SECOND ORDER CYBERNETICS

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Summary

Second order Cybernetics (also known as the Cybernetics of Cybernetics, and the New Cybernetics) was developed between 1968 and 1975 in recognition of the power and consequences of cybernetic examinations of circularity. It is Cybernetics, when Cybernetics is subjected to the critique and the understandings of Cybernetics. It is the Cybernetics in which the role of the observer is appreciated and acknowledged rather than disguised, as had become traditional in western science: and is thus the Cybernetics that considers observing, rather than observed systems.

In this article, the rationale from and through the application of which, second order Cybernetics was developed is explored, together with the contributions of the main precursors and protagonists. This is developed from an examination of the nature of feedback and the Black Box—both seen as circular systems, where the circularity is taken seriously. The necessary presence of the observer doing the observing is established. The primacy of, for example, conversation over coding as a means of communication is argued-—one example of circularity and interactivity in second order cybernetic systems. Thus second order Cybernetics, understood as proposing an epistemology and (through autopoietic systems) an ontogenesis, is seen as connected to the philosophical position of Constructivism.

Examples are given of the application of second order Cybernetics concepts in practice in studies of, and applications in, communication, society, learning and cognition, math and computation, management, and design. It is asserted that the relationship between theory and practice is not essentially one of application: rather they strengthen each other by building on each other in a circularity of their own: the presentation of one before the other results from the process of explanation rather than a necessary, structural dependency.

Finally, the future of second order Cybernetics (and of Cybernetics in general) is considered. The possibility of escalation from second to third and further orders is considered, as is the notion that second order Cybernetics is, effectively, a conscience for Cybernetics. And the popular use of “cyber-” as a prefix is discussed.

1. Introduction: What Second Order Cybernetics is, and What it Offers

The relationship of first order Cybernetics to second order Cybernetics is like the relationship between the Newtonian view of the universe, and the Einsteinian. Just as Newton’s description remains totally appropriate and usable in many instances (including flights to the moon), so first order Cybernetics also retains its value and frequently provides us with all we need (for instance, in many control arrangements). And just as the Newtonian view is now understood to be a special, simplified, restricted (and slow) version of Einstein’s view, so first order Cybernetics is a special, simplified, restricted (and linear) version of second order Cybernetics. Often, both the Einsteinian view and second order Cybernetics may seem recondite and almost irrelevant. But both are nearer to what we think of as a truth than the Newtonian view and first order Cybernetics: they better satisfy Occam’s Razor (tersely captured as: that which requires less to explain more is better).

The analogy goes further. One difference, in the cases both of the Einsteinian view and second order Cybernetics, is that the observer, essentially excluded from the Newtonian view and first order Cybernetics, is included—at once the strength and an apparent weakness. In Einstein’s universe, the observer is included through his frame of reference and his motion relative to the objects and events under consideration. In second order Cybernetics, it is through the relationship between observer (observing) and observed, particularly when this relationship is understood to be circular. In the case of second order Cybernetics, first order Cybernetics may be seen as the limited case where the link back from observed to observer is sufficiently weakened (or ignored). Under such circumstances, we assume the observer simply observes what is going on, neutrally and unmoved—instead of changing behavior in response to the observed's changing behavior.

Second order Cybernetics presents a (new) paradigm—in which the observer is circularly (and intimately) involved with/connected to the observed. The observer is no longer neutral and detached, and what is considered is not the observed (as in the classical paradigm), but the observing system. The aim of attaining traditional objectivity is either abandoned/passed over, or what objectivity is and how we might obtain (and value) it is reconsidered. In this sense, every observation is autobiographical. Therefore, second order Cybernetics must primarily be considered through the first person and with active verbs: the observer's inevitable presence acknowledged, and should be written about in the first person, not the third, giving us an insight into who these observers are. This is why this article does not always follow the conventions of traditional scientific presentation, and why this survey must be biased, partial, and incomplete. (The use of the first person in scientific discourse is far more common than we realize. Applied Linguists have studied text corpuses, discovering the use of the first person in published papers has increased, especially in the physical sciences. According to this work, the practice of scientific reporting no longer aims at the objective presentation of facts, but at joining favored factions.)

When second order Cybernetics was first proposed, it was known as the Cybernetics of Cybernetics, distinguishing the Cybernetics of observing, rather than observed, systems. This New Cybernetics was also known as second order Cybernetics, because it is the cybernetic (study) of Cybernetics: Cybernetics studied through the understandings that result from assuming Cybernetics as a way of considering the world we find ourselves in. In this text, these alternates are treated as synonyms.

