HISTORY AND PHILOSOPHY OF THE SYSTEMS SCIENCES: THE ROAD TOWARD UNCERTAINTY

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Contents

Summary

This chapter explores in its first part the historical roots and the progress of the deep questioning which affected the scientific worldview during the first half of the 20^{th}

century. In the second part it retraces the steps of the progressive emergence since 1945 of a new integrative approach to complex issues, their understanding and their management. It has been a process of creating growing links among a number of new notions of wide potential use. This has been a two-way process:

- Concepts emerging in a specific discipline have proven their usefulness in other disciplines
- Concepts of general character have become adapted to specific issues.

The general result to date is a renewed and wide embracing methodology for study and action, including a considerable and organized array of original concepts and models. This amounts now to a reconstructed scientific humanism, expressed in a transdisciplinary coherent language. It seems quite probable that this movement will proceed apace during the coming years.

1. Introduction

Western thought evolved slowly from the beginning of the Middle Ages in Western Europe. This evolution signals a progressive shift from a naive religious to an elaborated theological worldview and later on, toward complete separation from theology of a growingly rationalist and scientific approach. The first steps of this transformation are merely briefly sketched hereafter. They would however warrant a much more elaborated study, in view of their meaning as background to the complete laicization which became later the hallmark of scientific Western thought. This aspect is very important in order to appreciate the significance of the dynamic interplay of empiricism and abstraction that characterizes it and led recently to a very deep revision on its fundamental concepts. Systemics and cybernetics are vital parts of this renewal, in view of the new possibilities they do offer for the study of complex situations.

2. Medieval Universals

At the early beginnings of the Western Middle Ages, only very few of the leaders of society (quite modest lords of hundred of small fiefs and dozens of mini-kingdoms) were able to read. The only general source of knowledge was the Bible, as read and commented by priests and monks.

From the 10th and 11th Centuries on, the bits and pieces of Greek philosophy that had escaped total oblivion or had been rescued by Arab philosophers, became the first tools of reason, applied to a supposedly better understanding of the Scriptures. In this way a "logico-grammatical technique" emerged, as well as a dialectical method, as stated by Vignaux in 1938.

As a result, a family of general philosophical concepts was slowly constructed within which two currents are clearly visible:

- An extended nominalism, basically concerned with the construction of a sound technique for the use of reason.

- A theological one, whose highest expression culminated in St Thomas Aquinas "*Summa contra Gentiles*" and "*Summa theologiae*",... which are anyhow already a triumph of organizing reason.

3. The Snake of Rational Curiosity alive in Medieval Garden

However, since the plucking of the Apple from the Tree of Knowledge in Paradise, reason has been many times the bane of simple faith. Medieval thinkers, even if most of them were monks or priests, could not escape this curse.

The slippery slope started at least with Saint Anselm (1033-1109) with his "Monologion", if not before. While saying: "I am not trying to understand in order to believe, I am believing in order to understand", he started to seek logical "arguments": What would we have to say to explain God rationally?

From there on, philosophy escapes slowly from the embrace of theology.

But it was more difficult to loosen the embrace of belief, even if "arguments" became evermore subtle, competitive and critical until the end of the 15th Century. (Eckart, Abelard, Duns Scot, William of Ockham)

This is a very protracted history, but its general meaning is obvious, as related to the development of western critical rationalism, and later on, of science

4. The Slow Dawn of Technology in Medieval Europe

Simple techniques had in general purely empirical origins. They needed only Homo Faber's practical understanding and their development much precedes historical times.

Most of the simple but important medieval inventions had already been brought forth independently and centuries before, mainly by the Chinese. However, for some reason, China lost its leadership and many of its inventions had to be rediscovered in Western Europe.

The most significant medieval inventions were the wheelbarrow, the windmill, the watermill, the horse collar, the magnetic compass, the crane, some new types of ships, the spectacles.

The adoption of Indian-Arab numerals, whose introduction is attributed to Leonardo de Pisa in 1202, was also very significant.

Simple tools were not technology in its elaborated sense, but they were to lead to more interest in, and understanding of their workings. Accordingly, tools led to technology and became a root of scientific curiosity and posterior research.

5. Descartes, the not very Systemic Systemist

Descartes, the father of the analytic method, recommended the study of the simplest parts one by one in order to divide difficulty... but, doing so, he severed **in an implicit way** most of the links between the parts.

He developed no methodology for the reconstruction of the analyzed object from its parts, i.e. provided no way to study the complex network of links.

Coherence was delegated to God: "Creator and Watchmaker" (Until God became a "not-needed hypothesis" in Laplace's famous comment to Napoleon).

