A Landmark in the History of Science

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H. von Foerster's *Cybernetics of Cybernetics (1974)*

Carlos Eduardo Maldonado[1] · Eduardo Villar Concha[1]

Abstract

This paper presents and discusses an authentic landmark in the history of science, namely H. v. Foerster's *Cybernetics of Cybernetics*, 1974, a most fundamental book based on the students' notes. This is a book rarely known even by many specialists. This paper claims that von Foerster's book constitutes a unique achievement in the history of science and provides reasons. A thorough presentation is introduced that brings a complete panorama of concepts, problems and approaches.

Keywords System science · History of science · Control communication · Epistemology

1 Introduction

Roughly speaking, since the nineteenth Century the advancement of science has been in the form of papers over books. A few notable exceptions include B. Mandelbrot's *The Geometry of Nature*. By the years 1973–1974 Heinz von Foerster was already a prominent figure in the academic world. Author of more than 100 publications, by then he had already published the most conspicuous papers and chapters that made of him a leading feature in a field that crossed physics and philosophy and the father of second order cybernetics.

In 1974 Heinz von Foerster's students compiled the notes of a course taught at the University of Illinois, Urbana in an exhilarating book of nearly 500 pages. Since it is a true rarity even for insiders, this paper presents the book, its structures and contents, and frames it in the context of history of science in general, and the history of systems science in particular. The argument here is that von Foerster had very carefully thought and developed a second order cybernetics which can be adequately be grasped as control of control or also as the communication of communication. The book can be said to be an authentic landmark in the history of science.

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To the best of our knowledge, the book was never published afterwards, which makes of the 1974 an authentic jewel in the history of science, systems science in general and cybernetics in particular. Hence, a thorough presentation becomes compulsory. This is the first section of this paper. The second section is devoted to a discussion of von Foerster's book within the framework of systems science at large. Some key elements are highlighted that help understand complexity and systems approach. The third section evaluates the interplay between systems science and complexity science under the lights shed by the 1974 book. At the end some conclusions are drawn.

2 Cybernetics of Cybernetics

Von Foerster's book can be read and presented in a manifold ways. Thus, for example, it is possible to say that, aimed as a course it offers always firstly some key concepts by the American-Austrian professor followed by undoubtedly the most important text from source-authors. It could also be read as the weave of authors that serve as pivots and references when walking into the realm of second-order cybernetics.

The concepts are no studied alphabetically or lexicographically. Such a strategy could be discussed here. However it would take a long and perhaps speculative path. Here we have opted for a descriptive presentation of the book. Von Foerster's own strategy consists in introducing and briefly explaining some concepts, central for cybernetics in general. Immediately after that a series of readings are recommended. (The readings are typed transcriptions, for at that time there were not photocopying machines.) The book is split into two parts, the first one pivots around first-order cybernetics, whereas the second is centered around second-order cybernetics.

The presentation that follows may seem probably dry to the reader. The reason for such a description lies in the fact that the book may probably not be available for readers, particularly because the book "might not be well sold", as some editors might argue. In any case, let's read this section with a specific pace.

The first concept-problem is "cybernetics"—a three pages introduction, and then a photocopy of a N. Wiener's passage taken from "*Cybernetics*". In order to introduce Wiener to the students, the book contains the list of 241 papers and books written by Wiener.

Cybernetics of Cybernetics is a book organized in two main sections, thus: "First Order Cybernetics", and "Second Order Cybernetics". The subtitle of the book reads: "The control of control and the communication of communication". It was the book of a course Von Foester delivered from the 29 of August 1973 to April 24th, 1974.

Furthermore, a copy of G. Pask's "The Background of Cybernetics" and W. R. Ashby's "What is New" are included. Whereas no further bibliography by Pask is mentioned, the book adds the publications by Ashby, a total of two books and eighty-eight articles. Interestingly, a list of the then existing societies of cybernetics around the world, from the U.S.A to the U.R.S.S., including the journal and reviews on the field are presented, too.

The subject that follows is "General System Theory" accompanied by some notes and drawings made by von Foerster himself. Regarding the concept of "Feedback" the course includes W. T. Powers' "Feedback: Beyond Behaviorism", followed by P. Clough writing on feedback, its history and on Powers.

