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What is complex in the complex world? Niklas Luhmann and the Theory of Social Systems

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Introduction

This paper discusses Niklas Luhmann's conception of complexity, its role in his theory and the different ways of using it. Niklas Luhmann is considered one of the most important German theorists of our times. His most significant contribution is the update of the theory of systems, based in a fundamental paradigmatic change: to cross over from the distinction of the system as one whole and the parts to the distinction of system and environment, with the concept of complexity as a referential. The importance of the concept is present in diverse parts of his theory, from complexity as a synonym for modernity, to complexity as an analytical category to apprehend the system/environment difference. Luhmann starts from the theory of the systems, the Parsonian structural-functionalism, in which the notion of system is essential to comprehend the extreme complexity of the world: its role is to reduce it. He was also part of the theoretical scene outlined in the 20th century that represented a profound paradigmatic change in general science, with a new element emerging, one that will break up with the Newtonian model, that is, "*to deliver the coup de grâce on the classical view of the world - the complexity*"*** (Basarab, 1999).

1 - Conceptual revolution directed at the complex world

The issue of complexity attains theoretical reference only in the 20th century, at least in the sense it is commonly used nowadays. This specific sense, differentiated in time, evolved from transformations that occurred in the natural and mathematical sciences early in the 20th century; these transformations, among others changes, questioned the epistemological and ontological statute of Newtonian physics, which were related to the ideas of a determinist universe, reductions to the last causes, mechanism and reversibility, useful expressions to understand the previous concept of complexity and the reasons why the mathematical sciences were so alluring. Thus, Descartes (1596-1650), searching for a universal mathematic to combine distinct fields of knowledge, defended the progression of superior terms through information from the previous ones, as if everything could be originated from the first causes: "*to produce effect by putting into action adequate causes*" (Granger, 1979: p. 21). To the mathematical order corresponded the natural order, its simple, invariant and universal laws:

> *1st HYPOTHESIS: We will not admit more causes for the natural things than that which are true and, at the same time, enough to explain the phenomena of everything. The nature, to all intents and purposes, is simple and does not make use of the luxury of superfluous*

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> *causes for the things. 2nd HYPOTHESIS: Therefore, natural effects of the same species have the same causes. Thus, the causes for the man and the animal's breath, the falling of rocks in Europe and America, the light in the kitchen fire and the sun, the light's reflection in the Earth and the planets* (Newton, 1979: p. 18).

This universe, nonetheless, is ordained and harmonic; after Newton (1642 - 1727), there is an idea of totality that can be described by elegant and simple laws. In this sense, ontological simplicity will always have as a reference a systematic epistemology that represents the relations between things through mathematical laws. This investigative exercise is the pure representation of the substance, without any significant disproportion between *cogito* and reality[1].

To come to the point, what was constructed here was a world view that was supported by premises such as the order of things, universal legislation, mathematics, the systematization of what is real, the absolute, the machine. This comprehension of the universe will influence other fields of knowledge, in part due to the triumphs of the scientific revolution that was at the end in the 17th century, thanks to Newtonian mechanics and its laws of movement. Even the human sciences would pay tribute to such enterprises that reshaped the world view of that time[2]. For example, Thomas Hobbes (1588-1679) applied the Newtonian and the Cartesian geometric principle to the moral sciences, that is, to the humanities.

> *As it is known, the system of Hobbes is based on absolute mechanist materialism, capable of unifying Logic, Natural Philosophy, Civil Philosophy (or politics) within a rigorously deductive model* (Crespi e Fornari, 2000: p. 43).

The social sciences, in their first century, would have the same proposals as a model, printed in the 1800's Positivism, mostly in Auguste Comte (1782-1857). According to Comte, only the scientific rationality, the model of Physics, is able to establish the necessary nexuses and objective laws that exist between the forms of knowledge and social reality (Ibid: p. 72). The idea of quantification would become clear with Émile Durkheim (1855-1917), who promoted the reduction of the social facts to their measurable dimensions and brought, in his theory of the society, the menace of imminent disorder, the anomie resulting from the absence of normative lines of behavior. Hence, these sciences opposed natural order to possible disorder, obtaining, in the process of normalization and control, the counterbalances necessary to order[3].

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[1] The other source of the 16th century revolution was Francis Bacon (1561-1626), who wrote in *Novum Organum*: "Nature long surpasses, in complexity, the senses and the intellect. All of those beautiful human mediations and speculations, all of the controversies are bad things. And nobody notices it" (1979: 14)." This is connected to Descartes rationalism and Bacon's empiricism, a difference manifested in Bacon's refusal to accept simple reasoning as being capable to reach the universal from the particular, to achieve it, one must proceed by means of experimentation, excluding "contrary examples that could invalidate the induction of an universal affirmation from particular cases" (Crespi e Fornari, op.cit.: 32). Bacon starts from the principle of the intellect's inadequacies to the complexity of things (complexity disproportion), Descartes argues for the accurate measure between on thing and another.

