**SECOND ORDER CYBERNETICS AS**

**A FUNDAMENTAL REVOLUTION IN SCIENCE**

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Second-Order Cybernetics as a Fundamental Revolution in Science

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**Context •** The term “second-order cybernetics” was introduced by von Foerster in 1974 as the “cybernetics of observing systems,” both the act of observing systems and systems which observe. Since then the term has been used by many authors in articles and books and has been the subject of many conference panels and symposia.

**Problem •** The term is still not widely known outside the fields of cybernetics and systems science and the importance and implications of the work associated with second-order cybernetics is not yet widely discussed. I claim that the transition from (first-order) cybernetics to second-order cybernetics is a fundamental scientific revolution which is not restricted to cybernetics or systems science. Second-order cybernetics can be regarded as a scientific revolution for the general methodology of science and for many disciplines as well.

**Method** • I first review the history of cybernetics and second-order cybernetics. Then I analyze the major contents of von Foerster’s fundamental revolution in science and present it as a general model for an alternative methodology of science. Subsequently I present an example of practicing second-order socio-cybernetics from within. I describe some consequences of doing science from within, and I suggest some new horizons for second order cybernetics

**Results •** Second-order cybernetics leads to a new foundation for conducting science and offers important contributions for a new way of organizing science. It expands the conception of science so that it can more adequately deal with living systems.

**Implications •** Second-order cybernetics extends the traditional scientific approach by bringing scientists within the domain of what is described and analyzed. It provides models of research processes when the scientist is within the system being studied. In this way it offers a new foundation for research in the social sciences, in management science and in other fields like the environmental sciences or the life sciences.

**Keywords •** Epistemology, general scientific methodology, cybernetics, social sciences, action research, Heinz von Foerster.

# Introduction

1. Heinz von Foerster published in a variety of disciplines, including on the mechanism of memory (Foerster 1948), population growth (Foerster, Mora & Amiot 1960), self-organization (Foerster 1960), constructivist philosophy (Foerster 1973), and ethics (Foerster 2003b). However, von Foerster also made a more fundamental contribution by showing how to expand the scientific enterprise with a new way of operating scientifically. My goal in this paper is to explain how von Foerster did that, and how that work has developed. This is not only about a scientific revolution in cybernetics but in the way science is done. It involves advances in the practice of science, and it leads to major shifts in our conception of the goals of science.
2. In order to make von Foerster’s intended fundamental revolution for the science system more intelligible, I will proceed in five stages, first, by offering a short history of second-order cybernetics, second, by analysing the major contents of von Foerster’s fundamental revolution in science, third, by describing an institute which acted for decades in accord with this new approach, fourth, by showing the advantages of this unfinished revolution, and fifth by suggesting some new directions for research in second order cybernetics.

# Part I: A short personal history of second-order cybernetics

1. After World War II there was excitement about the utility of applied science. One outgrowth of that excitement was the Josiah Macy Jr. Foundation conferences in New York City between 1946 and 1953. They were chaired by Warren McCulloch. Gregory Bateson and Margaret Mead were influential in starting them and continuing them. The title of those conferences was “Circular Causal and Feedback Mechanisms in Biological and Social Systems” (Pias 2003). After Norbert Wiener published his 1948 book, *Cybernetics: or Control and Communication in the Animal and the Machine*, the conferees began to call the meetings the “Macy conferences on cybernetics.”
2. As a student when I first heard von Foerster talking about the role of the observer, it sounded to me very similar to what Thomas Kuhn said in *The Structure of Scientific Revolutions*, which was popular at the time. In a well-known passage, Kuhn writes,

“…the proponents of competing paradigms practice their trades in different worlds. One contains constrained bodies that fall slowly. The other pendulums that repeat their motions again and again […] Practicing in different worlds, the two groups of scientists see different things when they look from the same point in the same direction. Again, that is not to say they can see anything they please. Both are looking at the world, and what they look at has not changed. But in some areas they see different things, and they see them in different relations one to the other. That is why a law that cannot even be demonstrated to one group of scientists may occasionally seem intuitively obvious to another. Equally it is why before they can hope to communicate fully, one group or the other must experience the conversion that we have been calling a paradigm shift.” (Kuhn 1962: 150)

1. However,when I showed this passage to von Foerster, he told me, that was not what he meant by including the observer in science. After he published the article “On Constructing a Reality” (Foerster 1973), which described a number of neurophysiological experiments, I realized what he had in mind. I thought von Foerster was proposing a third view of the scientific enterprise. Not the normative view of Popper or the sociological view of Kuhn but a biological view that included awareness of how the brain functions. I felt von Foerster’s idea offered an opportunity to make a scientific revolution (Umpleby 1974). An early description of the three points of view is given in a table, “Three Versions of Cybernetics” in Umpleby (1997), A reformulation of the table according to the three authors (i.e., Popper, Kuhn, von Foerster) is in the table, “Three Philosophical Positions” in Umpleby (2007).
2. There are many neurophysiological examples dating back at least to the 1960s and 1970s that support von Foerster’s article, including the well-known cocktail party-effect (one can focus on a single conversation among many conversations going on at a party); the physiological fact that even though images on the retina are bottom-up we still see things upright; the existence of the blind spot on the retina which is not perceived as a gap since the brain fills in this space with the sensation that surrounds it; and Held & Hein’s (1963) experiment with kittens showing that **t**he brain constructs three dimensional space by coordinating signals from both muscles and eyes.
3. These experiments illustrate that the brain works in ways that we are not aware of. The brain seems to “construct a reality” based on sensory input. Since people have different experiences – language, home life, culture, religion, academic training, and job experiences – each person’s “reality” is in some respects unique, though our knowledge of the physical and social world has many common features.
4. These and many more neurophysiological experiments provide the *biological* foundation of second-order cybernetics. The experiments are essential for second-order cybernetics because they show that “observations independent of the characteristics of the observer” are not physically possible. This is quite a different view from what is assumed in the usual methodology of science. As Humberto Maturana and von Foerster have pointed out, “Anything said is said by an observer to an observer” (Foerster 2003a: 283) or “Everything said is said by an observer to another observer, who can be himself or herself” (Maturana 1978: 31). Our experiences are interpreted using conclusions we have drawn from earlier experiences (Maturana & Varela 1992). Varela and Singer provided empirical support for the prediction that only about 20 percent of neurones to the visual structure of the brain are from the retina, while at least 40 percent come from the visual cortex (Varela & Singer 1987). Visual interpretations seem to be based more on past experiences than on present sensations.