The next concept studied is "Ultrastability" for which a set of readings by P. Clugh, and R. Cough are included. En passant, it can be said that in the bibliography on systems science the concept is not so much used or highlighted, up until to-date.

The next concept is "goal", around which pivots the concept of "homeostasis". The reading here is: D. Hawkins "The Nature of Purpose". Three concepts follow afterwards, namely "process", "control and "hierarchy", for which von Foerster suggest reading W. S. McCullouch's "A Heterarchy of Values Determined by the Topology of Nervous Nets". A list of publications by McCullouch follows including 213 different texts.

Thus, clearly the Austrian-American Professor identifies N. Wiener, Ashby, and McCulloughs as the three fundamentals for getting into cybernetics. Von Foerster, of course, knew them personally.

Then the turn goes to "holism", a central concept in systems theory. For reading we find G. Pask's "Industrial Cybernetics", and S. Beer's "Managing Modern Complexity". A series of concept are then considered that include "conditioning", "adaptation", "reticular formation", and "organization" among others. In order to dig further into these the book considers sufficient to read: Ashby's "The Self-Reproducing System".

The concept of "Autopoiesis" is next considered, for which H. Maturana's "Neurophysiology of Cognition" is a necessary reading. "Reproduction", "evolution" and "scientific method" are the concepts next studied in the book. Two short readings supporting this chapter of the book are von Foesters's own "Cybernetics of Cybernetics (Physiology of Revolution)", and "On Making a Scientific Revolution" by S. A. Umpley.

"Intuition", "algebra", "number", and "algorithm" are the concepts studied afterwards. Remarkably, the reading is just by Kolakowski, "In Praise of Inconsistency". Now, for the concepts "program" and "computation" two readings are considered, namely by D. Schultz ""Reflections on Notation and Cognition", and "Cognitive Systems: A Personal View", also by D. Schultz.

Next, in order to understand the concepts of "computer", "machine" and "artificial intelligence" the author takes on N. M. Amosov's "Simulation of Thinking Processes". Here it would be good remembering that the then Soviet scientists and researchers had developed a robust understanding and work on cybernetics—something that at least in its forefront letters changed completely after the collapse of the Soviet Union in 1989.

"Future", "time" and "order" are certainly key concepts in science. To dig into them the reading suggested is L. Löfgren's "Evolution of Order and Evolutionary Systems". As for "randomness", a self-sufficient concept on its own apparently, von Foerster takes as to G. Kowak's "If You Smile at Me I Will Understand". Two concepts follow afterwards, namely "entropy" and "neguentropy". Here the reading goes to a text written by B. Feldman, B. Garrett, J. Glassman, G. Kowak, D. Langerman, L. Murphy, S, Sloan, and H. von Foerster: "Information Theory. Partitions, Coalitions, Tables", together with J. A. Todd's "A Table of Partitions". By and large this section or chapter is the most technical and large one in the book.

Necessarily, the concepts of "distribution" and "redundancy" follow, for which von Foerster's reading is: "On Self-Organizing Systems and their Environments". Therein, the book opens up some space of its own to "Self-Organizing System. The reading is Ashby's "Principles of the Self-Organizing System".

This is basically the book reviewed here. Afterwards, a section called "Parabook" is introduced. It is a section that includes sort of Table of Contents of the concepts alphabetically considered so far. After the list of concepts the names of the American Society for Cybernetics is included, with names, institutions where the members work, and their phone numbers. As it can be seen, the aimed was setting up and socializing a real network of the people interested in the subject of the book—for the students. Immediately after that, the book includes the organizations of the second and first order cybernetics existing at the time. Only the American Society for Cybernetics is considered for the

second order cybernetics. As for the first order cybernetics, there appear different associations from the U.S.A., Argentina, France, Greek, Hungary, Mexico, Poland, Austria, Spain, the Netherlands, U.K., India, and Germany—a most interesting map of the subject in that period.

Cybernetics of Cybernetics is a book that had been previously discussed with several other researchers and scholars. Von Foester offers Zielinski's proposal for the book, which is a new logic on its own and to some extend different organization of the concepts considered, along with the texts that supported the concepts studied.

The second part of the book includes a different set of concepts bearing a more philosophical atmosphere, as it happens. Thus, it opens up with "concept", "predication", and "conversation", for which the reading selected is J. Habermas' "Preparatory Remarks to a Theory of Communicative Competence".