[2] But not in the whole world, the Newtonian world did not exceed its territorial limits. It is clear that its scope of application was transposed even to the movements of the stars, but its cosmology was restricted and, as it was proven in the 20th century, its applicability itself was circumscribed to certain phenomena. Its limitations became clear with the advancements in quantum Physics and Einstein's general theory of relativity. But what really matters is that Physics, with its laws and its method, began to be pursued by the other sciences, and even today it still fascinates epistemologists unaware of the peculiarities of diverse disciplines (on the difference between Human and Natural Sciences, see Habermas, 1988).

[3] This conception of society is reminiscent of Bacon's intent in "New Atlantis" (1979), an Earth kingdom where happiness rules thanks to the scientific control of nature. In this sense, there seems to be a similar purpose between Bacon, Hobbes and Durkheim in relation to the difference between order and disorder, favoring the first side of the form and the idea of harmony.

In the 20th century, this paradigm of order, symmetry, regularity, and the intellect's adequacy to the things is in crisis. To a large extent, it is due to the reflectivity of this way of thinking, which looks at itself and discovers its own limits and weaknesses. Boaventura Santos (2000) states that this crisis results from the first formulations of early 20th century Physics, more particularly those asserted in Einstein's General Theory of Relativity - "*without universal simultaneity, Newton's absolute time and space does not exist anymore*" -; Heisenberg's Theory of Uncertainty - "*The idea that what we know of reality is only that which we introduced into it* (...)" - and Prigogine's Theory of the Dissipative Structures, "*dynamic systems, far from being balanced, that exchange energy with the environment (Output) following a way of unpredictability that leads to entropic chaos, unless this tendency is counterbalanced by an external power source (Input)*"[4].

It is from these formulations that a new universe comes into view, this time founded on bases radically opposed to those of modern science. There is the rehabilitation of chaos, procedural irreversibility, indeterminism, the observer and the complexity. The whole of this new universe will affect other sciences, from Biology to the Human Sciences, raising the theory of complexity to the category of paradigm.

> *It was through technical applications that science was forced to descend from the ivory tower of pure phenomena and find the complexity as one of the elements of the modern world, first in the structures elaborated by man, and later in the nature where it was, nonetheless, so evidently inscribed. Little by little, it prepared itself to deal with it: the matricial calculation, calculating machines, centralization of information, increasing number of qualified technician collaborators, great bibliographies, card indices and repertoires, the ways of global controls, successive approaches, etc… appear amongst the instruments that science created to face the complexity of organisms such as radars, the television, great interconnected nets, telephonic circuits, human physiology* (Moles, 1971: p. 22).

The science of complexity recognizes instability, evolution and fluctuation everywhere, not only in the social arena, but also in the basic processes of the natural arena, as stated by Wallerstein (2002: p.201).

The impact of this scientific revolution, in the sense of Kuhn (1992), echoed in Logic, Cybernetics, Chemistry, Biology and the Social Sciences. Even if in a different way, within these disciplines the treatment given to complexity demanded new conceptual forms to approach a universe that resisted apprehension by laws, presenting phenomena comprehended only through the use of probabilities: the future can not be predicted anymore and becomes a mere possibility[5].

It is in this context that the attempts at a General Theory of the Systems can be found, among the different disciplines that have the extreme complexity of the world as the main problem of the theory. The first formulations come from Biology, with Ludwig Von

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[4] The paradigm of the general theory of systems, at this moment, thought of these systems as open, susceptible to external influences. Besides, this notion was applied in living systems, with the addition of informational interchange to energy. On the subject of open systems, see Morin, 1990: p. 30; Luhmann, 1996a: p. 45.

[5] Nothing could differ more from Laplace's celebrated formula, which somehow serves as a summary of the science practiced in the 19th century, in opposition to the one that emerged in the next century: "*An intelligence that for a given instant knows all of the forces that animate nature and the respective situation of the beings that compose it, if besides that it was sufficiently wide to submit these data to analysis, it would take in a single formula the movements of the greatest bodies and those of the least atom; nothing would be uncertain to it, and the future, thus, just like the past, would be present to its eyes. Every effort of the human spirit in the research of truth, tend incessantly to approximate it to the intelligence that we have just conceived*" (Laplace Apud. Moles, op.cit.: p. 16).