Reflecting on the observer and the importance of interpretation have long been themes in philosophy, the humanities in general, and occasionally in science. However, in the post World War II period in the United States scientists sought to emphasize the objectivity of science and to condemn any suggestion of subjectivity as antiquated, inappropriate, uninformed, and wrong. Even in the definition of science, scientific methods were described as a way of eliminating observer bias.

1. In 1974 von Foerster used the term “second-order cybernetics” for the first time at a meeting of the American Society for Cybernetics in Philadelphia (2003a). Also in 1974 the book *Cybernetics of Cybernetics* (Foerster 1974) was published which mentioned “second-order cybernetics” as the “cybernetics of observing systems”, in contrast to first-order cybernetics as the “cybernetics of observed systems.” By this time there were a number of theoretical achievements in the field of cybernetics. McCulloch (1965) had defined and developed experimental epistemology. Gregory Bateson (1972) was doing work on schizophrenia and the double bind and had published *Steps to an Ecology of Mind*. Wiener’s (1948) concept of a second industrial revolution was widely known. Computers and robotics were advancing rapidly. There was some work being done by artists and composers (Reichardt 1968; Brün 2004). Maturana’s concept of autopoiesis was attracting considerable attention as a way of explaining the organization and operation of living systems (Maturana 1975). Work on second-order cybernetics was just beginning when funding from government research grants ceased due in part to the Mansfield Amendment.
2. In the early 1970s, there was turmoil on college campuses in the United States, and Congress wanted to cool the campuses. One of the causes of the turmoil was that much research on campuses was funded by the Department of Defense (DOD). At the same time students were opposed to the Vietnam War. So Mike Mansfield, a liberal democrat and Senate Majority Leader, proposed the Mansfield Amendment. It required that all DOD funding have a military mission. That meant that von Foerster, who was being funded by the Air Force Office of Scientific Research and the Office of Naval Research, had to declare the military mission of his research. He said the research had no military mission. Consequently he could no longer receive funding from the people who had been funding his research (Umpleby 2003). In contrast people in the artificial intelligence (AI) labs at MIT, Stanford and Carnegie Mellon, when asked about the military implications of AI, invented the concept of an electronic battlefield. That justification was very well received, both at the Pentagon and in Congress, because it held the promise of fewer American casualties in wars. The result was that the flow of federal money shifted from both cybernetics and AI to just AI and robotics.
3. The Biological Computer Laboratory (BCL) at the University of Illinois in Urbana-Champaign had been a leading center for cybernetics research since it was founded by von Foerster in 1958. There were efforts to find other funding for BCL, but they were not successful at the previous level of support. So the laboratory was closed in 1975 when von Foerster retired and moved to California. Those interested in cybernetics then did not have a laboratory in the U.S. dedicated to cybernetics research, since Warren McCulloch and Norbert Wiener, both at MIT, had died in the 1960s. In the late 1970s, to continue our conversations about cybernetics among the scholars who visited BCL, including Humberto Maturana, Francisco Varela, Lars Löfgren, Stafford Beer, Gordon Pask, Ranulph Glanville and others, we moved the BCL network into cyberspace. This period was the early days of experiments with digital messaging. Murray Turoff had created the Electronic Information Exchange System (EIES) at New Jersey Institute of Technology in Newark. The National Science Foundation was funding several experimental trials on small research communities, using EIES. I received one of nine grants for these experimental trials. I invited the former BCL people to communicate with each other using this new medium. (Umpleby 1979; Umpleby & Thomas 1983)
4. The American Society for Cybernetics (ASC), which was founded in 1964, had passed through a period of inactivity in the mid 1970s due to personality conflicts. The conflicts were resolved and ASC was revived by Barry Clemson, Doreen Steg, Larry Heilprin and Klaus Krippendorff (Krippendorff & Clemson 2016). In addition to electronic messaging and collaboration via EIES, we resumed holding annual conferences in 1980 (Umpleby 2016). Usually on the first day of these conferences, we held a tutorial for those new to the field. The tutorials covered both first and second-order cybernetics. We felt we were beginning a scientific revolution in the field of cybernetics. The field had always had two orientations, which were becoming more well-defined (Corona & Thomas 2010). There were those who wanted to design electrical and mechanical equipment and those who wanted to understand human cognition. For the engineers good work meant building something. For the biologists, philosophers and social scientists good work was a contribution to knowledge. These different goals led to some harsh exchanges and a further separation between the technical and philosophical branches of cybernetics.
5. We also conducted tutorials for the European Meetings on Cybernetics and Systems Research (EMCSR) in Vienna, Austria, the Dutch Systems Group in Amsterdam and a few other conferences. Gordon Pask, Ranulph Glanville and Gerhard deZeeuw organized symposia for the Vienna and Amsterdam conferences. Von Foerster, Maturana, Varela, and Ernst von Glasersfeld were invited as keynote speakers. We were working on the introduction of the notion of second-order cybernetics and related ideas. Several definitions of first and second-order cybernetics were created (see Table 1).