2. Background—the Logical Basis for Second Order Cybernetics

2.1 A Reflection on First Order Cybernetics

Cybernetics (first order Cybernetics), described by Norbert Wiener in his eponymous book, is "communication and control in the animal and the machine"; that is to say, communication and control in general (see History of Cybernetics; Existing Cybernetics Foundations). A typical example of a simple cybernetic device is the thermostat. A thermostatic system (in a cold climate) consists of two main components: a heater, and a sensor/switch. The heater provides heat and the sensor/switch, in conventional language, controls the heater, turning it on and off according to whether or not the sensor attached to the switch has exceeded a goal-temperature. When the environment is so warm that the goal-temperature is exceeded, the switch turns off the heater. When the temperature drops below the goal-temperature, the switch turns the heater on. (We normally ignore the heat sink, which sucks the heat out of the environment.) In traditional language, a feedback loop exists between the heater and the sensor/switch, said to control it.

The stability in this system does not exist either in the sensor/switch or in the heater. It lies between them. It is the whole system that is stable, achieving the desired constant temperature. The traditional causal description (of first order Cybernetics), in which the switch/sensor controls the heater, does not stand up to scrutiny. It is driven by a notion coming from the physics of energy: the element in the sensor/switch that uses less energy (the control system) is said to control that which uses more (the heater). We should not be surprised: the notion and word "feedback", tapping an insignificant amount of energy in the system to send a signal back so behavior can be corrected, suggests a sort of inequality. Indeed, Wiener insisted cybernetic systems were subject to the laws of physics.

When the arrangement of the thermostat is looked at not in terms of the physics of energy, but of organization and message passing, a different understanding emerges, laying a base for second order Cybernetics: the understanding that, in Cybernetics, circularity is central, controller and controlled are roles given by an observer, each being controller to the other's controlled.

Wiener was aware of limitations and dangers in the way he was thinking of Cybernetics, which he explored in his later book "The Human Use of Human Beings" (1950). Others who contributed to the formation of the subject and who, together with Wiener and chairman Warren McCulloch, formed the core of the Macy Conferences from 1946 to 1953 (especially Gregory Bateson and Margaret Mead) understood the notion of feedback could be translated into circular causality (the full theme title of the conferences was "Circular Causal and Feedback Mechanisms in Biological and Social Systems"). This term emphasizes the organizational (structural) insights and epistemological changes Cybernetics brought with it, in contrast to the view proposed by physics. They also all understood the centrality of finding pattern and regularity.

Cyberneticians frequently claim Cybernetics as a science. Science claims (amongst other things) to discover regularity and repeatability, and, as an extension of that, to make predictions testing regularity. To claim predictability, science looks for mechanism, the embodiment of regularity and repeatability. If there is mechanism, predictability results (see History and Philosophy of the Systems Sciences: The Road Toward Uncertainty). Yet there are circumstances where mechanism is obscured. When this occurs, we may invoke the Black Box concept originated by James Clerk Maxwell.

This concept, trivialized by later behaviorist psychologists, allows us to operate while remaining essentially ignorant. The principle of the Black Box is that, where we observe some change in a behavior, we construct and insert a Black Box allowing us to interpret the change as the result of the operation of an invisible mechanism, held within the Box, on what is now seen as input giving rise to output. The observer/scientist develops a description functioning as a mechanism/explanation (i.e. model) which accounts for the transformations of what are now input into output. The explanation is purely historical and the product of the interaction between the observer and his inventive, fictional insertion, the Black Box, although we come to believe that this explanation opens up (that is, Whitens) the Black Box—even if this Whitening is excluded, by definition. We do not know the cause, we have not looked inside the Black Box and, therefore, cannot observe it (hence its appeal for psychologists, for it allows us to develop understandings without "opening up the head").

The Black Box was annexed to Cybernetics by W Ross Ashby. In what may be the key basic text, his 1956 "Introduction to Cybernetics", he uses the Black Box artifice to permit the (scientific) observer to construct a description explaining the behavior to date of some system that interest us. The Black Box contains a presumed mechanism, which cannot be seen and is the product of the observer's interaction with the whatever-it-is. Ashby went so far as to suggest the Black Box might not be just a useful device, but universal, suggesting that we never really see what's causing a change, only some explanatory principle we take as a mechanism. The concept of essential obscurity was remarkable at the time, and still causes problems to many.

By way of a crutch to those for whom science has been understood as removing obscurity to reveal the hidden, I offer Szent György's astonished remark that the physicist cannot tell us exactly where just two electrons will be at any one time. We easily enter realms of the unknown and the unknowable.

