SECOND ORDER CYBERNETICS

Ranulph Glanville,
CybernEthics Research, UK and Royal Melbourne Institute of Technology University, Australia

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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.)

3.2 Precursors

Second order Cybernetics did not come about "out of the blue". As indicated, many of the questions that give rise to second order Cybernetics are now clearly visible as inherent in first order Cybernetics.

While there is no doubt that Ashby foreshadows second order Cybernetics, especially his understanding of the Black Box (see above) and variety, and what he called "essential variables", which closely match the second order Cybernetics idea of organizational closure (see, section 4.1), in actuality, there was a whole body of argument that almost belongs to second order Cybernetics. The foundations from which second order Cybernetics was created depended on the perspicacious work of many people. Von Foerster and Mead clearly understood this—indeed, Mead's early (and pre-Cybernetics) anthropological work in which anecdote and participatory observation by the anthropologist were so central to the polemic is one such obvious precursor.

In certain respects, then, second order Cybernetics was waiting to happen. Since it tackles what had, in recent history, been thought of as the problem of inclusion of the observer, it is naturally associated with those subjects in which observer inclusion is seen as a difficulty. This is particularly so in the social sciences (see, section 5.2.1), but also held in, for instance, biology and physics. No doubt that is one reason the subject was first formally indicated by an anthropologist, Mead, whose major contribution might be considered to be the enactment of a methodology involving anecdotal evidence collected through an active and present observer, recognizing the personhood of the provider of the information.

One would therefore anticipate that the most polymath/polyglot of all early cyberneticians, Gregory Bateson (also an anthropologist, and for some time married to Margaret Mead), was also a major precursor. Bateson's greatest value in Cybernetics may have been that he was unclassifiable except as a cybernetician: if

his basic concern was epistemology, it was Cybernetics that gave him the framework within which to work. He moved through fields, evolving a knowledge which was essentially based in an all-embracing meta-approach. In particular, Bateson's handling of different types of logical structure and the importance of metaphor are essential stepping-stones for the development of second order Cybernetics. In his assertion that information is the difference that makes a difference, Bateson introduces the sort of language and conceptualization that came to characterize second order Cybernetics, as well as the importance of difference and the unavoidability of the observer. Of all the cyberneticians at the early Macy conferences, Bateson seems the one who was intuitively closest to second order Cybernetics all along.

The language Bateson used is echoed in George Spencer Brown's calculus of indications and distinctions, published in his book "The Laws of Form". Spencer Brown built a whole logical system on the notion of some unnamed actor distinguishing values, and his initial command "Draw a Distinction" became something of a clarion call to second-order cyberneticians. His logic was later developed by Francisco Varela into a calculus for self-reference. Although Spencer Brown's work has been deeply influential in (especially second order) Cybernetics, he has no interest in the subject at all.

Self-reference (which later transforms into autopoiesis and organizational closure) was one of the key start-up concepts in second order Cybernetics—inevitable when circularity becomes so central and a subject becomes its own object (or subject!). The logical problem of self-reference (seen, generally, as vicious and embodied in the mediaeval figure of the Oreborus) was appreciated and approached by the logician and autologist Lars Loefgren, who distinguished certain occasions and contexts when, in spite of Goedel, it is possible to talk meaningfully, in the world of mathematics, of at least partial self-reference. Loefgren's work made it possible for others to accept that circularity need not be vicious. In a similar manner, Gotthard Günther's developments of transclassical logics accommodate both subject and object in that there are no attributes of either without the other: thus opening the way for others to dare to include the observer, without excuses (see, *Axiological Systems Theory*)! Günther had a deep personal influence on Maturana and von Foerster, and both he and Loefgren worked at von Foerster's Biological Computer Laboratory (BCL).

Last, but by no means least, Stafford Beer's work on the management of large systems of great complexity must be mentioned. Beer's work has always been associated with second order Cybernetics, especially by Beer himself. He is precursor, developer, and practitioner all in one, and it might be argued that he should feature amongst those who developed the field per se.

