Analogies between systems, an « epistemological loophole ».

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Abstract : Analogy is the basis of systemic and cybernetic paradigms. Yet it seems that scientists as Wiener or Bertalanffy find themselves embarrassed when inquiring about analogy ; what can be the source of such difficulties ? This presentation provides a brief panorama of the ambiguous epistemological status and signification of analogy, coined as an « epistemological loophole ».

Résumé : Analogies entre systèmes, un « vide épistémologique ».
L'analogie est au fondement des paradigmes systémique et cybernétique. Il semble toutefois que Wiener ou Bertalanffy se trouvent arrêtés lorsqu'il s'interrogent sur sa validité méthodologique ; qu'est-ce qui peut bien être à l'origine d'une telle difficulté ? Cet exposé propose un rapide panorama de la signification et du statut épistémologique ambigu de l'analogie, désigné comme « vide épistémologique ».

At the time I heard about system science and cybernetics, a polemic was raging which was given the name of « Sokal Affair ». Physicists Sokal and Bricmont would roughly condemn a number of analogies worked out from mathematical or physical notions by social science figures [(1)]. The violence of the debates would reveal a striking paradox : the use of analogy in scientific activity is considerable, however very badly recognized, and nobody can refer to a methodology that would make possible to discriminate analogies which are relevant from those which are not. Sokal and Bricmont's attack could make one believe that analogy could only be current on the side of soft science, as if it didn't exist either in mathematics, physics or biology. From this point of view, it would be necessary to have clear and firm boundaries between the different research fields. This configuration gives no place to an interdisciplinary initiative decided to supply itself with tools for describing objects which properties are independant of their nature : systems.

It's nothing to say that analogy is important for system science : it is the basis of it. The idea of system theory comes from the statement that some recurrent problems exist in various fields. Bertalanffy foresees the epistemological stake of analogical reasoning, and he assigns to his theory the vocation of becoming a rigorous methodology for sorting valid and superficial analogies. There is in Bertalanffy's book a tension that is interesting for the subject of this presentation : on the one hand he wishes his theory to take a logico-mathematical form, but on the other hand he acknowledges that General System Theory (GST) does not reduce itself to a collection of formal tools. Indeed, he writes, if GST was only concerned with formal isomorphism, then it would only be a label to indicate a branch of applied mathematics. But then, what type of analogies is it concerned with ? What makes the generality of system theory ? Bertalanffy's indications about this are not particularly clear : in order to provide valid « laws » or « principles » for every system irrespective to its nature, first, GST « demands new ways of mathematical thinking » ; next, the « ordinary language » can however play a part there. In the first case, we do not see how GST could avoid the criticism encountered by Bertalanffy : whatever new the mathematical tools are, they remain mathematical, and thus « system theory amounts to no more than the trivial fact that mathematics of some sort can be applied to different problems. (...) it has no more significance than the fact that elementary arithmetics is applicable to all countable things, that 2 plus 2 make 4, irrespective of whether the counted objects are apples, atoms or galaxies »[(2)]. Bertalanffy does not specify how those required « new ways of mathematical thinking » would permit to go beyond that obviousness, in the case GST would reach a whole logico-

mathematical form. Nevertheless, at least provisionnally, he admits that common language could participate in the theory. In this second case, the common points to systems are given as notions or concepts, or phenomenological descriptions of similar processes (Bertalanffy mentions for instance a parallel between the evolution of the Germanic languages and the evolution of the titanotherium). But the criteria he gives to discriminate relevant analogies from superficial analogies are ambiguous and definitely not satisfying, as he then only maintains the superiority of mathematical isomorphism, without further precision. We shall not blame Bertalanffy, but neither shall we content ourselves with his considerations upon isomorphism. Those are pretty far from attaining the objectives assigned to GST.

Thus do we face the following situation : if the Sokal Affair seemed to ignore system science, is the reverse true ? Do researchers in system science care, and to what extent, about epistemological questions regarding analogy ? We can find yet remarks of Bertalanffy that are more relevant and subtle than his paragraph about isomorphism. As he mentions the syntax analogy between the equations of thermodynamical entropy and information theory, he adds carefully that the interpretation of this analogy causes controversial discussions. By this implicit recall that even mathematical expressions do not reach an absolute univocity, he points out an important track of epistemological reflexion. At the first glance, this interpretative prudence doesn't seem to be respected by a Norbert Wiener, for whom information « attaches itself very naturally » to entropy, as he writes in *Cybernetics* [(3)]. The comparison of the two men, whose position in the history of science is to a certain extent similar, reveals two different attitudes towards the epistemological status of analogical reasoning. Wiener is easily reproached too big a spontaneity and too big a fascination for analogies. Actually, Wiener shows himself both more careful and more precise than Bertalanffy, as is suggested by a number of remarks furnishing technical criteria to restrict analogies (especially upon the limited adequation of statistical tools for the study of human facts)[(4)]. Yet one more time, one realizes that his indications are only negative, and one would search in vain for positive methodological proposals. I've had great hope, as working to provide french translation of Wiener's writings, when I heard about an unpublished text called « The nature of analogy »[(5)]. But this 1950 paper, which was obviously intended to get integrated into a book (maybe *The Human Use of Human Beings*), is actually very short and apparently unfinished. It seems then that scientists as Wiener or Bertalanffy find themselves stopped when inquiring about analogy ; what can be the source of such difficulties ?