|  |  |  |
| --- | --- | --- |
| **Author** | **First-order Cybernetics**  | **Second-order Cybernetics** |
| von Foerster | the cybernetics of observed systems  | the cybernetics of observing systems |
| Pask  | the purpose of a model  | the purpose of a modeler |
| Varela | controlled systems  | autonomous systems |
| Umpleby | interaction among the variables in a system | interaction between observer and observed |
| Umpleby | theories of social systems | theories of the interaction between ideas and society |

Table 1. Varieties of second-order cybernetics in the 1970s and 1980s

1. Ronald Kline ends his 2015 book, *The Cybernetics Moment*, with the assessment that the cybernetics movement ended in the mid 1970s, the moment when second-order cybernetics was invented. The great majority of U.S. scientists thought that paying attention to the observer was a return to a subjectivist epistemology which they regarded as a fundamental error. Von Foerster, Maturana and other second order cyberneticians thought that not including the observer was inconsistent with an understanding of neurobiology. The transition from first-order cybernetics to second-order cybernetics is a fundamental transition, as I will discuss in the next part.

# Part II: Von Foerster and a revolution of the general scientific method

1. In order to discuss in more detail the new perspective which was developed by von Foerster from the late 1960s onwards under the name of second-order cybernetics, I will address the following questions:
* What are the characteristics which separate first-order from second-order cybernetics?
* Where do the advantages of second-order cybernetics lie when compared to first-order cybernetics?
* And why should second-order cybernetics be considered as a general model for new scientific operations in other disciplines and for an alternative methodology of science?
1. Von Foerster’s distinction between first order and second order cybernetics is the difference between excluding the observer from explicit mention to including the observer. Including what had previously been neglected makes for a larger conception of science, a conception than can deal with a wider range of phenomena. In terms of the Law of Requisite Variety (Ashby 1952) second order cybernetics expands the variety in science and hence the variety in the world that scientists can describe.
2. One answer to these questions would be that von Foerster was adding a new dimension, namely the amount of attention paid to the observer. This change would not be limited only to cybernetics but would potentially affect all of science.
3. However, certainly in his later years, von Foerster did not intend merely to understand cognition and to pay more attention to observers, but to replace the traditional methodology with a new one and with new ways of practicing science. Von Foerster wanted to change the established or traditional scientific methodology as well as the conventional ways of practicing science which, in due course, were to be reduced to small niches only. In one lecture von Foerster described his approach as a demolition.

“Everywhere, also in the United States, the oldest and most beautiful houses are nowadays demolished and instead steel and glass-skyscrapers with 36 stories are being constructed. I want to emphasize the reverse process. I start with a 36 story steel and glass-skyscraper and demolish it. But I am not building a baroque castle instead, but something completely different: maybe a beetle, maybe an ant colony, maybe a family.” (Foerster 1988: 20, my translation)

1. The metaphor of the steel and glass-skyscrapers applied to the accepted scientific method becomes clear in von Foerster’s lecture on “Cybernetics of Cybernetics.” In these short lecture notes von Foerster characterizes second-order cybernetics as a fundamental paradigm change which he did not attribute, as Kuhn suggested, to anomalies and to defects in the older paradigm, but rather to its very “flawlessness.” (Foerster 2003a: 284) Von Foerster points to two historical instances in science of elimination of a paradigm by success or perfection. The first case was the Copernican Revolution resulting from “the novel vision of a heliocentric planetary system” (ibid: 284) even though “the Ptolemaeic geocentric system was at its height in the accuracy of its predictions” (ibid: 284). For von Foerster, the second instance was the accepted, hegemonic scientific method with its “flawless, but sterile path that explores the properties seen to reside within objects.” The Ptolemaic geocentric system was replaced between the 15th and the 17th centuries. And, according to von Foerster, the hegemonic scientific method we know today is to be reduced significantly in the years and decades ahead and substituted by an alternative, with second-order cybernetics as its prime example.
2. The replacement of scientific methodology was not intended as a nostalgic move towards premodern forms. Several elements of scientific methods like the production of hypotheses or theories, experiments, collection of relevant data, the production of new instruments or empirical testability and falsifiability need not be changed. But a general replacement of the current method is required for two reasons.
* First, researchers or observers as necessary components in any research process are included in the prevailing research method only in an implicit and hidden way.
* Second, the current research process has the goal of removing this implicit inclusion so that objective accounts can emerge which are strictly independent of researchers or observers. Observer effects, subjective biases or personal preferences, while recognized and necessary initially, are to be excluded from accounts of the research process as much as possible.
1. Eric Kandel summarizes the traditional scientific method and its emphasis on objectivity in the following way.

“Scientists make models of elementary features of the world that can be tested and reformulated. These tests rely on removing the subjective biases of the observer and relying on objective measurements and evaluations.” (Kandel 2012: 449)

1. Thus, von Foerster describes the traditional scientific method as “a particular delusion within our Western tradition” which he characterized by the postulate of objectivity: “The properties of the observer shall not enter the description of his observations” (Foerster 2003b: 285).
2. The fear has been that allowing the properties of observers to be included in their descriptions would open the door to subjectivism, biases and irrationality. Wild pluralisms would be the mildest symptoms in science if researchers and their properties were admitted without further constraints. Nevertheless human observers are biological organisms. Not to incorporate an understanding of the biology of cognition in our practice of science requires discarding relevant experience and knowledge.
3. At this point a specification of the foundations for the new scientific method is needed. In the paper “Ethics and Second-Order Cybernetics” von Foerster develops a distinction between two attitudes towards one’s environment or world.