Then, the concepts considered are "access", "language", "metaphor", "paradox", "hallucination", "illusion", "perception", "paradox", and "consciousness", for which the reading suggested is R. Fischer's "A Cartography of the Ecstatic and Meditative States".

Next in the list follow the terms "self-consciousness", "cognition", and "knowledge", for which Von Foerster thinks that the most appropriate reading is J. Habermas' "Knowledge and Human Interests: A General Perspective".

"Understanding", "learning", and "learning model" are the concepts that follow next. The readings therefore are G. Pask's "Anti-Hodmanship: A Report on the State and Prospects of CAI [i.e., Computer-Assisted Instruction—C.E.M.-E.V.B.]", and S. Sloan's "Innovation, Imagination and Education: A Recapitulation of Gordon Pask on Learning".

Two concepts included next are: "holist" and "memory". The reading that supports them is: H. von Foerster's "Memory Without Record". After them "model" is studied. For that the students were to read H. Brün's "The Need of Cognition for the Cognition of Needs".

As for the concept "socialization", the course was to read von Foerster's "Personalities, Affinities, Genes, and Happenings", as well as R. H. Howe's "Theses on Literature". "Individual" is the concept that follows, supported by a text taken form P. Cloug without an explicit title. One more single concept follows, namely "individual", for which the text to be read is "Self-Description" by B. J. Ford.

"Chance", "necessity", and "need" are three closely intertwined concepts. These are studied under the lights shed by two short reading written by H. Brün, and R. Rebitzer—both without an explicit title.

As for "evidence", which is the concept that follows next, the reading is "Law: Reflections", by J. Hackman. A set of concepts were studied afterwards. These are: "argument", "value", "relevance", "fact", "objectivity", and "reality". The reading to dig into is von Foerster's "On Constructing Reality".

Then as for "competition vs. cooperation" follows a text by H. Brün: "Competition vs. Cooperation: Graphic Analogues", and G. Hardin's "The Cybernetics of Competition: A Biologist View of Society". By and large, "observer" is a most crucial concept in the field. For this it would be convenient reading G. Pask's "The meaning of cybernetics in the behavioral sciences".

"Surveillance" and "double-bind" are the concepts studied afterwards. The reading is K. Wilson's The Establishment of Connections" and by B. J. Ford's a text having exactly the same title.

"Intention", "extension" and "description" follow next. Here the reading is "An Approach to Formal Psychiatry" by H. T. Hermann, and J. C. Kotelly. "Abduction, "explanation" and "heuristic" are next studied, for which the reading to dig into is: R. H. Howe's "Positivism and Reflection".

Regarding "context" the supporting text is by B. and J. Rebitzer, a poem without a title, and "metaface" a poem written by K. L. Wilson. As for "autonomy" the reading is by H. Maturana; "Cognitive Strategies".

"Desire" is a concept that emerges alone. The reading herein is H. Brün's "Drawing Distinctions Links Contradictions". "Communication" "composition" and "ontology" are the last concepts studied, for which G. Gunther's "The historical category of the new" is more than appropriate.

The book ends up with the concept "Truth", for which von Foerster does not include any reading to dig into, but a few pages of reflection.

3 Systems Science: A Re-appraisal

Cybernetic is and has been included into a more general framework, namely Systems Science. By now, this is a field already steadily established and certainly part of spearhead science. As such, it can be understood as both encompassing and extending from physics, economics, philosophy, biology, computing science, mathematics, and communication, on to culture, business, administration, policies, strategy, and government. However, at the same time, systems science can be said to gather further cross-disciplinary fields such as cybernetics, systems approach, holism, systems dynamics, self-organization, and autopoiesis, among others (Von Bertalanffy 1976, 1968; Von Foerster 1974).

A careful reading of von Foerster's book allows gathering the most central authors that contributed nurturing cybernetics including Ashby, Beer, Brün, Pask, McCullough, and Maturana—all leading systems science pioneers.

Interestingly, though, by the time the course was lectured, von Foerster does not include von Bertalanffy, H. Simon, W. Weaver, or J. Forrester at all, among other prominent authors openly reckoned as founders of both cybernetics and systems thinking—some of whom he knew very well, as a member of the Macy Conferences. The intension of the 1973–1974 lectures is not a historical introduction, but a systematic approach to just cybernetics and systems science in general, but to second-order cybernetics. To be sure, this is the real value of the 1974 book reviewed here. Midgley (2003) offers a very solid historical approach, instead. Furthermore, regarding a more general view of the concepts that define systems science, Meyers (2009) provides a large and solid encompassing panorama.