Bertalanffy, back in the 1930s, gaining force only in the 1950s. What intersects the disciplines is the fact that there are systems that, when they interact with the environment, they build internal forms for their maintenance, looking for a balance with the environment, not in the sense of thermal death, but promoting dynamic adaptive transformations. But to the systemic procedural simplicity is opposed the complexity of the world, constantly forcing the system to coexist with chaotic noises, since this complexity can not be covered in its totality. This coexistence demands processes such as discard, ignorance, indifference or exploitation. The system is organized under such conditions: order, this time, comes from disorder, as indicated by Heins Von Foerster in the 1960s, in his famous concept of "*order from noise*"[6] (Luhmann & Of Georgi, 1993: p. 28-42).

Cybernetics, facing this emergent reality, comes into the systemic discussion to establish itself as the study of these conditions of systemic unpredictability, defined by Norbert Wiener, who created the term in 1948, as "*the science of control and communication, in the animal and in the machine*" (Apud Ashby, 1970: p.1; Beveridge, 1981: p. 74). He proposes a method to deal with complex systems, whose complexity is a condition of its own operations, being impossible to ask for simple exits. According to Ashby (op. cit.: p. 11), the difference is the basic concept to Cybernetics, i.e., the idea that distinctions between two things can be observed, or their differentiation in time, what takes us to another concept, that of change. Every system is dynamically differentiated from another, and its properties are not related to its mass, its "largeness" is in the number of distinctions that can be made. Thus, the expression "too big" can be said only when it concerns an observer with defined resources and techniques, implying that the totality of the system can not be entirely described, controlled or calculated.

Here one can notice the "turn" in direction to the observer who builds internal differentiations planning to explain the complexity. In this sense, the access to reality occurs with internal constructions in the observation process, the object is not unfamiliar to the observer anymore. All references to the environment of the systems are, then, proper references. The "totality", the "parts", the "system" and the "environment", and even the "complexity", lose their ontological domain, this time demanding studies that can present the form of specific observations built within the system, allowing the reference to reality. In this sense, there is a new turn, this time directed at the Epistemology[7].

More recent contributions to the general theory of systems have focused mostly the system/environment relation, directed at defining the qualities involved in energy and informational exchanges. From Biology, come out approaches that take into consideration the phenomenology of the cell as an integrated, self-organized process, maintaining a dynamic balance with the environment[8]. The same characteristics are present also in the biological theory of the Chilean biologists and philosophers Humberto Maturana and Francisco Varela (1997), whose basic concept is related to self-organization of cellular processes, a phenomenon they called autopoiesis[9]: the systems are defined (they create identity) by their own operations. Such operations depend on the system in which they are produced, what in turn produces the system

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[6] Later used by Henri Atlan in his studies of biological systems (Atlan, 1992). Concerning the discussion on order and disorder, see Passis-Pasternak, 1992.

[7] This is recurrent criticism on Luhmann's works, the development of a single epistemology of the social. On this point, see, for example, Domingues, 2001: p. 52.

[8] Atlan (op. cit.) compared the living beings to the flame of a candle "*oscillating between the rigidity of the crystal and the fluidity of the smoke*", presenting emergent properties that can not be reduced neither to rigid qualities nor total fluid ones; its eccentricity dwells specifically in this plasticity. This is how Ashby refers to these emergent properties, whose principle concerns the complexity and not the reducibility of certain scopes to others (op.cit.: p. 129):

"*(1) Ammonia is a gas, as well as the chloridric acid. When both gases are mixed, the result is solid - a property that none of the reagents had; (2) Carbon, Hydrogen and Oxygen are all practically without taste; but the particular composition 'sugar' possesses a characteristic taste that none of them had before; (3) the twenty (or such) amino acids of a bacterium do not possess, none of them, 'auto-reproductive' property, while the group, together with some other substances, present this property*".

[9] The term comes from the Greek words *auto* (itself) and *poién* (to produce), meaning: the capacity of the system to develop, from within, its structure and the elements that give it form (Luhmann, 1991).

itself. Therefore, a circular process of components' self production follows, able to make sense of the information coming from the environment and, consequently, able to distinguish itself from the same.

Here it is proven a rupture with the traditional systemic thought, which regards the systems as structuralized but opened units. From now on, the systems are considered closed on their own operative basis. These studies will be used by Maturana in his research on the nervous system (1990), and they will have an effect both on the cognitive theory and in conceptions that support the opening of the nervous system, inserted into theories intent on representing the world: access to the "real" world is given through the building of internal structures that allow proper contact with the environment. These structures appear in the evolving process of the species through the differentiation between system and environment.