Beer's work on regulation, developing from Ashby's "Law of Requisite Variety" (which states, in my paraphrase, that for any system to effectively control any other system, not restricting its possible outcomes a priori, that system must have at least as much variety as the other system—where variety is a measure of the number of possible states the systems may attain), and developing through a veritable library of books starting with metaphors of the firm as an organism, caused him to consider how effective a model might be, and to indicate how often the models we use are structurally incapable of any but the most limiting behaviors. His address to the

House Committee on "Managing Modern Complexity", one of the texts treated cybernetically in von Foerster's "Cybernetics of Cybernetics", is a model of lucid argument concerning complexity, modeling, delay, and information overload. In particular Beer's "Viable Systems Model", in which "self-similarity" plays a crucial role, epitomizes the truly second-order cybernetic system.

Beer's work is immensely ambitious and wide-ranging: and he communicates using possibly the most classically pure cybernetic language of all (see, *The Geometry of Thinking: Integrative Systems Methodology*).

There is a strand that emerges from, and as parallel to, the concerns that give rise to second order Cybernetics: Constructivism. Second order Cybernetics, being concerned with the inclusion of the observer, cannot but consider what reality the observer is observing, when the observer is always present in the observing. For a long time Ernst von Glasersfeld had worked through these questions: his understandings, many of which preceded second order Cybernetics, came to be vitally important to the refinement of its concepts. The relation between second order Cybernetics and Constructivism is covered in section 8.0.

It is reasonable to wonder what Wiener, as "founding father", would have made of the development of second order Cybernetics. According to Gordon Pask, who knew him well, he would have been delighted. Pask told me that Wiener understood there were further steps to be taken in developing Cybernetics' platform, but was not sure what they were or how to take them: and that he would have understood the developments of second order Cybernetics, and welcomed them.

4. Theory of Second Order Cybernetics

4.1 The Development of an Approach, Theories, and an Epistemology

While many played roles in developing second order Cybernetics, only a few made it a primary aim to construct the central position and understandings, together with an appropriate theoretical base, that lie at the heart of the discipline: that is to say, an approach and an epistemology. These are Heinz von Foerster; Humberto Maturana, and Francisco Varela working together; Gordon Pask and colleagues (particularly Bernard Scott and Dionysius Kallikourdis); and myself. Of these, Varela was student of, and co-worker with, Maturana; Scott and Kallikourdis were students of Pask; and I was student of, occasional co-worker with, and academic colleague of Pask. It is, of course, difficult to know how to position oneself in a survey such as this. I have chosen to be straightforward and direct.

We will consider the concepts that come to epitomize second order Cybernetics in the next section: and the work of others who have used these concepts, developing both theory and (in a reciprocal manner) application in the following one.

Von Foerster's significance/role in second order Cybernetics is without equal. He was the impresario and entrepreneur who impinged upon, promoted, and supported, in some direct manner, the work of all those mentioned above: and who created funding and opportunities. At his Biological Computer Laboratory of the University of Illinois he accommodated Pask and Maturana and many others as visitors. As already indicated, he founded the ASC. At the BCL he ran courses, one of which

produced the book "Cybernetics of Cybernetics", a collection of papers in Cybernetics with commentaries, content-graphs, topic (concept) definitions etc., in which Cybernetics texts were subjected to analyses stemming from the same sorts of understandings as they promoted: shades of Margaret Mead and her paper prompted by von Foerster.

Von Foerster is a diffident, modest, perceptive, and energetic man, happier to talk about the others' work than his own. But his own work is full of creative insight and the rigor which effectively, according to Dirk Baecker, distinguishes second order Cybernetics from "mere" post-modernism (because, while allowing that—as Paul Feyerabend has it when talking of scientific theories—anything goes, second order Cybernetics generates a structure to permit and support this). In his work, von Foerster's observer explains himself to himself, avoiding what a second order cybernetician might understand as the irrational nihilism inherent in post-modernism. His role as catalyst and facilitator, providing the metaphorical glasshouse that sustained the development of second order Cybernetics, is crucial. But that is almost minor in comparison to his own contribution.

Von Foerster's own work introduced three essential concept-areas.