Cartesianism led to a preference for linear functions and "anatomical" or mechanical structures, thus starting the road toward highly useful specialization, but also toward mutilating reductionism.

This trend was continued by mathematical innovations: especially Newton's and Leibniz differential calculus.

6. The Expansion of the Universe of Knowledge

The new approach produced an expansion of knowledge leading to an ever growing disconnection between specialized fields, receding away from each other like so many mental galaxies ... and progressively losing contact.

This was the absolutely dominant trend until the 2nd World War, and is still now very powerful.

Its main mental tools are linear causality and rigorous determinism, sustained by experimentalism, on the conceptual base of the "*et ceteris paribus*" principle, which of course artificializes reality, even if leading to very productive practical simplifications.

7. The Twilight of Scientific Simplicity: A Can of Conceptual Worms in 20th Century Science

- *Worms in Newton's Apple:*

At the end of 19th Century, Poincaré considered the 3-body problem in celestial mechanics, showing it to be never perfectly soluble, even when simplifying assumptions are admitted.

Shortly thereafter, Einstein, introducing relativity, showed that there was more about celestial mechanics than the pure Newtonian model.

- *Elusive ambiguity in the new field of microphysics:*

Heisenberg's uncertainty principle emphasized the impossibility to determine exactly at the same time the velocity and the position of a particle, thus seemingly weakening the bedrock of classical physics, already shaken by Planck's introduction of quanta.

Bohr tried to rescue microphysics from uncertainty by introducing the more common-sense-based "complementarity" concept, but this has been no more than a "Copenhagen

Interpretation".

Schrödinger's hapless cat as a potential victim of wave collapse shows the ambiguity of all these explanations, at least from the macroscopic rational viewpoint. Finally, we ran into some awkward questions:

- Is human thought, or at least common sense, adapted to microphysics?
- Or even to the basic understanding of the nature of reality?
- Can some mathematical models make sense for common sense?
- Is common sense in science important, compared to rigorous abstract formalisms?

- *Riddles of classical thermodynamics*

Clausius' Second Law and its consequence, Ostwald's *Warmestod* (lukewarm death), seemed to prescribe universal cosmic decay.

Boltzmann's statistical anatomy of thermodynamical disorganization even explained this in some sense.

One seemingly obvious conclusion was that general evolution toward life and higher biological complexity was in theory impossible... at least without some miraculous (divine?) tinkering.

Maxwell's thought experiment with such a tinkerer, supposedly able to restore diversity in thermodynamically homogenized systems, his famous Demon, seemed precisely to illustrate this situation.

This conceptual dead-end led biology into its own dead-end, reinforced by the apparent miraculous growth of two well developed sea urchins from only one embryo, artificially divided in laboratory by Driesch. The final result was the postulation of a mysterious "vital force", a mere conceptual bottleneck which blocked progress unto understanding life. This ended only with fresh developments in biochemistry in the 1920-30's by Huxley, Needham, Spemann and Weiss, among others as related by Needham in 1936 and the new concepts of biological organizer and organicism introduced by Spemann, Woodger and Bertalanffy.

Maxwell's Demon's exorcism by Szilard in 1929 was helpful for them, as he demonstrated that this trickster needed in fact some energy from outside in order to enable him to upgrade organization in the supposedly perfect - but in fact purely abstract and illusory model of an isolated system - the only kind of systems to which the Second Law of thermodynamics can be applied in an unrestricted way. Szilard's work pre-announced in fact the need for a wide extension of thermodynamics. [see "In search of a new coherence" - #10. Thermodynamics reconsidered]

- *Mathematical monsters: The trouble with infinity,recursiveness and space dimensions*

Peano curves and Cantor sets introduced an interesting - as well as intriguing conundrum about the meaning of infinity. Strange topological beasts started also to appear from mid-19th Century on: From Möbius strips to Klein bottles, Koch snowflakes and Sierpinski sieves. It became clear that there were still gaping holes in our understanding of the geometrical space, already shaken by non-Euclidian geometries (Lobachevski, Riemann).

The proposal of a fourth dimension and next, the search for its possible meanings, opened up more uncanny conceptual territories.

- *Logical pitfalls*

Jesting Epiminides, the Cretan lying juggler with logical paradoxes, was finally silenced: In their epoch-making *Principia Mathematica* Russell and Whitehead firmly established a satisfactory logics of classes.

However, new logics also appeared, the least not being Korzybski non-Aristotelian logic, based on the denial of any possible perfect identity of two or more different "real" objects. With his structural differential, Korzybski also highlighted the perceptive and cerebral conditioning of the process of abstraction.