By asking myself this question, I have to forget to find rapidly an answer in a reference book or article. Thus, not only is there no operative methodology for analogies, but also and almost do we find no explanation to the lack of such a methodology. Analogy has scarcely been a source of inspiration for epistemologists and science philosophers, by comparison with other topics such as the structure of scientific theories, the validity of induction or crucial experiment, and the like. The few available publications are rarely satisfying, beyond the fact that, as every publication, they are condemned to oscillate between precision and exhaustivity. Although this number is growing, it doesn't clarify the matter, it doesn't prevent prejudices, sterile and rough polemics from growing, as the Sokal Affair suggests again. Being inspired by the expression « legal loophole », it seemed to me one could call the situation of analogy an « epistemological loophole ». What I propose here then, is a brief panorama of the difficulties that may contribute to this epistemological loophole. The overall aspect of this presentation will feature an inevitable superficiality ; I believe however that the ambition of a global perspective, even of course incomplete, can throw lights that have precisely be missing until now. Analogy has a bad reputation in the traditional rationalist image of science. Yet it is a well-known fact that it plays an important part in several domains : one readily acknowledges that it takes part in didactical contexts, or in classification processes. In these cases, in some way peripherical to the hypothetico-deductive structure which represents

science in the most emblematic way, mainly under the features of physical sciences, analogy is tolerated. But it seems much more scandalous to see it having a privileged situation in the process of hypothesis elaboration. It is the context into which it most poses problems to a precise epistemological characterization.

Analogy typically appears in cases of a lack of scientific laws, or lack of commensurability between different fields. The first case is that of sciences at primitive stages, that need to collect material before thinking about the laws that rule it, as botanics, zoology, anatomy, and chemistry for a long time. That is classification, which goes together with the identification of regularities. Thus, the search for invariants, and the process, that it precedes, of organization of categories which gather similar individuals, are related to analogical reasoning. Every discipline does not however aim at establishing laws concerning individuals distributed in classes. Some, especially those which deal with human facts, study irreducibly singular situations : it is the case of legal, historical or clinical sciences. Each situation cannot refer to any general rule, but can only be compared with such unique situations. Some logicians thus wanted to consider analogy as a reasoning processing from peculiar to peculiar, at the same level as deduction processing from general to peculiar, and induction that processes from peculiar to general. This point of view is not satisfying, for at least two reasons : one the one hand, there exists a peculiar-to-peculiar syllogism (DISAMIS syllogism)[6], and on the other hand, one can contest, at a phenomenological level, that the peculiar-to-peculiar process can occur without an abstract mediation, even gross or fugitive, without an implicit generalization process. Other analysis have tried to assimilate partly analogy with induction, by arguing either it is a « less sure induction »[7], either it is a « started induction », which is supposed to end with a crucial experiment [8]. A probabilistic contemporary interpretation proposed, in the way of John Stuart Mill's enumeration principle, to get round the ban already imposed by aristotelian logic to the following question : if a number of common properties belong to two objects, may we infer these objects to have some more common properties ? Normally, we may not, as the two objects can simply belong to two different classes. But one expects the two objects to have *probably* some more common properties, if the number of former common properties passes a certain threshold [9]. This argument is as poorly accepted as that of Mill (if we have observed *n* A objects which possess a certain property, then we can induce all the A possess this property). But induction is not the only form of inference that is threatened by an indistinction with analogy : Peirce considers that « this reasoning has a mixed character because it is in some way linked to the others as the fourth figure of syllogism is linked to the three others »[10], without giving more precision. Gonseth is ready to hold that every deduction rests upon an analogical structure [11]. We can discuss this argument, but we mention it as it is an addition to the lack of consensus upon a logical characterization of analogical reasoning.