Some of the authors mentioned above were to remain fundamental references in the history of science at large, and particularly in the framework of systems science and cybernetics. Almost the majority of them, though, seem to vanish as both the history and philosophy of science are settling along the rhythm of time. This is something the present at each moment cannot foretell. Indeed, some names in the present seem to become sort of ghosts after a while. A refined scholar life appears to stand on a different ground when compared to scientific life—as time sheds its own its lights onto.

4 Understanding System Science and Complexity, Revisited

Largely and widely there has been a confusion in the literature, namely complexity science, systems science and even complexity thinking (=E. Morin) have been loosely be taken as synonyms or equivalent. This is not the place to elaborate demarcation criteria among them. Such a task, if plausible, remains the subject for a different paper. A concepts map

that contribute to the possible confusion has been worked out and continuously updated by B. Castellani (2020), namely the Map of Complexity (cfr. https://twitter.com/complexcase/status/950749146713133057, for the 2018 version of the map).

The story about the origins of the sciences of complexity has been told several times (Waldrop 1992; Casti 1994). Therefore, it would be convenient just to highlight that the first centers and institutes working on complexity were the Center for Studies of Nonlinear Dynamics, at La Jolla Institute (founded in 1978); the Santa Cruz Institute for Nonlinear Science, in the early 1980s; the Institute for Nonlinear Science, at UCSD (founded in 1981); and the Santa Fe Institute in New Mexico (founded in 1984). Afterwards a number of Centers and Institutes were, and have been, founded around the world (cfr. Scott 2007).

Being as might be, complexity science and systems science stand, so to speak, on the same side shooting against reductionism, determinism, and mechanism—the common "enemies" that define modern or classical science. Yet, a fine-tuned approach should no oppose but just distinguish what largely has been taken as a wide family—indistinctly called sometimes as systems science, or also complexity theory, or as a-no-problem-link between them.

5 Conclusions

Cybernetics of cybernetics is a book not precisely about cybernetics but about cybernetics of cybernetics. Throughout the book the role of self-referential concepts is continuously highlighted and stressed. It can be considered as a landmark in the history of science. Several reasons allow such a claim. We would like to pinpoint them as follows:

- It is book that gathers the most sensitive nutrients of von Foerster's thought
- It is a wonderful x-ray of the central concepts, problems, and phenomena defining second-order cybernetics
- A complete panorama of authors and concepts weaves reflection, teaching, and construction—of and about the world at large
- The very remarks, comments, and consideration written by von Foerster are an array of insights and hints that both materialize a history and open brand new paths

Science is not so much an achievement as a process, namely the process of researching. Research, though is crystalized in a variety of forms, being the most obvious papers, chapters, books, patents, and the like. A book such as *Cybernetics of Cybernetics* can and should be seen as a crystallization of thought, inquiry, and life.

Heinz von Foerster arrived in the U.S.A as an invited speaker for the famous Macy Conferences. As soon as he finishes his talk he is invited to stay in the U.S. He will be a professor at the University of Urbana, Illinois through 1976. His courses and seminars were always crowded because his reputation preceded them. Not long before 1973 von Foerster teaches a course on cybernetics of cybernetics. The course was so successful that he was asked to repeat again. However, people did not know that the Asurian-American professor disliked repeating a course. After insistence from students and professors von Foerster agreed under one proviso, namely he would ask the participants to organized the whole course. The outcome was the 1974 book here reviewed, and the way it comes through the times to us.

Without exaggeration, von Foerters' *Cybernetics of Cybernetics* is a touchstone in the history of science, even though its scope is originally education. Sometimes, a paper or book ends up having a different destiny than its author once intended. A unique, indeed, for to the best of our knowledge there are no other books by prestigious thinkers such as the one reviewed here. Hope there would be other cases as the one considered in this paper. Curiously, von Foerster will one of those remarkable thinkers who never wrote a book of its own, but only papers and chapters—of various kinds. Nonetheless, the content, the strategy and the organization of this 1974 book is to remain as an authentic jewel of thought, research and ingeniosity.

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