“Am I *apart from* the universe?’ Meaning whenever I *look*, I’m looking as if through a peephole upon an unfolding universe; or ‘Am I *part of* the universe?’ Meaning whenever I *act*, I’m changing myself and the universe as well.” (Foerster 2003b: 293)

1. Von Foerster re-iterated the dualism of apart/a part in the form of the following question – “Am I an observer who stands outside and looks in as God-Heinz or am I part of the world, a fellow player, a fellow being?” (Foerster 2014: 128). From there he expanded this distinction to an intriguing list of characteristic differences between two fundamentally different ways of interacting with an environment or the world in general.

|  |  |
| --- | --- |
| **Traditional** | **New** |
| Appearance | Function |
| World and I: separated | World and I: one |
| Schizoid | Homonoid |
| Monological | Dialogical |
| Denotative | Connotative |
| Describing | Creating |
| You say how it is | It is how you say it |
| *Cogito, ergo sum* | *Cogito, ergo sumus* |

Table 2. Two paths for interactions with the world/environment

1. Von Foerster emphasizes one distinction from Table 2 as being very significant.

“For me the most important distinction in the table is between ‘Say how it is’ versus ‘It is how you say it.’ These for me are the really fundamental differences between ‘standing outside’ and ‘standing inside’ – and here, of course, syntax fits as the set of rules you can see from the outside. Semantics, however, is like a roast that is being prepared and will soon be served.” (Foerster 2014: 129)

1. The dichotomy of “standing outside” or “standing inside” can be transferred to the domains of science methods where the traditional and still hegemonic method follows the practice of science from outside whereas the new alternative corresponds to a science from within.
2. These two epistemic modes of doing science from outside or inside belong to the group of undecidable questions. For von Foerster analytical questions, such as mathematical proofs, are already decided, so we cannot decide them. Undecideable questions, such as values or goals, are up to us. Von Foerster characterized undecidable questions with two propositions.

“Only those questions that are in principle undecidable, we can decide […] We can choose who we wish to become when we have decided on an in principle undecidable question.” (Foerster 2003b: 293)

1. The new general scientific method as an alternative *modus operandi* and as scientific practices from inside involves activities that are highly interactive and recursive. Louis Kauffman’s contribution for the present issue describes the configuration from inside with researchers as interactive units in reflexive domains. He points out the decisive role of consensus-formation and of the emergence of eigenforms within these reflexive domains. He also provides a fascinating re-invention or re-construction of the scientific method from within. Kauffman’s article makes clear that solipsism or subjectivism are not necessary outcomes of operating from within.
2. Finally, von Foerster is quite explicit that the epistemic distinction of doing science from without and practicing science from within refers also to the separation between first-order and second-order cybernetics. The short description of first-order cybernetics as the “cybernetics of observed systems” and of second-order cybernetics as the “cybernetics of observing systems”…

“is nothing else but a paraphrase of […] the two fundamentally different epistemological, even ethical, positions, where one considers oneself, on the one hand, as an independent observer who watches the world go by; or on the other hand, as a particular actor in the circularity of human relations.” (Foerster 2003b: 303)

Thus, first-order cybernetics becomes the study of cybernetics from without whereas second-order cybernetics becomes cybernetic analysis from within. Any scientific field can be studied in two significantly different epistemic modes where researchers play highly active roles in the mode “from within” or, as Karl H. Müller (2016) has described it recently, in an endo-mode as opposed to the still dominant exo-mode of the traditional scientific method. Any scientific observation is addressed to a community of observers.

1. In the decades between von Foerster’s introduction of the concept of second-order cybernetics in 1974 and his distinction between two epistemic modes of scientific world making several years later the science system was transformed significantly. (Gibbons *et al.* 1994; Hollingsworth & Müller 2008) Science became more diversified, complex and open to new alternatives. Approaches from within, while still not widespread today, emerged especially in the social sciences, in feminist theorizing (Haraway 1988, 1991), in the diffusion of participatory methods (Cooperrider & Whitney 2005; Christakis & Bausch 2006; Umpleby & Oyler 2007) and in the environmental sciences.
2. In the next section I will focus on a specific institute for social and community research which operated since its beginnings in the 1950s in a mode from within. The next step is important because it shows that the perspective from within is neither utopian nor does it lead to an unrestricted subjectivism, but becomes a feasible way of exploring the social world in a significantly different manner than traditional sociologists are used to.