The first has been discussed. Von Foerster understood that you could take Cybernetics seriously enough to apply the understandings developed in it to the subject matter of Cybernetics itself. It was this, above all, that lead to the Cybernetics of Cybernetics, i.e. Cybernetics being applied to itself in a second order operation.

In a recent interview with Yveline Rey, von Foerster gave as an example of this process how we consider purpose (a most cybernetic concept). (Almost) anything may be seen to have a purpose. This leads to a vast proliferation of purposes. But, studying the purpose of purpose, we find an underlying unification. This is the reflexive, second order of purpose. Other similar formulations have been developed: Pask's learning about learning (and learning to learn), the general philosophical effort to understand understanding (and, recently, to be conscious of consciousness), and my own doctoral thesis "…The Object of Objects, the Point of Points…", are all examples of a similar sort.

The second is the inclusion of the observer. Von Foerster understood—insisted—that the presence of the observer was inevitable and could be seen as desirable. This is apparent in the titles of his publications, for instance "Notes on an Epistemology for Living Things". The word epistemology is used because to live, to inhabit an environment, is to be an epistemologist. In this paper, written in celebration of the developmental psychologist and genetic epistemologist Jean Piaget, von Foerster exploits an understanding that form and content interrelate, in much the way Gregory Bateson talked of the unity of the mind and body (dissolving the so-called mind/body problem). And while Humberto Maturana came up with the encapsulating phrase "Everything said is said by an observer", the aphorism, implicit but unspoken in von Foerster's earlier work (and in McCulloch, Günther, Ashby, Loefgren, and Pask), is apposite to von Foerster. (Von Foerster's has insisted that "an observer is his own ultimate object", and extends Maturana: "What is said is said to an observer.")

From this interest in the involvement of the observer (the "dance" of conversation, as he called it in an interview with Christina Waters), and a theory of knowledge determined by a knower rather than simply being "there", comes an explicit concern for ethics. When what is observed is observed by an observer, that observer is responsible for the observation, the sense he makes of it, and the actions he takes based on that sense. Since each observer is different, it is difficult to make general ethical points, because the responsibility belongs to each particular observer. This is his first ethical point: ethics is the property of the observer, not argument applied to observers in general. (In contrast, morals are applied by others to others.) Nevertheless, there are general points to be made, for instance, the act which increases opportunities is the better one—because it makes it easier for each observer to claim his own responsibility. Von Foerster gives an Ethical Imperative: "Act always so as to increase the number of choices."

(This is joined by an accompanying Aesthetical Imperative: "If you desire to see, learn how to act." Designers have long understood that it is best if their actions take nothing away from the existing, merely adding more options or richness. This is rarely possible, so they approximate by adding more than they remove. This is "generosity in design". Hopefully, the similarity of this intention to von Foerster's Ethical Imperative is obvious. Both positions are (contrarily) based in the generous intent in Occam's (parsimonious) Razor!)

The third is that we construct our realities. Von Foerster builds on earlier work on self-organizing systems (he organized conferences on this theme around 1960) and on the work of Piaget, his old friend Ernst von Glasersfeld, and the logic of Spencer Brown. In his seminal paper "On Constructing a Reality", von Foerster takes as his abstract the initial command of Spencer Brown's "Laws of Form": "Draw a Distinction!" When the observer cannot separate himself from his observations, it is impossible to know how these observations may relate to the fabled "Out There", or what Herbert Muller, in his web debate, so appropriately refers to as "Mind Independent Reality." Von Foerster's interest is in how we might compute stable realities (which he came to call "objects") through recursive observation (i.e., continuously re-distinguishing the distinction). He finds a (mathematical) model in eigen functions, functions which, applied recursively, reach stable and (dynamically) self-perpetuating states. His objects are (self-referential) tokens for eigen systems. He is interested in how these mechanisms relate to the functioning of the nervous system, following his mentor Warren McCulloch, working with Walter Pitts and the Chilean neurologist Humberto Maturana, an interest that can be traced back to von Foerster's early proposals on memory. Others have found, in von Foerster's central interest in recursion, the concepts that allow theoretical development in their work, especially in the social sciences.

