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Complex Systems Theory and Social Systems Theory in the controversies of complexity

Gastón Becerra **https://orcid.org/0000-0001-9432-8848**

Conicet/ Universidad de Buenos Aires, Argentina, gaston.becerra@sociales.uba.ar

Abstract: The irruption of complexity in the 1970's and 1980's motivated a certain diagnosis of crisis as regards science and scientific knowledge. Clarifying the scope of this diagnosis is key to understand the meaning acquired by "complexity" in two particular programs: the Theory of Complex Systems (TSC) by Rolando García, and the Theory of Social Systems (TSS) by Niklas Luhmann. To advance on this goal, we propose a counterpoint on 3 particular problems –the scope of explanations and scientific predictions, interdisciplinarity, and the social and transforming nature of knowledge– which we address with each program's metatheoretical characteristics and epistemological assumptions. We conclude by advocating an interpretation of TSC in which a more moderate position is observed than that in TSS in the controversy of complexity.

Key words: complex systems, social systems, complexity, Niklas Luhmann, Rolando García.

Resumen: La irrupción de la complejidad en las décadas de 1970 y 1980 motivó un cierto diagnóstico de crisis de la ciencia y el conocimiento científico. Indagar el alcance de este diagnóstico es central para comprender el sentido que adquiere la complejidad en dos programas particulares: la Teoría de los Sistemas Complejos (TSC) de Rolando García, y la Teoría de los Sistemas Sociales (TSS) de Niklas Luhmann. Para aclarar este problema planteamos un contrapunto en torno a tres problemas particulares –el alcance de las explicaciones y las predicciones científicas, la interdisciplina, y el carácter social y transformador del conocimiento–, que atendemos junto a las características metateóricas y los supuestos epistemológicos de cada programa. Concluimos abogando por una interpretación de la TSC donde se observa una posición más moderada que la de la TSS en la controversia por la complejidad.

Palabras clave: sistemas complejos, sistemas sociales, complejidad, Rolando García, Niklas Luhmann.

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Introduction

Studies on complexity and complex systems are a multidisciplinary, little integrated field. Among the various trends that ask for a place in the understanding of complexity, two are noteworthy; on the one side, the systemic-cybernetic that studies phenomena from various domains from a systems' standpoint, and which has Ludwig von Bertalanffy, Ross Ashby, Norbert Weaver, Gregory Bateson and Heinz von Foerster, among others, as main referents; and on the other, the "sciences of complexity", characterized by their algorithmic approach to deal with adaptive, dynamical, unbalanced and nonlinear systems, with referents such as Edward Lorenz, Benoit Mandelbrot or Ilya Prigogine. The meaning of the "complexity" notion is neither univocal through these trends –whose developments have taken place with certain independence (Phelan, 2001)– nor inside them –there are more than 40 definitions applicable only to "sciences" (Lloyd, 2001). And this not to mention the large amount of literature that identifies the complexity with a worldview of spiritual, literary, ethical and political ideas.

The irruption of complexity in the 1970's and 80's –and still today in the current projections– has had a large impact on the way we understand scientific knowledge. There is controversy as regards this irruption, for some authors, studies on complexity are a scientific revolution in the making (for instance, Waldrop, 1992; Wolfram, 2002); for others, it is a discourse inflated with unscientific overtones (for example, Horgan, 2015). This controversy is the broadest context where our analysis locate (for the defense of the controversy as an analytical framework, Nudler [2009] may be consulted; for a background of such approach in the field of complexity, Rodríguez-Zoya and Rodríguez-Zoya [2014] can be consulted).

Our goal is to elucidate the meaning acquired by complexity in two particular programs, i.e., Rolando García's theory of complex systems (henceforward, TCS), and Niklas Luhmann' theory of Social Systems (TSS). Both programs deal with complexity and complex systems in a relevant manner for social sciences, nourishing on the contributions from the two trends above. To do so, we propose to locate both programs in the controversy on complexity, focusing on three specific problems: the scope of explanations and predictions of scientific theories, disciplinary specialization, and the social and political character of knowledge and its capacity to transform and intervene on reality.

This work is organized as follows. In the first section, we briefly clarify the controversy, which for us, revolves around a certain diagnosis of crisis

regarding science in the name of complexity, and then we point out three specific problems to other the counterpoint. In the second section, we include a quick presentation of TCS and SST –more complete presentations of such programs have been developed in other works cited in context. In the third section we make a counterpoint between TCS and SST regarding each particular problem. We conclude with the summary and assessment of how each program approaches the diagnosis of the crisis of science.