This "conceptual environment" of deep epistemological transformations in sciences served as substratum to Niklas Luhmann's theory of social systems. In this sense, he does not start from the idea of unit, but from that of difference. He looks into the idea of complexity to overcome the cause-effect relation, the concept of totality, so dear to the classics; Luhmann supports the fragmentation of the individual's logic and his action; he goes on to the analysis of communication and system; and ultimately from that of the opportune subject/object duality to the system/environment difference (Neves & Samios, 1997).

2 - Complexity in Niklas Luhmann

Luhmann discussed the issue of complexity in many of his works, giving it a coherent methodological improvement with his theory of autopoietic systems, operationally closed, functionally differentiated. He starts with a conception of complexity related to its object of analysis - the world -, such as the totality of all the events (in the world), and goes to an epistemic-methodological conception elaborated and better developed in his theoretical texts, when he begins to accept complexity as a concept of observation and description, that is, counting on the necessary presence of an observer who observes the complexity: the second order observer[10].

Luhmann, in his social theory, imagines the "world[11]" (Welt) as the highest unit of reference. The world is not a system because it does not have an environment from which he could be delimited. It also can not be seem as an environment, since each environment presupposes an interior that, in turn, does not belong to the environment. Thus, the world is neither a system nor an environment, but it encompasses all of the systems and their respective environments; it is the system/environment unit. Everything that happens, happens in the world. Changing situations, maintenance of systems, systems' disappearance, all of it occurs in the world. This is the reason why the world as a category was chosen by Luhmann as the ultimate reference. The world can not be surpassed; it does not have boundaries through which an environment extends, to which it could expand. Therefore, to Luhmann, the world, or the complexity of the world, is the main problem of his (functional-structural) analysis (Luhmann, 1973).

In this context, complexity means the totality of possible events and circumstances: something is complex if it involves, at least, more than one circumstance. Increasing the number of possibilities, the number of relations between the elements grows in proportion and so does the complexity. The concept of world complexity represents the last boundary, or the ultimate last limit. If it is possible, it is possible only in the world.

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[10] It concerns the observation of observations, that is, to identify the differentiations the systems make to observe. In this sense, the second order observer does not observe "facts", but how the systems operate to access the facts of the environment in accordance with its structure.

[11] Luhmann considers the concept of the world as a concept paradox that always represents a combination of determination and indetermination, unit and difference. The world as a unit of the past and the future, observer and observed one, Ego and Alter Ego (Corsi et. ali 1996).

This ultimate complexity of the world, in this form, can not be understood by the human conscience. The human capacity can not apprehend the complexity, considering all possible events and all the circumstances in the world. Too much is asked of it, frequently. Thus, between the ultimate complexity of the world and the human conscience there is a gap. And it is there that the social systems play their role. They take on the task of reducing complexity. Social systems, to Luhmann (1990), interfere between the ultimate complexity of the world and man's limited ability to work the complexity.

Luhmann developed this approach to the social systems, the function of reducing the world's complexity[12], since they exclude some possibilities and select others, in his work "*Social Systems*" (1984), which started the great theoretical turn when he considered the systems not as one whole anymore or as an entirety resulting from the sum of the parts, but as difference. The system is defined by its difference in relation to the environment. The system that contains its difference within itself is an autopoietic one, self-referring and operationally closed, defined as such by reducing the complexity of the environment. If the social systems operate to reduce the complexity, on the other hand they also build their own complexity. The system has to close itself operationally in relation to the environment for it to happen, producing its own elements, (autopoiesis) operating, thus, the building of its own complexity. And it is undoubtedly in this process that evolution occurs.

Hence, the constitution of systems results from the reduction of the world's complexity by operating the distinction between what is the system and what is the environment. The relation between system and environment is characterized by the differentiation of complexity degrees. The environment, as it has been seen, is always more complex than the system: it encompasses all of the possible relations, possible events, and possible processes. The differentiation between system and environment occurs when the system begins to act selectively:

> *The system operates in a selective way, as much in the plane of the structures as in that of the processes: there are always other possibilities that can be selected when one pursuits an order. It is precisely because the system selects an order, that it becomes complex, since it is forced to make a selection of the relation between its elements* (Luhmann, 1996a: p. 137).

Luhmann emphasizes the relation between the systems' movement of functional differentiation, which means operational closing in relation to the environment and, at the same time, its own constitution through the selection of interrelated elements that lead to an increasing complexity (complexity of the system).