Gödel's incompleteness theorem introduced the following logical limit to knowledge: "A universal feature of knowledge is that one must get outside of a system in order to really understand it" as expressed by J. Casti. This amounts to the impossibility to ever achieve a complete and absolute general knowledge: a conclusion also reached at through different ways by Popper.

- *The observer observed*

Human observation of the world "outside there" is plagued by numerous limitations.
To begin with, observation presupposes perception, and human perception is physiologically quite limited.

To mention some of these limits to perception: Infra- and ultra-sounds cannot be heard; infrared and ultraviolet light cannot be seen; perception of size, colors and forms must be educated; very slow or very quick changes in relation to our own time scale are quite difficult to register; animal perceptions are in many cases quite different from ours as stated in von Uexküll and Kriszat's work of 1934.

There are also psychological and cultural conditionings to perception: three-dimensional perspective is differently represented in western and eastern (Chinese, Japanese) painting; perception of colors is more precise and differentiated for painters than for untrained people; Raga- Indian musicians perceive quarter and even ninth of tones.

Moreover, we perceive in relation to our needs or specific interests: The sound of a hooter in a factory acquires a different meaning as an air raid alarm during a war. We make a selection among our perceptions according to our needs, using as a simple background that which is not highly significant here and now. This is known as "Perceptive intentionality" (Brentano and Merleau Ponty)

Gestalt psychology (Wertheimer, Kohler, Koffka) summed most of these aspects into general principles of perceptual organization, i.e. the basic features that allow us to coordinate and make sense of the flow of inputs that we are able to pick up from our environment

However, as a general synthesis, we must agree with Wittgenstein: "In order to discover whether the picture is true or false, we must compare it with reality (...). How could one possibly carry out that comparison?" ("*Tractatus logico-philosophicus*"). Accordingly, objective truth can be approached only in a progressive and never absolutely secure way and we must content ourselves with better plausibility after recurrent falsification and revalidation based on new experience or information, as proposed by Popper.

- *Human Sciences adrift*

This problem acquires still a more problematical dimension when we focus our attention on humans or human groups. The velocity of light can be experimentally measured, or the molecular structure of water modeled, in accordance with its properties. But debate in psychological and social sciences is endless and still generally inconclusive.

This obviously corresponds to the multilevel nature of human problems, from the individual as such or as social elements, to the hypercomplex global society presently in the making. Moreover, in this last aspect, the historical dimension cannot be ignored, while our knowledge of the past depends on our own always debatable valuation of the no less debatable surviving testimonies of a more or less randomly selected number of observers... among those who did not ended up in total historical oblivion.

In Warfield's words: "It is only within the last two hundred years and in a sense almost within this generation that man has become widely conscious of his own societies and of the larger sociosphere of which they are part"

Consequently we still have to build new hypercomplex models of multiple different, simultaneous and multilevel interactions needed for a better understanding of human societies.

This cannot be done before a suitable understanding of the very nature of sociality is acquired (possibly from molecules unto animal and human sociality). And, of course it should be the endeavor of systems sciences to put an end to the present deficit of conceptual tools in social sciences, a challenge of the highest level.

8. In Search of a new Coherence

8.1. Overview

During the last 100 years, and much more so after the 2nd World War, numerous new concepts and models have appeared in the most various disciplines. Many of these are becoming interconnected and lead now toward a more integrated general view of numerous hitherto unsuspected or ill-understood situations and phenomena. The old humanist centered view became too narrow to encompass modern knowledge. But this same new knowledge is now in dire need of its own synthesis, i.e. possibly a kind of re-integrated scientific humanism.

For the time being the synthesis seems yet to be incomplete and in the making. What we already have is a vast and still growing collection of many strands.

To represent it satisfactorily a multilevel and multi-dimensional graph of interconnections is needed. Until now it does not exist.

Accordingly, those many strands have been enumerated hereafter in a tentatively ordered way.

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Biographical Sketch

Charles François is a belgian citizen, born 1922 and retired from the Belgian Foreign Service since 1987. He was educated in Belgium and lived in Central Africa from 1945 to 1960, first as an administrative officer and later on as owner of his own business. His first contact with Cybernetics was in 1952 through Wiener's foundational 1948 work on the subject. In 1958 he became a member of the former Society for General Systems Research (now ISSS). Participant from 1970 on, in numerous meetings of various Systems and Cybernetic Societies, he is member of the board of some of them, and integrates the editorial board of four of foremost journals on Systems and Cybernetics. He is also author of numerous papers and books on systemic topics and also of the International Encyclopedia of Systems and Cybernetics, edited in 1997.

François lives in Argentina since 1963 and created the Argentine National Division of the ISSS, in 1976, being presently its Honorary President.