In asserting his essentially constructivist position, von Foerster recounts a story about the philosopher JR Searle. Searle was deeply concerned that the trees and rocks should outlast him when he died: and von Foerster wondered, tersely, how on earth that could matter to Searle? Without being there to observe, what is or is not has no conceivable interest to him!

While some of von Foerster's work relies on Maturana's work, much of Maturana's (including the provision of working conditions) relies on von Foerster's. Maturana is responsible, with his colleagues Francisco Varela and Riccardo Uribe, for the

development of "Autopoiesis" (from the Greek, self-making).

Humberto Maturana and Francisco Varela, both outstanding neuroscientists, were associated with that group of Chilean intellectuals who worked with President Salvador Allende in his efforts to help Chile attain effective management. After Allende's CIA-sponsored demise, they and others escaped Chile with help from (among others) von Foerster, Beer, and Pask. Maturana has become a major figure in international seminars, through which autopoiesis has become the most known aspect of second order Cybernetics.

Maturana's early work led him to an understanding of the nervous system as autonomous and organizationally closed (organizational closure is a generalization of autopoiesis, with slightly relaxed constraints). He came to deny not only the notion of a miniaturized idealization the objects of perception represented in the brain, but of the nervous system as representing any external reality whatsoever. The nervous system is: it computes "realities" within and through its functioning (see, *Biological Intelligence and Computational Intelligence*).

These ideas, together, give a basis for the conceptual step involved in proposing the ontogenetic system type referred to by the term "Autopoiesis." In Maturana's words, autopoiesis is:

"… a class of mechanistic systems in which each member of the class is a dynamic system defined as a unity by relations that constitute it as a network of processes of production of components which: (a) recursively participate through their interactions in the generation and realization of the network of processes of production of components which produce them; and (b) constitute this network of processes of production of components as a unity in the space in which they (the components) exist by realizing its boundaries."

"The autonomy in living systems is a feature of self-production (autopoiesis) … the basic consequence of the autopoietic organization is that everything that takes place in an autopoietic system is subordinated to the realization of its autopoiesis, otherwise it disintegrates."

An autopoietic system "grows" and maintains itself by reference to itself. In this way it reflects von Foerster's eigen function, with which it is contemporaneous. It uses a self-referential circular process, in a system of continuous self-making. When used to express life, autopoiesis studies the verb "live" rather than the noun "life", avoiding the bizarre paradox in which biologists are obliged, sometimes, to kill the living to study it. An autopoietic system is stable through its (dynamic) ability to keep on making itself anew. And while it is open to information, its organization remains closed.

The concepts of autopoiesis, organizational closure, and the associated notion "autonomy", originating in biology, have become by analogical extension some of the most powerful and developed concepts in second order Cybernetics. For instance, Luhmann and Mingers (see, section 5.2.1) have applied it in the social sciences, and business and management (providing platforms for Maturana to address new audiences). Organizational closure has come to be understood alongside autonomy, especially in Varela's work, providing insights into how there

can be systems that sustain themselves, retaining their identity in spite of all. Varela worked on a calculus for self-reference, extending Spencer Brown's logic of distinctions (although some argue that Varela's work is more a restatement than an extension). He also proposed the immune system be thought of as an autopoietic system, concerned with self-maintenance rather than fighting others. In the case of viruses, this avoids the need to develop new descriptions so every new virus can be recognized and appropriate counter measures taken. Maturana and Varela have developed this collection of notions, in "The Tree of Knowledge", into a bio-cybernetically based understanding of epistemology and cognition (see, *Living Systems Theory*).

Gordon Pask's work borrows the term organizational closure from Maturana and Varela, although the concept was already present in Pask's work in the form of his interpretation of "self-organization", which is closely allied to Ashby's notion of the informationally closed system. Pask's contribution was always intended to be universal in applicability, and the reflexivity and relativity implicit in autopoiesis were already explicit in Pask's work (see, *Cybernetics and the Integration of Knowledge*).