The controversy on complexity

This work sets off from the following proposal to focus the controversy that erects around complexity: the quid or heart of such controversy is a certain diagnosis of the crisis of science and scientific knowledge. The shared supposition that enables this controversy is that complexity introduces changes and contests some salient characteristics of modern and classical science and scientific knowledge; the dispute takes place over the scope of such questionings. Beforehand, we may have two suppositions:

a) Those who state that developments on complexity concur on "scientific revolution", or that are a "new science" with questions regarding multiple aspects –logical fundamentals, social organization, theoretical dispositions, method, intentions to act on the world, etc.– so that their emergence has made a "crisis" of science evident.

b) Those who understand that development on complexity update the classical science in some particular aspects, but they do not manage to modify its core features, and which as regards the former, understand that in the background of the "revolutionary" preaching of complexity there is an "unscientific" tendency.

With a view to comparing the programs of TCS and SST, here we propose to limit the controversy to three problems in the scope of scientific knowledge construction, and in this way, to the scientific endeavors in conflict due to complexity.

The first problem deals with the scope of the explanations and predictions of scientific theories. In this regard, a number of authors have stated that various ideas associated with the emergence of complexity –such as self-organizing logics, nonlinearity, the constituting heterogeneity of complex phenomena, the demonstration of incompleteness, and the recognition of the historic-social and contingent nature of scientific knowledge– suppose a critique to some features associated with a science marked by the physics of the XVIII century –such as the atomist, deterministic and causal tendency–, but also the explanatory and predictive attempts of science ever since (Mikulecky, 2007; Najmanovich, 2002).

The second of the problems deals with the tendency toward disciplinary specialization. The following observation on the reception of complexity in social sciences is a good example of how these developments usually become interdisciplinary.

> Complexity calls to link and articulate the evident dispersion of knowledge, with a view to increasing and improving the comprehension of the natural and social world. To do so, it is necessary to overcome the disciplinary boundaries, carry out an oblique reading (nonlinear) of reality and articulate it with the logic of complexity and the need to express how the multiple dimensions of knowledge are comprehended (Aronson, 2013: 17).

The third problem we are interested in approaching refers to the science-society relationship. In recent years, science has been contested by the society that presents it with problems and want to have a voice in the assessments made on it, considering the potential risks of the applications, of the costs implied and more so, in the way of relating the intervention and transformation of reality. It would be erroneous to state that the emergence of complexity is the (only) cause for these complaints, indubitably though, it expresses as regards the controversy that enfolds it supposes to contest the meaning and scope of knowledge. As indicated by Nowotny (2005), the meaning of "complexity" is severely impoverished, if it does not include the intricate relationships and mutual uncertainties produced in the co-evolution between science and society.

The three aforementioned problems address scientific knowledge, the conditions of its production and its link with reality and society. The stance of the programs in the controversy will be heavily marked by their particular epistemology, and since the two programs inscribe in the broad field of constructivism (Becerra and Castorina, 2018), it will be necessary to consult their suppositions in this regard and contrast their differences in order to contextualize and elucidate their stances in relation to complexity.

Brief presentation of TCS and SST

Rolando García's TCS is an integral framework to analyze complex problems that require an interdisciplinary approach (Becerra and Amozurrutia, 2015; García, 2006). TCS comprises a brief theoretical formulation with a conceptual language and a set of general principles on the composition, dynamic and evolution of a system, methodological guidelines that conduct the interdisciplinary work and a constructivist-based epistemological substantiation.

For TCS, complexity is and adjective applicable to a cut of reality, in such manner that an object of knowledge is complex for a subject when this does not have the capabilities to interact with the relationships of the components of the system. This excludes its use as a noun, referring it independently from a phenomenon and subject of knowledge, or enabling the question: "what is complexity?" (García, 2000: 67).

For its part, the concept of system remits to a way to represent or organize phenomena with components of diverse material nature and in which various processes concur in an inter-defined manner (García, 2006: 21). As a representation, the systems are built by a subject of knowledge. A central element of this construction is the cut of some elements of the reality, relegating others to the surrounding. This decision is then reinserted in the analysis of the evolution of the system, following an open-system model with dissipative structure (García, 2006: 60-61).

A paradigmatic characteristic of TCS is its interest in building systems on problems that are not restricted to the material domain of a particular discipline (García, 2006: 33), but by those which involve physical-natural and social-science elements. This links the previously mentioned notion of complexity with the difficulty in TCS: it is a methodology that intends to accomplish an integrated analysis of the processes that occur in a complex system and that explain its behavior and evolution as an organized totality (García, 2006: 88).

The condition that enables this analysis is that the interdisciplinary team carries out a joint construction of the system, in virtue of sharing a certain "epistemic framework" understood as:

> [...] the set of questions doubts that a researcher proposes regarding the domain of reality they have decided to study. Such epistemic frame represents certain conception of the world and, on many an occasion, it expresses the hierarchy of the researcher's values (García, 2006: 36).