What is vital, for the development of second order Cybernetics, is that the Black Box is essentially and crucially a construct of the observer. When we use this concept, we bring the observer in to the process, rather than denying him. That the Black Box requires the observer's presence is acknowledged, and is circularly connected in. The observer watches and changes. What the observer learns he learns from interaction with the Black Box (which is his construct). Who can know what the (obscure) Black Box does?

2.2 Circularity

I hope it is clear that, even in the original Cybernetics (first order Cybernetics), circularity, interaction, and betweenness are present. But they were not always explicitly understood.

Let us return to the example of the thermostat. There are two remarks to make about the account so far given.

The first is introduced above. While, traditionally, we have called the sensor/switch the controller and the heater the controlled, in Cybernetics (even of the first order) this is not an accurate reflection of the understanding we are developing. Control theorists may wish to retain the old hierarchy as did early cybernetic texts; but reflection on and consideration of what happens leads the cybernetician to see it differently. The arrangement is circular, and its qualities derive substantially from this circularity. The sensor/switch causes the heater to turn on/off, but the heater, likewise, causes the sensor/switch to turn on/off. There is causality, but it is circular and does not lead anywhere: there is no primary cause. It is this understanding that allows, for instance, Feldenkrais therapists to retrain the brain by moving limbs. We conceive the brain as controlling muscles. Conversely, Feldenkrais manages to persuade the brain to be controlled by the muscles.

The second lies in how we describe the system. Let us imagine that we find an object that, no matter how cold its environment, remains at the same (warmer) temperature.

We do not know how or why, so we invoke a Black Box. This Box always gives constant temperature as output regardless of the input (always lower than the output). We might propose a mechanism, such as the thermostat, to account for this. We explain that there is a source of heat in the Black Box, modulated by some device that turns the source off and on as it exceeds or falls below this (output) temperature. But this explanation is not what actually is (although it might, in a Realist world, correspond to that): it is a construct through which we interact with the system. Under these circumstances, our account of the system is not through cool, impersonal observation—as traditional science pretends. (That this is a pretence can surely no longer be in question. Without listing examples in science where the observer's active presence has turned out to be central and unavoidable, we may recall Peter Medawar's by now legendary 1963 radio talk title: "Is the Scientific Paper a Fraud?")

Discussing the thermostatic system, we treated it as a given phenomenon we could examine, describe and possibly test—without our actions in so doing having any effect on the phenomenon. But Ashby's claim that the Black Box is universal means that no system can be described in this detached manner.

Cybernetics brings us circularity as its core insight, and, through that, the related concepts circular causality, interaction, betweenness, etc. When we think of situations in which we cannot see the mechanism we'd like to elucidate, we invoke the Black Box as a way of dealing with this so-called shortcoming. By definition, we cannot see inside the Black Box. The mechanism we find is made by us to explain what is actually an interaction. We can apply this recursively—and some do (recursion of observation is a central concept of second order Cybernetics). But the point, here, concerns how we understand our relationship with the systems we observe. As our example, we have taken the thermostat, considering it as an interactive and circular system (as opposed to a traditional control system). But we have still considered the system as lying beneath our gaze (subject), rather than as involved in a circular relationship between observer and observed. There is an ambiguity here—an inconsistency. We are not treating our relation to the system, as observer of the system, in the same way as we treat the relation between the observing part of that system, and the observed part.

Consider, for a moment, how science is carried out. As Peter Medawar pointed out, what we say happens is not what actually happens! Contemplate the scientific experiment, by way of example. In a scientific experiment, the observer first sets up the experiment in a manner he chooses. He then carries out the experiment, changing and adjusting until he achieves behaviors of the sort he is looking for. Then he modifies what happens so he gets still more behaviors appropriate to his interests. Then he stops. Remember how we set up and then maneuver the lens, screen, and light source in classical optical experiments. We do not just place these elements down on the rule. We move them to get the result we want.

Carrying out the experiment, the experimenter was actively involved in both its design and operation. The conventional account omits all this, talking as if somehow, by magic, "everything just happened" (see History and Philosophy of the Systems Sciences: The Road Toward Uncertainty). There was no adjustment, no design, no intervention, no interpretation of measurement and reading (and no interpretation or ideas). The observer is not part of the system lying under his gaze. Contrariwise in second order Cybernetics, the observer is accepted as being involved: in a circularity.