While developing his theory of systems, Luhmann, in addition to the use of the difference between system and environment, extends the analysis of the difference between elements and relations, improving it with the concept of complexity that, to him, is the one "*that better expresses the experience of problems in the new systemic investigation*"[13] (Luhmann, 1990: p. 67). The system is divided both into subsystems and into elements and relations. There are no elements without relational connections or relations without elements. In both cases, the

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[12] The system, in line with Luhmann, can not answer, one by one, the immense possibility of stimulations coming from the environment. This way, it develops a special disposition to complexity, in the sense that it disregards, rejects, creates indifferences, and closes itself. Such a process is what is called reduction of complexity, an expression that was first used in a book by Gerome Bruner, "Study of Thinking" (New York, 1956) (Luhmann, 1996a. p.133/134).

[13] Luhmann mentions in some of his texts the distinction between simple complexity, which makes possible to connect all of the elements, and complex complexity, which has a need for selection and, therefore, a gradual increase of its own demands. To exemplify the first type, he alludes to the tradition of the Middle Age's philosophy, in which, the paradigm of simplicity was found in history under distinct modalities, in various cultures, since it was about the necessity to come out with an order in line with nature's tracts or a divine intervention by means of the act of creation (Luhmann, 1996a: p. 138).

difference is a unit. The elements are elements only to the systems that use them as units and they exist only through these systems. This is resultant from its own autopoiesis.

Luhmann subsequently defines complexity: "*when within an interrelated set of elements it is not possible anymore for each element to relate at any time with all of the others, due to immanent limitations to the capacity of interconnecting them*" (op cit: p. 69). In this process it is necessary to occur the selection: "*complexity means commitment to the selection, commitment to the selection means contingency and contingency means risk*" (op cit. p. 69).

Each complex fact is based on the selection of relations between its elements, which it uses to exist and to maintain itself. The selection locates and characterizes the elements, even if there are other possibilities of relations, which Luhmann calls contingency. The real systems in the current world present the form of complexity as "*the need for maintenance of the selection of elements*", that is, the selective organization of the system's autopoiesis.

Luhmann, in many other texts, dealt with the problem of analytical manipulation of the complexity:

> *the problem of distinct levels of complexity has not been studied, in the theory of systems, as a problem of measurement of the complexity of the system's relation with the environment, since it was considered obvious that the environment would include a complexity larger than the system, and therefore, it was not necessary to measure this complexity* (Luhmann, 1996a: p. 139).

Both in "*Introducción a la Teoria de Sistemas*" (Introduction to the Theory of Systems), published in 1996, and in his last work, "*Die Gesellschaft der Gesellschaft*" (The Society of Society), published in 1998, Luhmann expands his reflections on complexity, emphasizing its importance in the systems' differentiation and constitution, stressing the role of the observer, recurring to new landmarks of reference such as that of operation and second order observation.

According to the author, "*different characteristics such as sense, self-reference, autopoietic reproduction, operational closing, with the monopolization of a proper type of operation, the communication, lead a social system (of the society) to build its own structural complexity and thus to organize its own autopoiesis*", what he calls organized complexity[14].

But what is complexity? Luhmann asks. Here, the author introduces in the complex system the figure of the observer[15]: "*Complexity is not an operation, it is not something that a system does or that occurs within it, but it is a concept of observation and description (including self-observation and self-description)*" (Luhmann, 1999: p. 136).

To understand what complexity is, Luhmann makes use, as he did in other moments, of the (methodological) resource of the form. It is necessary to ask for the distinction that composes it: "*The distinction that composes the complexity assumes the form of a paradox: the complexity is the unit of a multiplicity. A fact is expressed in two distinct versions: as a unit and as a multiplicity and the concept does not accept the fact that it is something distinct*" (Luhmann, 1999: p. 136*).*

Hence, complexity is not one or another, but both, that is to say, the unit of a multiplicity. But unit and multiplicity of what?

Luhmann one more time divides complexity with the assistance of the terms elements and relations, that is, supported by other distinctions. A unit is excessively complex, since it possess more elements and connects them (it joins them) for more relations. However, the social theory faced, according to Luhmann, two problems: the "limit" of connections of relations forcing the selection and the "time" factor.

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[14] To Luhmann, further than the complexity of the world, one can observe the complexity of a system and its environment. The environment always is more complex than the system. And it is only the complexity of the system that is organized complexity (Luhmann, 1990).

[15] Luhmann works with the observe/observer distinction, referring to the act of observing as operation, and the observer as a system that uses the observations in a recursive way as sequences to make possible the difference in relation to the environment (Luhmann, 1996a, P. 115-132).

The relation between the elements can grow exponentially when they are multiplied, and the system, consequently, grows. But in fact, the capacity of combining elements has limits, something that, even in a small number of combinations, forces a selective combination of elements.

Thus,

> *the form of the complexity is the limit to order, where it is possible yet for each element to relate at any time with other elements. Whatever exceeds it, requires selection and thus produces a contingent state, that is, every order possible of being recognized is dependent of a complexity, indicating that something different would be possible too* (op. cit.: p. 137).