As pointed out in other works (Becerra, 2014b; Becerra and Castorina, 2016a), the questions in the background of this approach are clearly pre-theoretical, what aspect of reality seems problematic? Why and what for do we want to intervene and generate knowledge?

Research on complex systems has two stages: the first points at the diagnosis and consists of identifying processes and mechanism involved in the genesis of the problem. The second points at a proposal for a plan to intervene to build an alternative scenario. The passing from a moment to another is not linear. The transformations induced in the system usually impact on scarcely studied areas of the system or its environment and cause

unforeseen behaviors, in which case the delimitation of the system must be revised again, even to the extent of needing contributions from new disciplines.

Niklas Luhmann's SST intends to be a general theory with which to define in a unitary manner the field of study of sociology (Luhmann, 1998). SST comprises a vast conceptual frame, methodological guidelines linked with second-order observation, and similarly to TCS, a constructivist epistemology. The first of the (various) meanings we find in SST about complexity implies dealing with the element / relation distinction (Luhmann, 1998: 47). This refers to a immanent limitation of the system in its capacity to link elements so that it is forced to reduce complexity by means of selecting which relations will be updated.

Far from meaning a simplification, this reduction is a construction of a complexity structured under the selectivity of the system and before the ungraspable complexity of the environment (Luhmann, 1998: 50). As in TCS, this first meaning deals with complexity as an attribute, the systems are complex owing to this compulsion to select. From such complexity, Luhmann (1998: 50) derives a second meaning that approaches a cognitive or reflective problem, which is referred to with the distinction between information / indetermination, implied by the measure of information the system lacks in order to produce their descriptions of the world and itself. In the systems that reduce meaning, this complexity may appear problematized as fear, insecurity, risk, planning problems, et cetera.

The reduction of complexity works as the driver of the evolution of the systems. The complexity structured by the system is subject to the same guidelines that have built it, in such manner that once a certain threshold of complexity is reached, the system cannot longer ensure its unity and new systems will appear inside of it to reduce complexity with more precise distinctions. From the theory of complexity comes a theory of differentiation, strongly linked to the evolution of adaptive systems.

According to Luhmann, a number of differentiation forms have taken place in society, being the functional the one that characterizes modern society. In it, the systems are arranged –for an observer– as specialized (and partial) forms on dealing with problems (Becerra, 2013).

Communication operates in a factual manner and is empirically observable. SST methodologically commits to a "second-order" observation work, understood as an observation destined for observing how another system is observed, what the distinctions and schemes it uses, and what the blind spots are. In particular, second order observation may be useful

for seeing how various social systems reconstruct a certain element of their environment, subjecting it to different processing. Luhmann (1998: 72) is explicit in the sense that such observations, in a systemic-functionalist proposal, is enabling comparisons and opening the existing to other possibilities.

This sort of analysis is characteristic of the meaning Luhmann gives the construction of theory: abstracting phenomena and observations building a proper complexity, which allows establishing increasingly more improbable comparisons (Luhmann, 1997: 294). For its part, this reorientation for theory advances a certain criterion of truth, heavily linked to redundancy and the demand for coherence, being these internal criteria of the operation of the science system (Becerra, 2014a and 2018).

TCS and SST in the controversy on complexity

Problem # 1. The scope of explanations and predictions of scientific theories

Those who state that studies on complexity and complex systems account for a crisis in science usually consider that these make us face a limit to our capability to predict and explain. Here, it is convenient to distinguish two sorts of questions underlay this claim; those that involve explanation problems –such as determinism, causality or emergence– and their relation with prediction, and those that involve epistemic problems regarding the construction of the system –as the cut of its domains or the availability of information about them–.

The main purpose of TCS is to explain the functioning and evolution of a system. In this endeavor, García (2006) is explicit on the fact that the orientation of explanations of TCS is causal.

> Research [on complex systems] consists in proposing successive modellings up to reaching an acceptable model, understanding as such a model that allows formulating causal explanations of the phenomena that are objects of study... the set of revelations therein invoked is the explanation of the functioning of the system (García, 2006: 84 [emphasis is ours]).

The "relationships therein involved" referred in the quotation are inferences that theoretically link the cut-up phenomena. As we have pointed out in other works (Becerra y Castorina, 2016a and 2018), the constructivism subscribed by García understood a subject –here science– builds knowledge approaching reality in an asymptotic and unfinished manner, taking notice of the resistances that it offers to its actions.