There are two aspects to circularity in cybernetic systems. First, there is the circularity of the system under consideration, that is, the observed system. And secondly, there is the circularity of the act of observing, that is, of the observing system observing the observed system.

3. Second Order Cybernetics—Historical Overview

3.1 The Beginnings of Second Order Cybernetics

The stage is set for a review of the argument (outlined above) for second order Cybernetics. What is now necessary is to examine how the argument was made, the different forms the argument took, and media it was developed in.

It was the understanding that we should consider observing systems, and that the circularity of the system under consideration (the observed system) is important, not to be ignored, which gave rise to second order Cybernetics. But it was also a feeling for consistency: that the insights found and developed in any particular area of study should be applied within the study itself: that the study should benefit from its own insights.

These insights came to light as a source of renewal and progression in Cybernetics in 1968. The revolution that shifted Cybernetics from first to second order was effectively complete, in principle, by 1976.

There is a precise marker indicating the beginning of this revolution: the first symposium of the newly formed American Society for Cybernetics (ASC), held during the American Association for the Advancement of Science meeting in 1968. In certain respects, this symposium reflects the Macy Conferences: organized by Heinz von Foerster, it was chaired by Warren McCulloch, and the keynote paper, "The Cybernetics of Cybernetics", was given by Margaret Mead. It seems the title and topic of the paper were given to Mead by von Foerster, and reflected his preoccupations more than Mead's.

The paper, displaying a remarkably ecological tone, concerns "Cybernetics as a way of looking at things and as a language for expressing what one sees", and, in its conclusion, asks "Why can't we look at this society [the ASC] systematically as a system with certain requirements, certain possibilities of growth, certain constraints … to some of which this society is to be responsive?"

Referring to an earlier meeting of the Society for General Systems Theory, Mead remarked that she had suggested that "they give a little thought to how they could use their theory to predict the kind and size of society they wanted". She repeated this for the ASC: "in a new organization, centered upon our knowledge and interest in circular self-corrective systems … it might be worthwhile … to really consider … what we are founding" (see General Systems Theory).

Mead started her paper by setting a context for her self-referential questioning: "The competence I had—or have—comes from the intensive analysis of very small, relatively isolated … communities which serve as living models from which one can sometimes develop larger, more formal models". This turns out to have been a very good description of the ASC!

She was asking that the understandings developed in Cybernetics, representing a way of seeing and providing a means of communication (between experts in different disciplines), should be applied to the embodiment of these understandings in a society. Cybernetic understandings should be applied to the embodiment of Cybernetics itself.

Mead's paper (though hard to trace) was tremendously important. Its value lies in its name, and in the reflexive notion of self-application proposed in it—the sort of idea which can wander into the consciousness of a group of workers and generate insight almost without any awareness on their part. In this sense, it was truly seminal.

Although Mead's paper was the place marker, it was not alone. In a paper in which I gave my account of the gestation of second order Cybernetics, I pointed to two other, crucial 1968 publications: George Spencer Brown's "The Laws of Form", and Lars Loefgren's "An Axiomatic Explanation of Complete Self-reproduction". The first is concerned with what happens when we take as the primitive act the drawing of a distinction. The second, with the relationship between what we might think of as a model and what it models. Both of these need to be seen against the discoveries of Goedel's Theory, which I paraphrase as saying that no formal system can construct, within itself, a description of itself that is simultaneously both complete and consistent. (For more discussion of both works, see section 5.2.3.)

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A website on (radical) Constructivism, with many useful links to other sites concerned with cybernetics:

http://www.univie.ac.at/cognition/constructivism/

Finally, *Cybernetics and Human Knowing* is a quarterly Journal focusing on second order cybernetic insights and is published by Imprint Academic, Thorverton, UK.

Biographical Sketch

Ranulph Glanville studied at the Architectural Association School in London in the 1960s and early 1970s, where he was mainly concerned with electronic performance music. On completing his studies he was sucked into teaching, mostly architecture, but also art, graphics, design, research methods, and cybernetics, at Cambridge University, the Architectural Association, University College London, and the University of Portsmouth. He has helped supervise doctorates at a number of other universities, been visiting professor, lecturer, and critic on six of the world's seven continents, and in a wide range of subjects. He is an adjunct professor at the Royal Melbourne Institute of Technology, Australia, and reader at the Bartlett, University College London. He gained two doctorates: the first (with Gordon Pask) in Cybernetics; the second (with Laurie Thomas) in Human Learning, has over 200 publications, is on the editorial board of several journals and the committee of more conferences. He has also been a chef in a highly regarded restaurant.