Of all those mentioned, Pask understood earliest the profundity and centrality of the notion of circularity and its extension in interaction: already in the early 1950s he was building computing devices which interacted circularly with humans. The most celebrated was MusiColour, a light show for musicians that flashed lights according to the model it built of what the musicians were playing. When the model didn't have to be changed because the musicians were playing what MusiColour considered similar material over a prolonged period of time, it "got bored" and started to respond in an unpredictable manner, thus leading the musicians to change what they were playing. This circular (and closed) organization lead to a type of interactive dialogue between musicians and machine—interactive because each changed, not according to predictable responses, but so that each developed in mutually surprising ways.

Pask was a theatrical man in several ways: in the development of theatrical devices (MusiColour toured nightclubs in the UK in the 1950s), but equally in his whole personal manner and appearance, and, as Paul Pangaro has shown, in his work. The notion of "the drama", as the ancient Greeks understood it, drives his work. He was also an outstanding teacher, and his concern with a concept of liberal education intimates why he was interested in the use of machines in education, and how he used them.

By 1970, Pask (with co-workers at his research organization, System Research Ltd.), whose main area of research was learning, was developing his quintessentially second-order cybernetic theory, Conversation Theory. Conversation Theory (CT) concerns both how a conversation can be held, and how a conversation (often between human and machine), might facilitate and test a student's learning of some subject matter. A conversation is, by definition, circular. But a conversation can also be used to talk about itself (it is reflexive). A conversation may be held about conversation, even within that conversation, being simultaneously both the subject of the conversation and the actual conversation itself. It is a second order Cybernetics system. The participants cannot be detached from the conversation: that is where they co-exist.

While conversations rely on circularity, they also insist on the separation of conversational-participants. The meaning in a conversation is not a transmitted, encoded message, but is whatever each participant makes of it. I speak what I can; you hear what you will—which you can repeat back to me in your own words so that I, listening, can make my understanding of what I take to be your understanding of what you took to be my understanding: and by comparing my two understandings, I may assess "error", that is, discern misunderstanding.

Through these considerations (usually embodied in actual, special purpose computing environments), Pask brought into "proper" debate conversation (dialogue); understanding (and consciousness); meaning and language; and knowables and representation. He did this through developing understandings, not only of the process of conversation, but of the organization necessary for participants to participate (p-individuals, as they were called) and whatever might be "talked about" (topics). In Pask's formation, p-individuals (psychological, as opposed to the mechanical individuals—m–individuals), the understandings they held, and the topics these understandings were of were all homomorphic through executing circularities, as was the conversation itself.

In later work, Pask (on occasion working with Gerard de Zeeuw) extended the ideas of conversation to greater generality in the Interaction of Actors Theory, and the supporting calculus L_p (See, *Cybernetics and the Integration of Knowledge; Cybernetics and Communication*).

Pask was my mentor. While he was developing CT, I was his doctoral student and experienced his ways of thinking and of teaching at first hand. With the rest of his class, I contributed to the development of his ideas through criticism, brain-storming, and the like. I became a student of his through of his interest in architecture and design, which I had previously studied (albeit mainly through performance and music): he was a consultant to students at my architecture school.

My work might be thought of as a generalization of the work of the others. My major initial concern was to develop a set of concepts that might explain how, while we all observe and know differently, we behave as if we were observing the same thing. What structure might support this? One supporting the essential difference while retaining the possibility of communication: when the basic assumption is that we are all different, we all see and understand differently. Pask had shown how to communicate when we all understand differently—the conversation—deriving from de Saussure's work on representation. My contribution was a structure developed to accommodate observation and difference. This was achieved by arguing mutualism, here glossed as "the reciprocal arrangement by which what may be of one may be of the other". When drawing a distinction, that which can be assumed for one side must in principle at least be possible for the other. This I have called the "Principle of Mutual Reciprocity".