In this stance, García is tightly bind to the epistemic realism underlying in Jean Piaget's work. Consequently, the causal models resorted to in TCS must be coherent with tis ontological supposition, and thus flow through imbricated structures in which emergent levels of proprieties, phenomena and autonomous behaviors –that is to say, a bottom-up causality built on relationships between elements–, in balance with the perturbations and restrictions of the totalities over the parts –top-down processes– (García, 2006: 187-190). That a perturbation triggers a compensating mechanism or a full restructuring is dependent on both the internal history of a system and its environment conditions.

Well now, TCS also recognizes that causal explanations for systems with imbricated structures will hardly allow for the prediction of their future states (García, 2006: 50-51). However, this difficulty does not imply that the system behaves unpredictably, which would render explanations impossible. In point of fact, García has insisted on the need to distinguish, predictability and determinism, especially from the teachings on Lorenz's deterministic chaos and the consideration of systems highly sensitive to initial conditions (García, 2006: 133-134; Inhelder *et al*., 1981: 144). At this point, the problems of explanation connect with those of the system construction. In other words, the empirical limitations in the construction of the system turn into limitations for the explanation. This is a characteristic situation in the explanatory attempts of complexity studies:

> Since complex systems are open systems, we need to understand the entire environment of the system before being able to understand the system, and of course, the environment is complex in itself. There is no human way to do so. [...] The problem aggravates due to the fact that what is left outside interacts with the rest of the system in a nonlinear manner and so, we cannot say what the effects of our reduction of complexity will be (Cilliers, 2005: 258).

Well now, the way of understanding this limitation is precisely the watershed in complexity studies. For example, following the previous quotation, Cilliers (2005) warns us about our being finite and that our epistemic attitude should be sufficiently modest to permit revision and criticism to later become a certain skepticism. For their part, the incompleteness of knowledge and the need for its continual revision are implied in García's constructivism, both in his critical realism and in his characterization of the social cognoscente subject and supported on them, García puts forward a proposal that makes the cut of problems the central moment of the building of the complex system, and that points at the balance between the denaturalization or reality and the feasibility of the study and

the aims of the team as its main challenge (García, 2006: 95). Though, the realism of his epistemology prevents him from taking postmodern stances.

Consequently, TCS affirms that the explanation is possible –even if these explanatins address a particular cut– and that these problems may be dealt with causally –with models of multiple and circular causality–. Then, predictability is a stringent requirement, for a certain degree of uncertainty is unavoidable, but not because of that, an endeavor that has to be abandoned, instead it becomes a fundamental objective of complex systems studies. The problem is practical, not metaphysical, which justifies the operation on the structuring. This is far from building a devastating vision of science. At best, the image of the science under criticism would be one overly restricted: that which equates explanation and prediction, which substantiates prediction with a pre-determinist vision of reality.

For SST, complexity expresses mainly as forced selectivity. In this there is no big difference with the statements above, though the orientation taken by these reasonings in Luhmann makes them more radical than García's.

In accordance with the cybernetic orientation, Luhmann (1998) opts for observing the observer observing their environment, becoming paradoxes. Here, SST might break these paradoxes with practical decisions, but the anti-humanistic and anti-normative conception of the author (Funes, 2004) works as a blockage. As he deals with such paradoxes, his approach enters into a cycle of unpredictabilities. It is before complex problems –such as ecological hazards– that this statement reaches its most characteristic tone:

> Knowledge on ecological contexts grows fast because of the knowledge imposed by natural sciences. We are aware, wider than any previous society, of complexity, and more than in any other society prospectively successful research possibilities are at sight. Nevertheless, un-knowledge grows disproportionately at once; to this pledge the mathematics and techniques of simulation, only to reaffirm the impossibility of predicting. Society, with its knowledge on the rise, (not in-spite-of, but because its knowledge increases) is not able to inform on the relationships established between societal changes and changes in the environment. What in the past appeared as an ordered kosmos, now appears as a sphere for possible catastrophes (Luhmann, 2007: 881).

As regards the explanatory models, these limitations favor the adoption of a functional-comparative standpoint regarding the various possibilities open to reduce complexity from the perspective of systems. From such point of view, observations based on causal relations appear as an attempt to make the paradox asymmetric: self-referential systems define the limits of the internal / external, in such manner that they stabilize this distribution

necessary for any ulterior imputation. However, even if causal explanations are wielded (Luhmann, 1998: 34), the version of constructivism upon which Luhmann locates makes us be precautious. Luhmann's (1990 and 2006) epistemological project has the entire radicalization of constructivism as a core, via considering society an epistemic system. An essential element of such radicalization is the denial of every exteriorization of the constructions of knowledge. Luhmann adheres a more skeptical version of constructivism than García, remarking there is nothing in the environment that might match cognition, since it depends on the distinctions introduced by the system with its observing (Becerra and Castorina, 2018). Perhaps, it is this limit that SST, unlike TCS, does not move from relations to causal explanations (in García's terms).