# Part III: An example of practicing social research from within

1. My goal in this section is to describe a way of doing social research, or second-order socio-cybernetics, that is compatible with an epistemic mode from within. I shall describe the work of the Institute of Cultural Affairs (ICA) and will contrast its work with the usual social science research which still operates in a conventional mode from outside.
2. In the 1950s a group of people trained in the ministry had been working with people in the suburbs on “church renewal,” encouraging members of the church to take a larger view of the community and to become more involved in community projects. After a few years they decided to work themselves with people in poor communities. They chose a community on the West Side of Chicago. The financing came from Head Start. One member of a couple would work on the Head Start project and the other person would work on community organizing. When Martin Luther King, Jr. was assassinated in 1968, they were burned out. Rather than give up, they decided to try again. They organized a meeting of a diverse group of people from the community along with a few business people and government officials.
3. They held a week-long conference using facilitation methods. Each day they asked members of the community to answer a question. On the first day, what is your vision for the future of your community? On the second day, what are the obstacles to achieving that vision? Why is it not already present? On the third day, what are some strategies that would remove the obstacles? On the fourth day, what tactics are needed to advance the strategies? On the fifth day, what actions should be taken to implement the tactics? That is, who will do what, when, and how to implement the tactics? At the end of the conference they had a set of plans and committees that worked to implement the plans in the subsequent months. Periodically, at least every 6 or 12 months, they would review that they had planned to do, compare the plans with what had been accomplished, reflect on what they had learned, and then generate a new set of plans.
4. This procedure worked very well in Chicago and a great deal was accomplished. They wondered whether the same methods would work in a developing country. Through contacts in the World Council of Churches, they decided to do a second Human Development Project in the Marshall Islands. Again there was notable success. So, they decided to do 24 projects, approximately one in each time zone around the world. Model villages would serve as examples of what could be achieved. After the first set of projects was done, they decided to do a second set of 24 projects (Umpleby & Oyler 2007).
5. During this time the people in the Institute of Cultural Affairs (ICA) were also doing other projects. They organized Town Meetings, a one day event, one in each county in each country having a Human Development Project. They had a program called Global Women’s Forum, which brought together women at the local level to share problems and possibilities. Finally, they received a grant from the United Nations Educational, Scientific and Cultural Organization (UNESCO) to bring together people from many Non-Governmental Organizations (NGOs) to share reports on their most successful projects. The final meeting was held in New Delhi, India in 1983. The reports were published in a set of volumes under the title, *Approaches that Work*(Burbidge 1988).
6. Many NGOs and church organizations do projects in developing countries. Usually they have a specific focus. They may dig water wells, build churches, build schools, improve housing or work on specific diseases such as malaria or dysentery. ICA had a different approach. They taught participatory methods, so people would learn how to work together to define their needs, invent solutions, and cooperate with nearby people who had resources. They created village institutions, usually a farmer’s cooperative, a businessman’s cooperative, a preschool for children, and a parent-teacher association. Depending on what village businesses already existed, they encouraged the opening of additional small businesses, such as a restaurant, a laundry, a hair-dressing salon, a bakery, and a baby-sitting service. Depending on local needs, they helped to organize sports teams for teenagers and weekly card games for seniors. They organized a weekly market where produce would be sold and people from neighboring communities could see the changes that were happening and sometimes adopt similar initiatives.
7. Each summer the people in ICA would return to Chicago to discuss the past year and define programs for the coming year. In the fall they would go to communities around the world to implement the programs they had designed. Local contacts and resources were suggested by members of the World Council of Churches. The next summer they would return to Chicago for reading and study. They would reflect on what worked and what did not and adopt or invent new approaches.
8. The financial model was that in each project there were 2 or 3 couples. One person in a couple would teach in an embassy school; the other would work full time on community development. In this way they were largely self-supporting, though at a very low income level. Donations to ICA paid for international travel. They recruited from nearby universities agricultural and business advisers and sought donations or loans of labor and equipment to dig wells, install irrigation pipes, provide books for children, etc. Many consultants today use group facilitation methods with clients and continually seek to improve their methods (Cooperrider & Whitney 2005; Bausch & Christakis 2015). To my knowledge ICA was unique in the scale of its work with poor communities. They outgrew their financial resources, and after 1984 the organization devolved into country-based ICA organizations.
9. It is interesting to compare the work that ICA was doing with the way that social science research is done in universities. Currently, the objective in social science research is to test a theory by collecting and analysing data. Experiments should be replicable by others. The researcher conducts the research but otherwise is not mentioned. Research is an effort to find causal relationships among variables at a high level of statistical significance. The goal is reliable theoretical knowledge, not social change or societal improvements directly. Success is measured by number of papers in leading academic journals.
10. ICA did research differently. They read widely, for example Kenneth Boulding, Margaret Mead, Paul Tillich, Ivan Illich and E.F. Schumacher. They would start with current knowledge and learn by doing. They would change methods as needed and use successful methods with additional communities. Many forms of communication were used – celebrations, a weekly market, a newsletter, signs and posters. The goal was to improve the quality of life – health, income, and education – as quickly as possible by using available knowledge and expertise (e.g., nutrition advice, irrigation, new crops, fertilizer and business practices). Success was measured by higher standards of living and the spread of participatory methods to nearby communities. Networks of supportive people were created and maintained.
11. When reflecting on the success of the very practical, grass-roots work of ICA, it is interesting to ask why social science research is so detached from societal problems today. Currently universities exist around the world and thousands of people are engaged in education and research on social systems. But in the traditional “mode from without” they work with data and statistical methods rather than with people in communities. And they produce articles with theoretical knowledge without exploring the possibilities of implementing it. I will address these problems again in the final part of this article.
12. The ICA people were deeply involved in communities – living and working side-by-side on a daily basis. They worked to resolve conflicts within the community. They paid attention to emotions, spiritual feelings, cultural beliefs and practices and they worked from within to create – through stories, songs, and symbols – a shared concern for the community and the world not just individual advancement. In short, they operated as second-order socio-cyberneticians, although the name of the field socio-cybernetics as well as the concept of second-order would be unfamiliar to them.

# Part IV: Important consequences of doing science from within

1. For a variety of reasons, second-order cybernetics as cybernetics from within has not been developed to its full potential especially in social, biological or cognitive sciences. The early pioneers of second-order cybernetics lost their momentum and did not produce a sufficient number of paradigmatic examples to guide further work. From the 1980s onwards Heinz von Foerster was situated far from laboratories and focused on lecture activities around the world. Ranulph Glanville provided a transcendental framework for second-order cybernetics (as discussed in Müller 2015), but co-operated mainly with designers and architects. Humberto Maturana did not develop his observer-focused autopoietic approach in the direction of scientific methodology, Niklas Luhmann (1997) and Dirk Baecker (2013) concentrated on an abstract framework of second-order observations and societal differentiations in an exo-mode, and other leading figures like Gordon Pask, Francisco Varela and Stafford Beer died between 1996 and 2002. In my view second-order cybernetics as a mode of research from within still has a significant future, especially in the social sciences, the life sciences and cognitive science.
2. In the fourth part of my article I want to show that the new science configuration from within, which was initiated by Heinz von Foerster under the name of second-order cybernetics, is part of a continuing evolution of science and produces significant advantages in relation to the traditional approaches from without. In this part I want to focus on four consequences of this on-going transformation from exo- to endo-science which are not visible at first sight, but which are important for further research in second-order cybernetics.
3. For the science system in general the reflexive turn to a mode from within or an endo-mode can yield at least four groups of new opportunities, namely
* the expansion of types of scientific problems and problem solutions
* a stronger emphasis of scientific knowledge production in applications and implementations and in translational or extension activities
* more diversified and more societally oriented career paths for individual researchers
* new possibilities for linking scientific research with ethical considerations
1. In all four areas second-order cybernetics can play significant new roles in promoting these various shifts and can build a new cybernetic research agenda across different disciplines in the natural and the social sciences.