In a universe of discourse determined by individuality and difference in observation, observing entities are taken to observe themselves: they are self-referential. Thus they attain identity and autonomy. (Observation should not be confused with seeing: observation as used here is a formal quality.) Therefore, observed entities must be assumed to have the possibility that they observe themselves. It is considered inconceivable that such entities (called "Objects") are simultaneously both self-

observing and self-observed. They are therefore taken to switch roles. This generates time (making time a central and integral concept in second order Cybernetics), allows observation by another Object, and sets up observational time as a way of relating observations of other Objects, giving a relational logic. Objects are seen as oscillating between the two roles, and this oscillation allows the continuity of the observation of self; and the observation of others in time, giving rise to relationships. Objects generate process, just as they are generated by process: another cybernetic circularity. Since observation can thus take place, it is assumed other activities can also occur.

The concepts associated with Objects are developed to account for aspects of memory, consciousness, representation, etc. Von Foerster described them as providing a calculus for Piaget's notion of the development by children of the conservation of objects.

This construction admits the notions of von Foerster, Maturana and Varela, and Pask. That is the whole point: it allows other observations the freedom to be. In this, it reflects a comment made at the outset: the relationship of first order Cybernetics to second order Cybernetics is like the relationship between the Newtonian view of the universe, and the Einsteinian. It also increases the number of choices: the Ethical Imperative (or generosity in design), again.

To use a metaphor: my work is the creation of games fields: others create the games to play in these fields and still others play them. Finally, some are spectators. The point of an account that admits others is not that it is right, but that it is general (and generous). Cybernetics is often considered a meta-field. The Cybernetics of Cybernetics is, thus, a meta-meta-field. My work is, therefore, a meta-meta-meta-field. We will return to the recursions of Cybernetics in section 7.1.

4.2 Central Concepts of Second Order Cybernetics

In a course description for the "Cybernetics of Cybernetics" book von Foerster and his students composed in the academic year 1973-4 at the BCL, the following paragraph occurs:

"'First Order Cybernetics' developed the epistemology for comprehending and simulating biological processes as, e.g., homeostasis, habituation, adaptation, and other first-order regulatory processes. 'Second Order Cybernetics' provides a conceptual framework with sufficient richness to attack successfully such second-order processes as, e.g., cognition, dialogue, socio-cultural interactions, etc."

What, then, are the central concepts of second order Cybernetics? They can be indicated thus:

1. Application of understandings to self. Second order Cybernetics is developed when the understandings developed in Cybernetics are applied to the subject itself, thus enhancing the subject.

2. Ethics. Second order Cybernetics provides an essentially ethical understanding.

3. Observer included. No observation can be made without an observer (i.e.

"Everything said is said by an observer"), and each observer is different. Therefore, what each observer observes must be thought of as different. So each observer is responsible for his own observations, for only he can make them.

4. Stability from within. In second order Cybernetics, stability, understood as continuing-to-be, is a quality that comes from within the system and its ability to sustain itself, not from comparison to an external reference.

5. Self-reference. The quality of continuing-to-be, of stability coming from the sustaining of the self, is self-referential. Self-reference is at the heart of second order Cybernetics, and brings with it autonomy and identity.

6. Mutual reciprocity. Arguments in second order Cybernetics depend on the Principle of mutual reciprocity, which requires that when a quality is attributed to one system, there must be a potential for the same quality to be attributed to the system it is distinguished from.

7. Conversational communication. Within second order Cybernetics, communication is conversational and meanings are personal: meanings are not communicated, but individually constructed by the participants, who are therefore responsible for them.

8. Improvement, not perfection. Second order Cybernetics does not claim to be right or truthful, in an old positivist sense. It claims that it accepts and works from some "truths" (such as that the inclusion of the observer); and that it is an improvement, but not that it is perfect.

9. Circularity. Circularity is to be taken seriously.

5. Praxis of Second Order Cybernetics 

5.1 Second Order Cybernetics Extended into Practice

The treatment of second order Cybernetics has focused on theoretical argument, because the application of Cybernetics to the subject of Cybernetics appears, essentially, to be a theoretical step. I also believe it is easier to explain this development in this way. However, Cybernetics is concerned with circularities: the division of theory from practice is akin to the breaking of a circle to make a line (a wheel into a trace). The distinction is made here to aid explanation. That is why the circle has been broken. But second order Cybernetics may better be seen to consist in a productive interaction between theory and practice: an interaction in which each supports the other.