Problem # 2. Disciplinary specialization and the challenges of inter-discipline

Another important point in the controversy of complexity occurs at the disciplinary limits organized by modern science. Among the strongest claims from those who notice a scientific revolution in complexity, there is the idea that studies on complex systems force to cross –or on occasion, to suppress– such limits. "Interdiscipline" is the term that gather this claim, one so generical that a bibliographic review is enough to notice there is a plurality of meanings; on occasion, it is associated with a research methodology, a challenge to the institutionalism of science, a philosophy and even an ideology (Klein, 1990).

Even if we refer to a single link between theoretical, methodologic and technical contributions from various sciences, we notice such variety of interdisciplinarity because there are taxonomies (Klein, 2010). Then, we opted to resort to a definition as a criterion. Else, we should enquire on the meanings involved when TCS and SST speak of interdiscipline.

As we mentioned, one of the central components of TCS is an interdisciplinary working methodology for research teams with a multidisciplinary background. The distance between the "multi" and "inter" is noticed, according to García (2006: 32), in the way of conceiving the problem and work:

> While in the case of multidisciplinary researches are usually added the contributions each researcher makes from their particular discipline on a general problem that can be analyzed from various standpoints, an interdisciplinary research implies the integration of these approaches for (that is to say, prior to) the definition of a problem.

In this definition we already find the central idea that social practice to generate theoretical instruments, which allow organizing the interactions with the system. Particularly, it is an approach integrated by various explanatory frameworks, tending to build comprehensive explanations regarding a problem with a synthetic model. The result is an interdiscipline that takes the form of a dialogue (García, 2013). The key of this integration is the joint construction of the object of study –the cut of the complex system proper. TCS points out as a main condition for this that the cognitive subject –research team– shares a diagnosis and guiding question. In the previous quote a common approach is referred to. To clarify that what is at stake here, one must go back to the terrain of epistemology.

In the constructivism by García, on the basis of his collaboration with Piaget, one particular notion is underscored, that of the epistemic framework. Even if it has acquired various meanings at different moments of his work (Becerra and Castorina, 2015), we understand that the center of its definition is the conditioning of the social over the cognitive (Becerra and Castorina, 2016b). From here, TCS is defined as an "extra-disciplinary regulation of social content" (García, 2006: 106), which is incorporated into the theorizations via the structuring practice.

More specifically, the epistemic frame is expressed in the cut of the problem, in view of certain social and political interests. Then, a dialectical march of interrogations and differentiations of specialist knowledge is set into motion; they are the center of the structuring activity and lead to the construction of a model,

For their part, the programmatic objectives of SST relate in a different form with interdiscipline. In SST, disciplinary specialization is the result of the internal differentiation of science, seeing its way of building greater complexity, and as a way to surpass the performance of a hierarchically ordered science (Luhmann, 1997: 327). Interdiscipline, in this vision, is the form in which the interdependence of such specialized systems is evinced (Luhmann, 1997: 327-329). Luhmann characterizes three situations:

1. The casual or occasional contact between parallel programs of science (theories and methods of various disciplines), by means of which a discipline incorporates a product of the other with unexpected effects on the science that incorporates it.
2. Cooperation between disciplines around a problem and in the context of a research project that defines a certain sort of work and regulates it by means of objectives – here we might locate the interdiscipline of TCS.

3. An effort to transcend the disciplinary boundaries, proposing abstract distinctions upon which new paradigms may be founded.

Meanwhile, the interest that motivates Luhmann is to revitalize the sociologic theorization. The interdisciplinary collaboration he points at does not go beyond theoretical dialogue. Even if Luhmann explicitly recognizes himself in the first situation of interdiscipline –especially because of the incorporation of autopoiesis into sociology– it is clear he leans toward the third –with the development of cybernetics and systems theory.

It would be to bridge conceptual gaps focusing on a particular theorization (systems), drawing analogies between domains and translating them into a more rigorous language. In any case, Luhmann does not offer any method, recipe, guidance or recommendation for this development. It may be conjectured that such lack of guidelines comes from Luhmann's efforts to free science from any kind of normativism, prioritizing the "inventive liberty" of theory, using Zolo's (1995) expression – which may be ironical. For SST, a novel theory is a communicational proposal in the evolution of science, a *pre-adaptative advance* to wait for propitious conditions (methodlogical, technical, educational, etc.) to be selected and replicated. Even, in the face of the usual criticism that SST is incompatible with empirical science, Luhmann (1992: 1439) suggests that the lack of more advanced methods and techniques for social sciences is to blame. This raises the question whether relationships with the sciences of complexity might be able to step forward, being this a derived problem for the comparison of TCS and SST.