## Diversification of Scientific Problems

1. The example of the Institute for Cultural Affairs (ICA) in the previous section and its operating mode from within makes it clear that the domain of scientific problems and scientific problem solutions becomes more diversified and complex. Operating within this new general science method from within will be accompanied by a widening of scientific problems and problem solutions from a predominantly theoretical focus to a mixed form of theoretical and practical problems where problem solutions are aimed at eliminating or significantly reducing societal or environmental problems. The theoretical background for this type of practical problem solving goes back to the 1950s and 1960s where a new approach under the name of action research was propagated especially within Latin America (Fals Borda 1978). Since then action research institutionalized itself, albeit in rather marginal proportions (Greenwood & Levin 2007; Reason & Bradbury 2001).
2. Under the old regime of the traditional scientific method a societal problem was solved once this problem was successfully modelled or explained. The theoretical problem solution could allow for additional features like forecasts or scenarios. Practical problem solutions require the reduction or elimination of a societal or environmental problem and this practical problem solution must have observable and positive consequences for the well-being of affected groups or communities. Practical problem solutions come about through co-operation and interaction between target groups and scientists until the goal of problem elimination or reduction is reached. Obviously, practical problem solutions will not replace theoretical ones in the years ahead, but practical problem solutions will gain in importance and ideally will be seen as a viable alternative to purely theoretical accounts of system behavior.
3. Table 3 presents an overview of the main differences between theoretical and practical types of societal problems and problem solutions. Under the traditional regime from without only the left column was admitted for (first-order) socio-cyberneticians. In the alternative mode from within both types of problems and problem solutions can be pursued by endo-social scientists.

|  |  |
| --- | --- |
| **Theoretical: Research Problems (RP)**  | **Practical: Societal or Environmental Problems (SEP)** |
| Mode from without (objectivity, observer-free)  | Mode from within (observer participation) |
| Building a theoretical model/ frame-work for RP  | Assessing SEP (history, problem solutions in the past, target groups) |
| Collecting relevant data  | Establishing and carrying out a work plan |
| Theory or model-testing  | Building a workforce and procedures for solutions of SEP |
| Explanatory account for RP  | Effective reduction or elimination of SEP |
| Success through publications and scientific impact  | Success by client groups acquiring skills for self-improvement of quality of life |
| Reliable theoretical knowledge  | Robust practical knowledge |

Table 3. Two types of scientific problems and problem solutions.

1. Second-order social cyberneticians can focus their work on new methods, instruments and heuristics for the practical solution of societal, environmental, medical or technological problems and can create new methods for more participatory and more active types of science.

## Advances in the Knowledge of Implementation

1. A second advantage of doing science from within is to improve our knowledge of implementation. Von Glasersfeld (2005) described knowledge as a combination of theoretical elements together with the know-how of their applications. In recent decades many research facilities were established worldwide as applied universities, as faculties or institutes for social work, for education, for management science and for other applied fields. Under the traditional scientific regime these institutes, faculties or universities were considered as second-rate compared to the research universities with their focus on basic research. The traditional scientific method emphasizes theoretical advancements and views applied work as lying outside science. If implementations were not progressing well, that was not a scientific problem. In addition, the interactions between basic and applied science were not strongly developed, due to the complex multi-disciplinary nature of applied problems relative to theoretical research. In the old regime the applied work remained under-developed and practical problem solutions seemed outside the realm of science.
2. Many societal or environmental problems are solved, in principle, in their scientific dimensions, but lack corresponding implementation stages. A developmental study showed for example (Suri 2008) that the problem of global poverty and hunger does not need enormous financial transfers from the North to the South. The crucial missing element is local knowledge and adequate knowledge distribution with respect to seeds, farming, and marketing. In the new regime of a science from within, agricultural universities, faculties and research institutes worldwide could develop a global program of poverty reduction through knowledge diffusion and concerted translation efforts worldwide.
3. The present time is characterized by an abundance of societal and environmental problems locally, nationally and globally where a high accumulation of theoretical scientific knowledge is accompanied by a deep deficiency in extension, implementation or translational knowledge. To a significant degree the current legitimation crisis in science (Nowotny, Scott & Gibbons 2001) is connected to the problem of under-developed implementation of new and avant-garde knowledge and technologies. This asymmetry can be attributed partly to the once dominant mode from without and to the resulting lack of practical solutions.
4. Second-order cybernetics in particular can become a vital element in pursuing research to close these asymmetries and deficiencies and to create an abundance of new bridges for transfers between basic and applied research and for the rapid diffusion of new technologies in areas like health, information or industry.