Luhmann insists that evolution does not withhold the growth of systems at the moment it is not possible anymore to connect each element to another element and also control each disturbance coming from the environment; consequently, the selection of elements is essential when one deals with real systems: "*the form of the complexity is therefore the need to maintain a selective-only relation of elements, that is, the selective organization of the system's autopoiesis*" (op. cit. p. 138).

As an instrument of observation and description, complexity can be applied to all possible states, if the observer is able to divide the unit of a multiplicity into elements and relations. Thus, the complexity of the world can be observed, just like the system can observe itself[16].

Hence, the concept of complexity becomes more complete and more realistic when one considers the number of elements, the number of possible relations, the type of elements and the specific time of the relation between the elements. This is what Luhmann calls the multidimensionality of the complexity (Luhmann, 1996a).

This way, hipercomplex systems can be attained; these contain a plurality of distinctions of complexities, resulting from the fact that an observer can describe another observer's description of complexity, in other words, second order observations. It is with the relating of this process that Luhmann calls attention to the importance of the concept of complexity to the social theory.

Another important fact that is revealed is related to the time factor. The complexity, dissolved in the time dimension appears not only as a temporal sequence of different events, but, at the same time, as a "simultaneity" of events that have and have not occurred (Luhmann, 1999. P. 140).

Luhmann also lists two important aspects in the constitution of highly complex systems: the first one regards the operations' high degree of self-reference and the other one the representation of complexity in the sense form. According to author "*the recursivity of the society's autopoiesis is not organized by causal results (outputs as inputs) and neither in the form of results from mathematical operations, but in a reflective form, i.e., by means of the application of communication on communication*" (op.cit P. 141). Luhmann calls attention to unavoidable infinity of communication, that is to say, there is no last word. Each communication leads to a new communication.

To this reflective solution to the problem of sequential recursivity, to Luhmann, converges the most important evolving achievement, which made possible social communication: "*the representation of the complexity in the form of sense*" (op. cit. p. 142). Once again, Luhmann makes use of the form to distinguish two sides: reality from possibility, or yet, considering its operational use, present time and potentiality (op. cit. 142).

And it is this distinction that makes it possible to represent the coercion put into the selection of complexity (one side of the form, the other one being the complete relation of the

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[16] Every observation is a systemic operation, but nor every operation is an observation. The complexity is captured by the observation. Currently the observation is much more complex, since the observational systems became complex themselves (Luhmann, 1996a).

elements) in the systems that process sense. Each update of sense will, at the same time, add potential to other possibilities. Whoever has experience on a certain thing can also access other experiences that, in turn, can be updated or made possible.

In this process, it is frequent the differentiation between the update of sense and the available possibilities, that is, once again Luhmann underlines the question of form, a form that has two sides, where both sides are given; one has already been updated, and the other has potential. Again emerges the time factor. Time is necessary to cross from one side of the form to the other, or, in the words of Luhmann, "*just like time is always necessary when one wants to update the potential*" (op. cit. p. 143).

Finally, Luhmann returns to the issue of complexity reduction, which he thinks should not have to be treated as some sort of "*annihilation*" (cancellation of sense, values), but as a recurrent transformational process of potentialities into updates. Complexity, according to Luhmann, can not be confused with complication. Complexity is not transparent and intelligible. But the central question is how it can be observed. Who is the observer that is observed? Luhmann points out "*without the observer there is no complexity*" (op.cit P. 144) and that is why he makes use of the second order observer[17], through distinctions that he conducts, i.e., about how much the observer is able to divide the unit of a multiplicity into elements and relations.

3 - Complexity and science

Luhmann defined the general principles of a systemic theory of society[18] in which he formulates the basic concepts that would give unit to a general theory. Subsequently, he concentrated into developing monographs about specific systems and their practical peculiarities, in accordance with his general theory[19]. His argument was that the functional differentiation in the current world did not accept a common operative basis or a unique rationality that could surpass the idiosyncrasies of society, present in the constant complexification of its communications inserted in independent social systems (Nafarrate, 1993: p. 24).

Thus, science, studied under this theoretical referential, presents properties different from those of politics, religion, education, and so on. One could only state that those systems operate in a closed way, that they evolve through communicative processes and that they deal with the complexity of the world in a self-referring way:

> *The system of science can analyze other systems from points of view that are inaccessible to them. In this sense, it can find and schematize latent structures and functions. In opposition, we frequently find - especially in sociology - the situation in which the systems, self-referentially, develop means to access the complexity that is not accessible to scientific analysis and simulation. It is then that reference is made to "Black Boxes"*[20] (Luhmann, 1995: p. 14)

The way distinct systems deal with the complexity both of the environment and their own, depends on their structure, developed in the evolving process of their concretization. To these structures are related specific codes that advance the operational closing of the system: the

[17] As an example of second order observation, Luhmann mentions the change that occurred within 18th century Pedagogy, "when it became clear that the child was not an adult in growth, but an individual with a legitimate perception of the world, with its own fears, another way of valuation, other interests. With this conception, the 18th century introduces a project of observation to value what is relevant for Pedagogy" (Luhmann 1996a, P. 126).