As mentioned in the introduction, the systemic-cybernetic approach and the sciences of complexity do not share a common history; the former were born at least three decades earlier than the latter, and have a much broader, encompassing approach. Ever since, the orientation of both has taken divergent trajectories; the systemic-cybernetic tradition has deepened into epistemological reflection –in which constructivism has a central role– fostering and problematizing interdisciplinary practice; they have opened and incorporated (qualitative) techniques and approaches of social sciences, all these scarcely explored aspects in the "sciences". Conversely, the latter have developed a sizeable number of formal models and have furthered the state of the art of computational techniques and tools (Castellani and Hafferty, 2009; Maldonado, 2012; Reynoso, 2006).

At the technologic-methodologic level, at the moment of referring the relation between TCS and the sciences of complexity, the scarce literature has repeated a passage worth quoting:

> In recent decades, a lot of literature has been produced as regards what is called 'the sciences of complexity', something I deem wrong. As it is known, the explosive development of this sort of output is due, to a large extent, to high-performance computers, extremely fast, that allow tackling problems that in the past were out of the reach of mathematical models. The variety of problems that were approached and the number of spectacular results obtained have allowed hugely expanding the comprehension of nonlinear processes, but this has also regrettably led to what I have allowed myself to call illegitimate mathematical extrapolations and correlated fallacies. A certain imperialism of computers prevails in present-day science; it makes every study on processes non "modellable" by means of nonlinear differential equations (or by other more sophisticated modellings) seem unscientific (García, 2006: 75).

In our reading, this passage must be interpreted as a warning not to disregard the epistemic problem that here, we located at the heart of TCS, which is far from disavowing the use of computational models and techniques in addressing complex problems.

In point of fact, giving the author of TCS a stance against these tools would be incoherent considering that not only did he boost the adoption of the first scientific computers in Latin America, but also worked with the earliest predictive models in the weather problem, in addition to explicitly possessive assessment regarding their usefulness in social sciences as prospective instruments of scarcely explored situations (García, 2006: 134). In any case, the problem is not the technique itself nor the effective possibility to quantify certain phenomena. What is criticized in these "importations" is the unnoticed incorporation of philosophical assumptions –as determinism or reductionism– and metatheoretical stances that influence on the techniques – as the reductionism of some simulations– incongruous with the vision defended by the constructivist epistemology upon which TCS supports.

For its part, SST virtually does incorporate any technical or methodological element from the sciences of complexity, maybe because of the lack of deeper methodological guidelines. Recent developments such as those that include simulation techniques and calculation of entropy in communication and emergence of attractors might reverse this situation, though at the moment, their application does not go beyond illustrating partial aspects of the theory and the very incipient stage of those effort prevents us from supposing they are capable of giving SST an approach that enables it to rethink their addressing of complexity.

Owing to the hegemonic place SST still holds as an exponent of complexity in sciences, this particular relation with the "sciences of complexity" makes us face two confronted readings. An optimistic,

Luhmann might be a catalyst of the interest in complexity; or else, he might be a distractor for the most novel methods of the sciences of complexity. Here, we believe that SST is likely both at once; a catalyst of the interest in complexity, in a broad meaning, –which amounts to an epistemological reflection, and which also includes a questioning for the complexity as a social and epistemic category–, and a distractor for the incorporation of techniques and models.

Problem # 3. The knowledge-society relationship and the intervention on reality

The final problem we are interested in addressing regarding the controversy on complexity refers to the goal sought by building scientific knowledge, something we locate in the science-society relationship.

The goal of TCS regarding complexity is to problematize the tools of knowledge by means of a reflection on the epistemic subject, their structures and actions to transform reality with them. In this knowledge-society-reality relationship, there are two central elements of constructivism upon which TCS supports.

On the one side, as we mentioned on the notion of epistemic framework, the cut and the signaling of the problems the construction of the complex system addresses in the interdisciplinary game are conditioned by a conception of the world and certain social and political values, which brings into play a certain ideal state of the system. Then, models tend to search for solutions; deliberate actions (strategies, tactics and operations) on the causal mechanisms (processes) identified in the diagnosis. Here, it is noticed why a certain compatibility with realism regarding the notion of systems is fundamental for TCS.

Furthermore, even if this consideration of the social in the epistemic construction of the systems is "state-of-the-art" in the context of interdiscipline debates (Boix-Mansilla, 2006), if we consider the subject of knowledge in García's epistemology, we discover a tension: the interdiscipline promoted by TCS is "aimed-at-specialists". This seemingly disregards the knowledge, meanings and valorizations of the social actors involved in the problems.

