumes the form of the *realization* of (M,R)-systems. As Louie writes, "functional organization cuts across physical structures, and a physical structure is simultaneously involved in a variety of functional activities" [Louie 2006, 36]. Hence there is no obvious translation ('realization') of an (M,R)-system into a biological individual. (M,R)-systems provide a conceptually very abstract framework in which to understand life.

The realization of life into actual organisms requires many more details extending beyond (M,R)-systems. The same applies to Luhmann' social system theory, which addresses only the most basic, the deepest, aspect of social systems. Many more details are needed in order to understand this or that concrete system. I for one fail to see why all this should be a problem.

The second problem that I shall discuss concerns the question of the structure of an autopoietic system. I mentioned above that structure is related to the second autopoietic cycle of an autopoietic social system. From the point of view of Luhmann's theory, the first autopoietic cycle realizes the constitution of the system, while the second cycle generates the system's identity. Interestingly, Rosen also stresses that the minimal (M,R)-system is based on two relations, namely *metabolism* and *repair*.

Metabolism is the basic activity that constitutes the system, repair is modification of the system's dynamics according to some norm. Whenever the system's dynamics (its metabolism) go awry, the repair component intervenes in order to reestablish order.

Thirdly, according to Rosen's distinction between self-referential and living systems, Luhmann's theory of social systems pertains to the latter class: it is the theory of a particular class of living systems. Within the said classification, the reference to self-reference is a necessary but not sufficient condition for characterizing social systems.

If we resume the four types of controllers presented in section 10 above, we can discover a further interesting subtlety. Let me first repeat the short description of the four controllers:

1. System with feedback controllers.
2. System with feed-forward controllers.
3. System with feedback controllers with memory.
4. System with feedforward controllers with memory.

One of the underlying difficulties with Luhmann's theories is that he uses only type 1 (and occasionally type 3) controllers in his reflections. Luhmann apparently has no idea of controllers of type 2 and 4. Even if Luhmann describes social structures as expectations [Luhmann 1995a], he apparently has no composite theory of anticipation. Rosen's theory may then help to articulate Luhmann's proposal by explicitly including feedforward structures in his framework.

Finally, an overview of the foregoing discussion may help. Luhmann's work can be broadly divided in two main phases. The first phase was mainly focused on the task of generalizing and giving a better grounding to Parsons' theory of social systems. The development of the theory of autopoietic systems in the 1980s triggered Luhmann's second phase. The categorical framework provided by autopoiesis gave Luhmann the tools with which to further generalize and deepen his previous efforts. The theory of social systems developed by Luhmann thus represents a generalization of autopoiesis theory through its application to social phenomena. This paper has drawn attention to the fact that the theory of autopoietic systems can be reconstructed as a specific fragment of the more general theory of (M,R)-systems developed by Rosen. Luhmann's generalization of autopoiesis still falls within the capacities of (M,R)-systems. The hypothesis has then been suggested that an explicit consideration of Rosen's theory provides room for a further generalization of Luhmann's theoretical framework. The intriguing phenomenon of anticipation and the problem of conflicts have been proposed as possible testing grounds to verify the fruitfulness of the generalization suggested.

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The Complexity of Self-reference

A Critical Evaluation of Luhmann's Theory of Social Systems

Roberto Poli

The paper presents the basic elements of Niklas Luhmann's theory of social systems and shows that his theories follow quite naturally from the problem of the reproduction of social systems. The subsequent feature of the self-referentiality of social systems is discussed against the theory of hierarchical loops, as developed in particular by Robert Rosen. It will be shown that Rosen's theory is more general than Luhmann's. The nature of anticipatory systems and the problem of conflict are used as testing grounds to verify some interesting articulations of the general theory of hierarchical loops.

Roberto Poli (PhD Utrecht) teaches Applied Ethics, Philosophy of the Social Sciences and Futures Studies. Poli is editor-in-chief of *Axiomathes* (Springer) and editor of *Categories* (Ontos Verlag). He is member of the Academic Board of Directors of the Metanexus Institute, Philadelphia (http://www.metanexus.net/Institute). Poli has published *Fra speranza e responsabilità. Introduzione alle strutture ontologiche dell'etica*, Polimetrica, 2006, he is the general editor of *TAO-Theory and Applications of Ontology*, 2 vols., Springer 2010 (first volume on philosophical ontology, second volume of computer-based ontologies) and coeditor of *Understanding Anticipatory Systems*, special issue of *Foresight*, 2010.

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