[18] In German, *Soziale Systeme: Grundriβ to einer allgemainen Theorie*, 1984

[19] Luhmann wrote on the politic system, the educational system, the legal system, love, science, religion, among other things.

[20] About the concept of *Black Boxes*, first appearing in cybernetics, see Ashby, op. Cit.: 100.

true/untrue code is related to science, the have/not-to have to economy, and so on. As an example, this article will show how science deals specifically with the complexity. The intention will be divided into the analysis of the reduction of internal and external complexity, but presupposing a process that works according to its own operative basis.

As to the internal complexity, it comes across the Mertonian tradition of sociology, particularly the differentiation and institutionalization of the scientific disciplines. It would mean a process of internal differentiation of the science, based on institutional processes and an understanding of the universe in the terms of the 16th century scientific revolution, that is, the division of the object in subparts, which led to a fragmented epistemological strategy. In this sense, the communicational structure of the system, based on a specific epistemology, leads to an organizational structuration that fragments the disciplines[21].

This perspective changed in the last century, when the paradigm of complexity gained contours and proper right. The idea that the entirety is not the sum of the parts, mostly through the understanding of emergent properties, made it possible to understand that, before it became clear, the fragmentation led to a complexification that made impossible the communication between some disciplines, therefore it avoided communication between differentiated scientific semantics. In this context emerge concepts so wide as "interdisciplinarity", "transdisciplinarity", and "multidisciplinarity"[22], the system's attempts at dealing with its own internal complexity, with an increasing fragmentation and the differentiation of disciplines that close themselves within their own semantic universes.

The scientometric studies[23] made an effort at quantifying this increasing complexity presenting tendencies of scientific production. It happened mostly because of the increase in communication[24], that is, the impact the press had since its introduction in Europe back in the 15th century, and the resultant reproduction of scientific works on a large scale. Luhmann (1996b: p. 170) refers to the consequences of this event in terms of loss of simultaneity of the perception's impression: "*communication is not capable even of making simultaneous compact impressions. Instead it produces the temporalization of the complexity in the consecutiveness of what is different.*" It is related to the complexification of the system, since it finds a way to capture the past; the perceptions that long ago were lost due to the limited operation of the human memory are now printed in the most varied forms[25], able to overcome the locality and temporality of the perception. To this increase in the internal complexity, the system answers with mechanisms such as periodicals of Abstracts and, more recently, search tools in electronic libraries. But the construction of historical reality, within science, produces another consequence, it makes possible the self-description:

> (...) *following a long development in the building of complexity, such systems can already describe themselves taking into consideration their own history. The European society reached this stage, at the end of the 18th century, and the theoretical-scientific self-description of science just now seems to be reaching this point, with Kuhn and others* (Luhmann, 1996b: p. 170)

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[21] The reference serves as background to this process: "In the theory of evolution it is considered that the diversity comes from a single success: biochemist in the biological one; communicative in the social one" (Luhmann, 1996a: 47). In the course of the communicative forms' evolution happened the complexification of institutional agendas.

[22] On this discussion, see Gibbons et al., 1996 and Basarab, 1999.

[23] On the increase in scientific production, see De Solla Price, 1976; Bem-David, 1974.

[24] On scientific communication, its history and evolution, see Meadows, 1999.

[25] The growth curve of scientific periodicals, according to De Solla Price (op. cit.: p. 146), has increased a tenth each half century since 1750. In 1830, the process reached extraordinary numbers: the information would not reach all scientists and, even if it reached, they would not be able to read everything; the complexity became insuperable.

Concerning the external complexity, Luhmann's theory of social systems is related to the sociology of scientific knowledge[26], since it uses the system/environment form to discuss conditions and possibilities of the knowledge of the environment. The author's general theory of the systems, as a theory of self-recursive and operationally closed systems, assumes the society, the system that encompasses all of the others, operates without contact with the environment in the level of its own operations (Luhmann, 1995; 1993). This theory has many consequences to the theory of knowledge.