In the absence of general laws, classification is not the only reaction to the noticing of regularities : another consequence is also the development of hypotheses to explain those regularities. Here we are entering the « Bermuda Triangle » of scientific discovery, delimited by the notions of invention, imagination and intuition. Classical rationalism does not investigate inside, and withdraws for understanding the mode of hypotheses development. Popper, as he refuses induction, leaves the way free for psychology. He considers that the stage of discovery cannot be given a logical analysis [12]. Studies in experimental psychology, for instance about brainstorming, either grant analogy a central role, or readily recognize the unconscious character of creative processes [13]. Nevertheless, when reflections uphold a logic for scientific discovery, as those of Peirce and Aristotle, one sees analogy appears in the formation of hypotheses, but it is not named. In Peirce, the formulation of hypotheses is related to the kind of reasoning he calls « abduction ». Now, one of the two definitions he gives for abduction (or hypothesis, as both are alike in 1878)[14] is a classical definition of

analogical reasoning, despite he doesn't name it as such. Twenty years later, in his Harvard Conferences, Peirce grants no more recognition to analogy, as he ignores it, or more precisely he seems to give up locating it clearly, because, as we have said, he considers it is « mixed » to other logical patterns. One face a similar situation in Aristotle's Topics. There must be a departure point, up the deductive syllogism chains, which cannot itself be obtained by deduction. In the empirical framework of aristotelian philosophy, induction is to be a privileged mean for the formation of premiss. Actually, not only is the exemple given by the stagirian an exemple of analogy, but also, in the further details, it is analogy once again which makes one of the four modes of premiss formation. However, one more time, it is not named as such, but only labeled as « perception of similarities »[(15)]. So we can suppose that the fact that those two major figures of logic, Peirce and Aristotle, come up against the question of the place of analogy in scientific process, contributes strongly to maintain an ambiguity halo around it [(16)].

Aristotle is certainly an essential knot in that affair. Today's ambiguity is the ambiguity set up by Aristotle. His oppposition between logic and rhetoric mounts a configuration we still encounter nowadays : analogy is reduced to being one of the forms of metaphor, consequently of no scientific value *a priori*. Yet, Aristotle uses analogy without naming it, in the formation of premiss, as we have mentioned, but also to make the classification of living beings easier by replacing Plato's laborious dichotomic method. It can be remarked here that one of the main reasons argued by Wiener and Bertalanffy for the recognition of analogy, is the advantage it provides of avoiding the repetition of demonstrative patterns already known in another field.

If logic is not a relevant framework to place analogy (as it is not a concluding reasoning, it can't be judged true or false), it might be sounder to envisage it as a primary functioning mode of the human mind. One will notice, for instance, that Piaget considers the spontaneous use of analogy, at the age of 2-3, to constitute the « birth of intelligence »[(17)]. The attempts to reconstitute the mind are *de facto* confronted to analogy, whether in cognitive science or artificial intelligence, through matters like problem solving, pattern recognition, categorization [(18)]. If we must look on this side of logic, and on this side of faculties (intuition, imagination), to have a more accurate view of analogy, it is one more reason to understand that epistemology and philosophies of cognition could meet difficulties to figure it out.

We have mentioned the absence of general law as the main context of elaboration of analogies. So we shouldn't be surprised that Kuhn considers them precisely taking place during periods of « paradigm shifts »[(19)]. But the absence needn't be total, whenever it could : as we have said, one can observe analogies in fields which are different but which laws are isomorphic. Then the situation is that of an absence of commensurability between various domains of reality. Analogies appear between domains that can't be *unified* by a general law. Analogy can be seen then as process, a temporary one, of homogeneization of phenomena of different nature. The most classical exemple is that of the electromagnetic theory set by Maxwell : from the syntaxic analogy between the equations of electricity and magnetism, he develops a more general theory which merges the former two [(20)], so transforming what had been considered for a long time as a « simple » analogy [(21)]. One can interpret cybernetical analogies in this framework ; one will then see them as an attempt to found an ontology upon the notion of information, and to make various domains of reality homogeneous from the underlining of information feedback ; but a failed attempt, as it hasn't managed to find an adequate concept of information to perform that role. Before Aristotle, the mission of analogy was precisely to make the universe uniform. In mathematics, analogy ensures the manipulation of uncommensurable magnitudes, and makes possible to resolve the crisis of irrational. Before that crisis, Pythagoricians were giving an account of the cosmic harmony with the « analogical process », the πραγματεια των ανα λογον which gives the measure

(λογος) making the magnitudes commensurable [22]. It is a commonplace to say that analogy was first a quantitative equality between two fractions (A/B = C/D) that later « slipped » to a qualitative equivalence, becoming then a non-rigorous way of reasoning. This prejudice is false, for the pythagorician mathematics is everything but a calculus upon quantities. The etymologic origin of the word « harmony » (αρμονιαι), refers to the iron stirrups holding together the planks of boats. Thus analogy performs in some way this function of fastening the different parcels of reality : mechanical, biological, psychological, social. Modern science expelled harmony from the cosmos, and replaced it by an inertial distribution of matter and energy in which things do not resonate with each other anymore. There could be a drift for system science, that one may sometimes encounter, in tempting to restore a universal harmony under the pretext of observing analogies between « systems » of various nature. In respect to this does it also matter to think about relevance criteria of analogical reasonings.