In fact, in TCS public participation is restricted to pointing out the problems (García, 1990: 570). These limitations render TCS criticizable by scientism. It may be conjectured that this blind spot does not come from the author's political position, but else, from his disciplinary conditioning, García was a physicist alien to the interactive lessons of social sciences; however, it should also be assessed what the influence on this limit is that the

systemic conceptualization of TCS moves closer to an early cybernetics than to the later of the self-referential turns (Becerra, 2016).

In any case, the works revised in this part of TCS (for example, Amozurrutia, 2012) suggest including –into the epistemic moment– qualitative techniques that promote the joint analysis with the actors, and then –at the prospective moment– the discussion of the various scenarios in workshops and working groups with local communities to ensure that actions and policies are sufficiently legitimized so as to be implemented.

For its part, the notion of "problem" which comes into contact with SST –particularly, with its functionalist methodological reflection– is not equivalent to the category of "problems"; while the former depend on the standpoint for the observation of each system, the latter are pre-theoretical and analytic-based. When Luhnmann changes the subject of knowledge from the individual to a differenced society, he fragments the base of the epistemic framework that might become a problem in order to reinsert it into each system. Then again, the relationship knowledge-science-society refers to two aspects characteristics of Luhmann's epistemology.

In the first place, the consequences of this fragmentation are noticeable: "the ecologic problems cannot be approached as a unit that may be unanimously solved in society, but such unit is broken down into the various perspectives of the systems of functions". (Luhmann, 1997: 149). Fuchs and Hofkirchner (2009: 114) have noticed the impact of radical constructivism on this stance; such radicalism calls in question the existence of actual problems to replace them with problems built on communication.

Moreover, differentiation implies that once the problem is known, the systems generate their own complexity in this regard; hence, the resonance spaces (in society) in which a modification of reality might unchain new balances double up (Luhmann, 1989: 118-120). This turns into a discouraging vision of the intervention of SST, considering the complexity. The author's tone is worth underscoring:

> It must come as no surprise that these analyses are not conducive to offering counsels that concur with the format of ecological problems... [S]ome relatively weak changes usually cause, on other systems, over-proportioned changes. [...]. In the face of the typical functional differentiation, therefore, face to face with a high complexity that reinforces and diminished itself, and that causalities cannot be centrally controlled, such a catastrophic development is, in the long term, probable (Luhmann, 2012: 91).

The place this leaves for the Science social system before the complex problems follows the epistemological paradox, founder of Luhmann's constructivism: (only) observing. More specifically, observing the observation

of the other systems and offer a reflection on the risks and latencies. In Luhmann's words (1989: 131), it is rather: "[...] expanding the perspectives regarding the problems than suppressing them". However, one may think that it is not so much the idea of intervention itself, which is rejected, but a simplistic or hierarchical one that expects science to dictate courses of action for the rest of social systems.

In fact, in *Ecological communication,* Luhmann offers the possibility of a non-hierarchical intervention on complex problems, –as regards the resonance proper to the various systems, their local process, time scales and feedback–; this is something that has been noticeably reflected in literature (Buchinger, 2006; Mascareño, 2011; Wan, 2011).

Though, secondly, this possibility seems to go against the anti-humanistic and anti-regulatory orientation of SST. As for anti-humanism, it must be assessed how the social values and individuals' actions (e.g., the team that deals with the problem) can condition the developments of science. Regarding the considerations on science, Luhmann (1997: 419-420) was explicit to deny this possibility, with a proposal that links autopoiesis and objectivity, understood in the most limited meaning of absence of values. Perhaps owing to this, some authors while pondering the systemic intervention go to the extent of promoting a critical review of autopoiesis (Fuchs and Hofkirchner, 2009).

As regards anti-regulations, it must be pointed out that the meaning that Luhmann gives to it is to avoid the introduction of asymmetries that condition the observation in relation to theoretical performance. The answer, maybe, is simpler here: various decades after the formulation of the theory, it may be affirmed that this has been fruitful enough to being able to suspend such demand without restricting the scope of their observations.

Conclusions: the diagnosis of the crisis of science in the name of complexity

We opened the work proposing a reading the controversy on complexity that located on the focus of the dispute a certain diagnosis of crisis of the science and scientific knowledge considering the emergence of complexity. That fact that developments on complexity introduce changes, innovations and questions on some aspects of science is trivial. The controversy unfolds on the intended scope and nature of these changes, do the developments of complexity face us with a new image of science, whose intentions and practices differ from "classic" science? Do

the developments of complexity update the science in some issues without modifying their central feature and most characteristic orientations?

The stance of TCS in relation to problem #1, which we have analyzed, allows us to observe that this program is far from denouncing a devastating crisis in science and scientific thinking from the considerations of complexity. The main challenges to explain and predict complex systems lead neither to ask for new understanding frameworks nor criticize the present tools of scientific thinking, not even to quit the iconic intentions of science such as advancing our knowledge of reality.