## Strengthening and Diversifying Science Curricula

1. Athird advantage of pursuing research from within is to transform the curricula especially in the social or the environmental sciences and to build these curricula on two different pillars. Shifting to a mode from within will add to the cognitive diversity in these fields in significant ways.
* First, researchers in the social or the environmental sciences are currently losing their direct contact with their fields of investigation. The predominant method of research used in journal articles in areas like sociology, psychology or political science is now based on survey data. Table 4 shows that in the period from 1950 to 1995 articles in high quality journals for economics, sociology, political science, social psychology or public opinion research are based more and more on the analysis of survey data.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Economics** | **Sociology** | **Political Science** | **Social Psychology** | **Public Opinion** |
| 1949/50 | 5.7 | 24.1 | 2.6 | 22.0 | 43.0 |
| 1964/65 | 32.9 | 54.8 | 19.4 | 14.6 | 55.7 |
| 1979/80 | 28.7 | 55.8 | 35.4 | 21.0 | 90.6 |
| 1994/95 | 42.3 | 69.7 | 41.9 | 49.9 | 90.3 |

Table 4. The rise of survey research from 1950 to 1995 in percent (from Saris & Gallhofer 2007: 2)

A mixed approach of dealing with theoretical and practical problems provides much richer perspectives on societies and their environments than an almost exclusive focus on survey data.

* Second, students and future scientists as knowledge producers will gain in their understanding of societies if they can shift between theoretical and practical work and can avoid, to quote Ludwig Wittgenstein, “a one-sided diet.” (Wittgenstein 1967: §593) Science from within and its variety of problems and problem solutions as well as its strong emphasis on implementation knowledge should allow more cognitively diversified career paths in research work.
* Furthermore, a more diversified and complex perspective on society and the environment should have a positive effect on the theoretical or the interpretive work of social or environmental scientists. Due to the more complex nature of practical problems and solutions it can be expected that in the long run theories or models will become more practical and the implementation or extension work will become more theoretical.
1. Again, second-order cybernetics can play a significant new role in the mediation of theoretical and practical problem solutions in the social and the environmental sciences and in finding intelligent new mixes in the construction of curricula and PhD-programs in these fields.

## Recombining Science and Ethics

1. The fourth advantage of the science mode from within is that it makes scientific operations more dependent, aside from the goals of researchers, on urgent societal problems, on the needs of different groups and populations or on local or national values. Here, science from within becomes significantly more negotiable and open to different normative contexts and more sensitive and receptive to ethical considerations.
2. Without losing its scientific credentials, second-order cybernetics could become a new instrument for the fine-tuning of successful theoretical and practical problem solutions and the adaptation to local or national needs. In this way, second-order cybernetics could operationalize von Foerster’s “ethical imperative” which was

 “Act always so as to increase the number of choices.” (Foerster 2003b: 227)

1. Following this general direction of an expansion in the number of choices, second-order cybernetics as cybernetics from within could develop a new function as a lever for humanizing science in a significant and sustainable manner.

# Part V: New horizons for second-order cybernetics

1. The research agenda for second-order cybernetics was restricted so far to the transformation from exo-science to endo-science and to special niches within these transformation processes.
2. But second-order cybernetics as a trans-disciplinary field for the study of communication and control from within can be advanced in a more general and systematic way. Here I will mention four broad domains with new objectives for second-order cybernetics which can be reached independently and outside the four areas in the previous section. These four general targets constitute new long-term research paths which could be undertaken in the years and decades ahead, namely
* shifting from the traditional epistemology of cybernetics and radical constructivism to the building of more advanced epistemic frameworks
* providing the foundations for actor-based disciplines like psychology, management and the social sciences
* widening of methodologies especially for the cognitive, the social and the biological sciences
* recognizing a multiplicity of scientific contexts, their differences, their implicit status and the need for mediations.

These four general and systematic domains for contemporary second-order cybernetics research and development can be described in the following manner.

## Building Viable Epistemologies for Radical Constructivism

1. The epistemology of radical constructivism as a research tradition which includes second-order cybernetics (Müller 2010) is mostly understood as being another variant of social constructionism or postmodernism. Among the group of radical constructivists Ernst von Glasersfeld probably moved closest to philosophical domains. He established a radical constructivist epistemology directed against scientific realism, against an objective and observer-free reality, with an emphasis on the active role of observers in constructing their realities and, finally, with viability as an alternative criterion for the contingent acceptance of statements, hypotheses or theories (See Glasersfeld 2007, Müller 2011 or Steffe 2007). In sum, second-order cybernetics and radical constructivism have relied on an epistemology so far which appears less refined when compared to the highly sophisticated approaches within contemporary epistemologies.
2. As a research program on cognition second-order cybernetics as well as radical constructivism offered various empirical explanations of the stability of reality constructions, especially through Heinz von Foerster’s postulate of epistemic homeostasis. “The nervous system as a whole is organized in such a way (organizes itself in such a way) that it computes a stable reality.” (Foerster 2003:244) But the relations between radical constructivism as an empirical research program and scientific realism as a hegemonic epistemological paradigm were restricted to a non-dialogue which can be summarized in a slightly paradoxical manner. Radical constructivism provides an explanatory account why realism seems so natural or obvious, while scientific realism continues to argue for the fallibility of radical constructivist arguments.
3. But a future epistemology for second-order cybernetics or radical constructivism should be linked to at least two recent epistemological approaches under the names of social epistemology (Goldman & Blanchard 2015) on the one hand and epistemological contextualism (Rysiew 2016) on the other hand. These were advanced without explicit references to second-order cybernetics or to radical constructivism and deal with a variety of problems relevant also for the traditional approach by Ernst von Glasersfeld.
4. As a challenging future objective, second-order cybernetics as cybernetics from within should produce new state of the art epistemologies which include elements from social and contextualist epistemologies and which produce more refined new conceptual frameworks for dealing with epistemological issues within the tradition of radical constructivism.