It is considered, then, that the construction of the scientific knowledge - without any unrestricted access to the environment, that is, the truth does not provide any guarantee of contact with a "real world" - is self-referring and, even if it is operating through heteroreferences, for example, when the system refers to phenomena of the environment, such as "politic crisis", "mithocondria", "to be", even then it uses its own communications to make this reference. Thus, since there is an increasing in complexity, smaller in the system and greater in the environment, the conditions of this unrestricted access, presupposed in realistic theories of science[27], are conditioned: the system does not have operational possibility to access all of the environment's characteristics, even the division in part of this environment operates with self-constructed causal selections, in accordance with the internal communications[28]. Therefore, the complexity is its own closing engine; the system closes itself to have access, and works methodically to differentiate the world, in conformity with its internal code, presupposing a reduction in the absurd complexity.

However, with the closing of the system and the self-reference, the resultant constructivism has to answer to an objection, which is, "*the technique that works*" (Luhmann, 1996b: p. 186). Complexity is a condition and not an impediment to the construction of knowledge. It means that, even operating autopoietically, the forms constructed within the system will present as a functioning possibility the environment itself: "(...) *the systems can only produce structures that are compatible with the environment* (...)" (Luhmann, 1996a, P. 203).

Thus, in line with the solipsism of which he is commonly accused, Luhmann devises what he has called the realistic cognitive theory (Luhmann, 1996b: p. 187), whose references, in the case of science, are constructions scientifically formulated in the systemic context, that is, a rupture with the references to individual perceptions in favor of the communicational historical of theoretical sources: "*therefore, the theoretically selected expectations are instruments to recognize something that remains unknown*" (Luhmann, 1996b: p. 187). The environment's complexity continues to be invincible, the world is not less complex with its knowledge, the world always "is".

These conceptions also have a pragmatic consequence that can be traced back to authors such as Bacon and Giambattista Vico (1668-1744)[29]. It is the idea that we only know that which we produce, and we produce it only with the expectation that the affirmations will be satisfied in the future. The temporality of the processes is reintroduced; it emerges in the process of constructing knowledge, Prigogine's arrow of time. Nevertheless, it must be said that the universe of Bacon and Vico was very much different from that of Luhmann or Prigogine and, somehow, consensual perceptions seems to be at play, at distinct places and historical moments, but with radically different theoretical bases.

Would not it be the return of what is always present, that is, the past of the scientific system communicatively captured in perceptive forms that, autopoietically, always return? What

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[26] The reference to the sociology of scientific knowledge is the seminal book of David Bloor, who created the Strong Program of Sociology of Knowledge of Edinburgh's School, "Knowledge and social imagery", 1991. See the article of Palácios, 2002.

[27] For example, in the logical empiricism of the Circle of Vienna.

[28] If it was only a matter of codification/translation, the improvement of the form would be solved, for example, with the evolution of formal sciences such as the Mathematics. The problem is the systems' operation: if the act of operating of the environment is rational, like Hegel wanted it to be, that of the system is too, but with its own rationality, without any reference in the environment. Thomas Mann's doubt in Doctor Faust persists: "Then which amongst the invented ones (languages) would it (the nature) choose to express?" (Mann apud Hochman, 2002: p. 231).

[29] On the Bacon's influence in Vico, see Burke, 1997.

becomes clear then is the extreme complexity of the scientific system, whose historical operation progressively adds more and more complexity.

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Summary

This paper discusses Niklas Luhmann’s understanding of complexity, its function in the theory and the different ways of its use. It starts with the paradigmatic change that occurred in the field of general Science, with the rupture of the Newtonian model. In the 20th century, the paradigm of order, symmetry, regularity, regulation of the intellect to things, collapses. Based on new formulations of Physics, Chemistry, etc., a new universe is built on bases radically opposed to those of modern Science. Chaos, the procedural irreversibility, indeterminism, the observer and the complexity are rehabilitated. This new conceptual context served as substratum to Niklas Luhmann’s theoretical reflection. With his Theory of Social Systems, he proposes the reduction of the world’s complexity. Social systems have the function of reducing complexity because of their difference in relation to the environment. On the other hand, the reduction of complexity also creates its own complexity. Luhmann defines complexity as the moment when it is not possible anymore for each element to relate at any moment with all the others. Complexity forces the selection, what means contingency and risk. Luhmann expands the concept of complexity when he introduces the figure of the observer and the distinction of complexity as a unit of a multiplicity. He also deals with the limit of relations in connection, the time factor, the self-reference of operations and the representation of complexity in the form of sense. To conclude, the paper discusses the complexity in the system of science, the way it reduces internal and external complexity, in accordance in its own operative basis.

Key words: Complexity, social systems, science, complex world, system and environment, autopoiesis, second order observation, interdisciplinarity, transdisciplinarity and multidisciplinarity.

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