There is criticism, however, a simplistic vision of science that supports such goals in suppositions such as atomism or linearity. And indeed, some warnings are offered: on the difficulty of generalizing conclusions outside the local considerations of each system, or on the need to accept that not every explanation will be plausible to be expressed in formal terms. These warnings seem to be aimed only at those who intend to assess studies on complexity under the criteria of physical and logical-mathematical sciences.

At most, what TCS puts forward, as something critical –in the sense of a necessary and urgent innovation– is the need to resort to interdiscipline to deal with certain problems. In the discussion of problems #2 and #3, we notice the conditions and limits of this proposal. It is clear that TCS does not deny the existence of other problems for which a sufficiently successful disciplinary science has been proven. At once, it is stated that the knowledge of specialists will be the main contributions to interdisciplinary research. To do so, it is necessary to ensure the integration of disciplinary knowledge, for which TCS put forward a methodology supported on its constructivist epistemology. Among the various contributions that epistemology makes for this methodologic proposal is noticing the importance of a joint structuring activity in at the epistemic moment of research, and evincing the constituent role of the epistemic framework –and via social values– of the multidisciplinary team.

To sum up, in TCS there is clear exponent of a moderate position in the controversy, which defines the features and criteria of modern science and which understands that the developments of complexity offer ways to update and renew it with a view to potentiating its capacity to face current challenges.

For its part, SST introduces a stronger diagnosis of crisis, though at once, more limited: what is necessary and urgent for Luhmann is to strengthen the theoretical capability of sociology and its proposal to do so is to offer a universal theory, open to dialogue. In our understanding, this crisis is

largely linked to the epistemic meaning of complexity; if sociology needs to increase its theoretical complexity is not because of the properties of reality –which would be an ontological complexity opposed to its skepticism–, but in comparison with the internal accomplishments of other disciplines.

This definition of the problem, its epistemological stance and the way of its explanations introduce new elements that some followers of this program usually understand as claims against traditional science. One of such claims is to "release theory" from its empirical production and its practical applicability as main assessment criteria to enable it to engage in observation (for example, Granja-Castro, 2001).

The self-referential and closed character of science, the function and meaning of the theoretical construction proposed by Luhmann support such claim. Another claim may be the acceptance of paradoxes as logical tools valid and coherent with the cybernetic mandates (for example, Castro-Sáez, 2011). Paradoxes are justified in Luhmann's epistemology due to the preeminence of the difference in the treatment of dualities, and SST makes us face them when the methodologic road of second-order observation is adopted, and when it points out at accounting for self-reference. But it has to be noted that these paradoxes are circumscribed into the reflection of the system, especially to the treatment of epistemological problems.

If a critical claim is made here against science, this does not seem to go beyond denouncing that certain logical constructions are attempts to hide a duality. At least, in dealing with these problems, in SST there does not seem to be the radical diagnosis of crisis observed by some readers, who have proclaimed a new thinking paradigm. The positioning of SST in problem #2 is coherent with the stance adopted in problem #1: interdiscipline offers a more complex theorization, within the already mentioned limits.

The diagnosis of crisis becomes more radical just in problem #2, where Luhmann's epistemological suppositions and his vision of science seem to block every practice of transformation that may make the social and political nature of knowledge more evident. However, as we pointed out, this is discussable, to the extent of introducing revisions in Luhmann's theorization, and more importantly, of disclosing and questioning some of the epistemological and meta-theorical suppositions that provide his program with identity. Until then, the stance of SST in the controversy is more radical than that of TCS, and allows for readings that enable supporting claims against some traditional features of science, which in the view of its critics, may resemble postmodern attacks.

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Gastón Damián Becerra. Doctor in Philosophy, University of Buenos Aires. Post-doctoral grant holder in Conicet and researcher and professor Universidad de Buenos Aires and Universidad Abierta Interamericana. Research lines: epistemology, philosophy of science, complexity, *big data*. Recent publications: Becerra, Gastón Damián (2018), "La epistemología constructivista de Luhmann. Objetivos programáticos, contextos de discusión y supuestos filosóficos", in *Sociológica*, no. 33, vol. 95, Mexico: Universidad Autónoma Metropolitana. Becerra, Gastón Damián (2018), "Interpelaciones entre el Big data y la Teoría de los sistemas sociales. Propuestas para un programa de investigación", in *Hipertextos*, no. 6, vol. 9, Argentina: Centro CTS, Universidad Maimónides. Becerra, Gastón Damián and Castorina, José Antonio (2018), "Towards a Dialogue Among Constructivist Research Programs", in *Constructivist Foundations*, no. 13, vol. 2, Balgium: Vrije Universiteit.