## Providing Foundations for Actor-based Disciplines

1. A very large task for second-order cybernetics lies in its role as a founder of last resort for academic disciplines with strong involvements of observers, namely for the social sciences, for the life sciences or for the cognitive sciences. This task may seem far-fetched and beyond the scope of second-order cybernetics, but Bernard Scott has provided an intriguing example for the foundations of psychology within this issue.
2. Bernard Scott characterizes second-order cybernetics as cybernetics of the observer and presents a study in second-order cybernetics on the foundations of psychology. He uses the framework of Gordon Pask’s conversation theory CT (Pask 1975a,b) with its differentiation of psychosocial P-individuals and biomechanical M-individuals and a variety of interaction patterns between these two units. This type of studycould be undertaken by second-order cybernetics for a variety of academic disciplines including my own discipline of management.
3. Another example for fruitful future work for second-order cybernetics lies in the foundations of the cognitive sciences where second-order cybernetics could emphasize three necessary requirements for cognitive science investigations which should be fulfilled simultaneously.
* First, studies on cognition should be based on Heinz von Foerster`s unity of cognition postulate where cognition is conceptualized with a multiplicity of faculties which cannot be isolated functionally or locally (Foerster 2003:105, Foerster & Müller, 2003). These faculties go well beyond the domains of perception, memory or inferring (Foerster 2003:105) and include learning, evaluating or movements as well.
* Second, in Humberto Maturana’s and Francisco Varela’s book The Tree of Knowledge (1992) enactivism was promoted as the middle ground between solipsism and representationalism and a variety of e-properties like embedded, embodied, enacted, environment, etc. have become essential building blocks for cognitive science studies (See also Vörös, Froese & Riegler 2016).
* Third, first person approaches should not be excluded but must become a significant and necessary element in the study of cognitive processes. This line of research was already pursued by Francisco Varela who argued vigorously for the necessity of these first-order approaches especially in studies of consciousness (Varela & Shear 1999).

Second-order cybernetics can provide new and more complex frameworks for cognitive science and can become a constant reminder that the foundations of the cognitive sciences are best developed in a way which remains consistent with these three requirements, which seem to get lost more and more in the wider stream of contemporary cognitive science research and publications.

## Creating Methods for Endo-Research across Disciplines

1. The contributions by Louis Kauffman as well as the editorial by Karl Müller and Alexander Riegler address the implications of second-order cybernetics for the field of general scientific methodology. Here I wish to add that a particularly fruitful task for second-order cybernetics in the future lies in the reconfiguration of available methodologies especially in the social sciences, the life sciences and the cognitive sciences from their traditional exo-designs to new endo-designs.
2. Over the last decades I worked on a number of methods for quality improvement, for process improvement and for service learning which were organized largely in an exo-mode and which belong to the methodology of management science. Second-order cybernetics can interpret these and other methods in an endo-format across a broad range of academic fields and can focus on the comparative advantages of these changes. This work would be consistent with the current interest in teams.
3. The tasks ahead in the fields of methods and methodologies are challenging. The primary objective lies in a stream of studies which use the revised endo-methods and endo-methodologies. In this way, the potential strengths of these reinterpreted methods can be specified concretely and multiple comparisons between the new endo-methods and the old approaches can be undertaken.

## Mediating between Different Contexts in Science

1. An important research field for second-order cybernetics as cybernetics from within lies in an enrichment of contextual differences, due to a new transparency of explicit differences in the goals of researchers, their academic specializations as well as their cultural backgrounds, especially because differences in contexts were rather ignored so far (Lissack & Graber 2014).
2. I have conducted this type of research since the 1980s when I worked to facilitate communication between cyberneticians and systems scientists in the United States and the Soviet Union (Umpleby 1987). During this period a very important theoretical framework was established by Vladimir Lefebrve under the name of reflexive control(Lefebrve 1982, 2001). It described two different ethical systems that characterized the United States and the Soviet Union.
3. The variety of issues in contextualizing science will produce challenging new research tasks for second-order cybernetics, which can become a mediator across different contexts and across different fields of scientific research. Currently, the American Society for Cybernetics (ASC) has moved the problems of contexts and contextualizations to its primary agenda, so this agenda is being pursued already.
4. In my view, these four roads ahead for second-order cybernetics offer a rich and diverse research program which can be undertaken beyond the frameworks and approaches inherited from the pioneers of second-order cybernetics.

# Conclusion

1. Early work in cybernetics provided a theory of circular causal, regulatory phenomena that occur in biological and social systems and in some machines. It offered a way of explaining goal-seeking and goal-formulation. A general theory of perception, learning, cognition and adaptation was created that influenced many fields and that helped to create the information age. This first wave of cybernetics ended around 1975 (Kline 2015).
2. Second-order cybernetics pursued a more ambitious goal which has not yet been taken up by the broader scientific community and, more paradoxically, by second-order cyberneticians as well. As I have described, second-order cybernetics has attempted to establish a new way of operating scientifically from within, from observing systems observe systems from within, as opposed to the traditional scientific approach from without.
3. By proposing the idea of second-order cybernetics von Foerster challenged a key assumption in the methodology of science, namely the goal of objectivity to be achieved by eliminating observer-effects. He showed that scientific disciplines or fields in general can be organized in two ways. Many scientific fields still use the traditional approach of observing from outside. Second-order cybernetics questioned this orthodoxy vigorously. In doing so, von Foerster initiated a still unfinished revolution in science. The new general methodology of science from within changes the status of the researcher from a hidden factor to an active participant within a highly interactive system. Some fields like physics will retain their traditional methodology, due to its focus on inanimate objects. But many scientific fields can gain significantly by shifting to a mode of observing from within. In this sense, second-order cybernetics provides a role model for operating scientifically in a new way which offers advantages in terms of problem solutions, knowledge production and robust scientific outcomes.
4. Finally, second-order cybernetics can expect a bright future by moving along the four new roads outlined above towards an advanced epistemology, to foundations and endo-methodologies for the social, the biological or the cognitive sciences as well as toward contextualizing science. In this way second-order cybernetics can still act as an avant-garde model for humanizing science and for making science more receptive to societal needs at the local, national and global levels.

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