Analogy being scarcely recognized, it is strictly speaking outlaw, and is put at work clandestinely, subject to a certain range of tolerance. The merit of systemic and cybernetic paradigms, in respect to this, is to make possible to set up a situation which is susceptible to provoke a sort of conscience crisis concerning the epistemological loophole around analogy.

NOTES :

(1) A. SOKAL, J. BRICMONT, *Les impostures intellectuelles*, Odile Jacob, Paris, 1997.
(2) L. VON BERTALANFFY, *General System Theory*, G. Braziller Inc., NY, 1968, p. 35. Please refer mainly to Chapter 3, § 7 « Isomorphism in science », p. 80.
(3) N. WIENER, *Cybernetics or control and communication in the animal and the machine*, MIT Press, 1961, p. 11.
(4) Cf. N. WIENER, *Cybernetics*, Introduction & Chapter 8 (1948) ; « Time and the science of organization » (1958), *Collected Works* vol. IV, p. 247 ; *God and Golem, Inc.*, pp. 87-93 (1963). Cf. also « Some maxims for biologists and psychologists », (1950), *CW* IV, p. 452.
(5) N. WIENER, « The nature of analogy », 1950, MIT Archive Collection Reference 29B 655.
(6) Cf. A. BENMAKHLOUF, article « Analogie » in Lecourt (ed), *Dictionnaire d'histoire et philosophie des sciences*, PUF, 2003, p. 32.
(7) M. DOROLLE, *Le raisonnement par analogie*, PUF, 1949, Chapter 2.
(8) E. GOBLOT, *Traité de logique*, Paris, Armand Colin, 1917, § 192.
(9) M. B. HESSE, *Models and analogies in science*, Indiana, UND Press, 1966.
(10) Ch. S. PEIRCE, Second Harvard Conference (1898) (tr. fr. in *Le raisonnement et la logique des choses*, Cerf, 1994, p. 195). Please apologize for, as I couldn't find the original text, I had to translate back from the french translation...
(11) F. GONSETH, *Les mathématiques et la réalité*, Blanchard, Paris, 1974, pp. 309-310.
(12) K. R. POPPER, *The Logic of Scientific Discovery*, NY, 1959, pp. 31-32.
(13) Cf. respectively the experiments of W. GORDON and M. WESTCOTT (see a french account in M.-L. ROUQUETTE, *La créativité*, PUF, 1973). Consult also the works of K. HOLYOAK or D. GENTNER.
(14) Ch. S. PEIRCE, « Deduction, induction and hypothesis » (1878), *Writings* vol. 3, p. 323 (tr. fr. « Déduction, induction et hypothèse », in *A la recherche d'une méthode*, Thééthète, 1993, p. 180).
(15) ARISTOTLE, *Topics*, Book I, §§ 12, 13, 14.
(16) Cf. also N. R. HANSON's article, « Is there a Logic of Discovery ? », in Feigl and Maxwell (eds), *Current issues in the Philosophy of Science*, NY, 1961 (tr. fr. « Y a-t-il une logique de la découverte scientifique ? », in Jacob, dir, *De Vienne à Cambridge*, Gallimard, 1980). But Hanson mounts a concurrence between analogy and induction, without being aware of the indistinction problem we have mentioned.
(17) J. PIAGET, *La psychologie de l'intelligence*, Paris, Armand Colin, 1947.
(18) For a recent account : M. MITCHELL, *Analogy-Making as Perception. A Computer Model*, MIT Press, 1993.
(19) T. S. KUHN, « Metaphor in Science », in Ortony (ed) *Metaphor and Thought*, Cambridge University Press, 1993.
(20) Cf. G. CHATELET, *Les enjeux du mobile. Mathématique, physique, philosophie*, Paris, Seuil, 1993, p. 264.
(21) J. H. VAN SWINDEN, *Recueil de Mémoires sur l'Analogie de l'Électricité et du Magnétisme. Couronnés & publiés par l'Académie de Bavière, traduits du Latin & de l'Allemand, augmentés de Notes & et quelques Dissertations nouvelles*, La Haye, Libraires Associés, 1784.
(22) J. LOHMANN, *Mousikè et Logos, contribution à la philosophie et à la théorie musicale grecques*, trad. fr. P. David, TER, 2004.

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For a wider, yet not only epistemological bibliography, please refer to Roland Müller's chronology : http://www.muellerscience.com/MODELL/Literatur/Lit.Analogie(1733-2001).htm