This section focuses on work that has come from or been developed more in praxis than in theory. This work should not be seen as secondary to or a consequence of theory: many practitioners also contribute theory; and theorists, praxis.

5.2 Subject Areas

Second order Cybernetics, concerned with interaction and observer involvement, fits

immediately with the social sciences and humanities, where the problem of the observer has always been so obviously tricky. Therefore, it is not surprising to find that much of its praxis has so far been in these areas. However, second order Cybernetics has an immediate impact in other areas, such as mathematics, computing, and design (not forgetting biology).

5.2.1 Communication and Society

Maturana's early work develops what he later called "the Biology of Cognition". From these studies came the notions of autopoiesis and organizational closure. In later developments, Maturana and Varela recycled the notions of closure back to cognition, arguing for what might be considered embedded cognition and closure in the nervous system. They developed a deep epistemology of what knowledge (of the world) is and how we understand and communicate it, not "as a representation of the world 'out there', but rather as an ongoing bringing forth of a world through the process of living itself" (from "The Tree of Knowledge"). This is a radical reformulation and has been applied by the authors and others in biological, human and societal fields.

For instance, the sociologist and social theorist Niklas Luhmann, who certainly considered himself a second order cybernetician, built extensively on these understandings. Luhmann came to view society as an autopoietic system, in which the glue that binds the process of self-generation and self-maintenance, effectively constituting society, is communication—with all the difficulties that implies when viewed through the second order Cybernetics lens of Pask's conversations. After all, communication is an assertion that we live with others (in society). He considered communication as a second-order, conversational cybernetic system. Semiotics allowed him to understand meaning as lying in signs rather than in minds, which create information from the meanings of these signs. For Luhmann, sociology, second order Cybernetics and semiotics may be considered as forming a "Frege-esque" triangle (to locate Luhmann in one German philosophical tradition), although others argue that his work stems more from the traditions of Husserl and of Kant. Luhmann's significance in second order Cybernetics lies not only in his own work and his position and influence in German intelligentsia, but in the "school" of German speaking second-order cyberneticians he taught and furthered, including Dirk Baecker, Theo Bardmann, Hans Ulrich Gumbrecht and Elena Esposito; and his extraordinarily generous attitude (not always reciprocated) towards the work of others.

John Mingers argues against Luhmann's position, holding both that it is difficult to assert that society is autopoietic (ontologically, although speaking metaphorically it might be so), and that Luhmann's theory excludes people who become, effectively, an environment through (and in which) Luhmann's societal communicating occurs. Mingers relaxes Luhmann's requirement of strict autopoiesis in favor of organizational closure, positioning himself in line with Jürgen Habermas, distinguishing between information (out there, i.e. existing in the world on which cognition operates—the environment) and meaning (personally held) in a manner more or less the opposite of Luhmann's. He recognizes different levels of complexity in organizational closure that lead to distinct behaviors.

The development of the Research Committee on SocioCybernetics of the

International Sociological Association (RC 51), through the ceaseless efforts of Felix Geyer, can also be seen as another extension of the basic pre-occupations Luhmann and Mingers share.

In contrast, Gerard de Zeeuw, along with his colleagues in Amsterdam, argues a more involved and pragmatic approach. Coming from a uniquely Dutch tradition of "Andragology", de Zeeuw is concerned less with overarching theories of society than with our involvement as we interact with, in, and through society, while we study and attempt to improve either it or the circumstances in which it is found. De Zeeuw's work concerns constant improvement, and his view is of a continuing conversation—in some respects, an extreme example of second order Cybernetics. For de Zeeuw it seems that involvement is more important than outcome. The point is less to reach some end point, than to continue being, together. I have characterized his work as concerned with a solution to a problem, whereas sociology is generally concerned with the solution to the problem, although de Zeeuw does not entirely approve of my distinction. His concern for continuity places him sympathetically with Pask, and they worked together for some time, developing the "Interaction of Actors Theory", which may be summarized as a theory for an unending conversation.

Computer-supported cooperative work should also be mentioned. The origins of this field are various, but second order Cybernetics has on occasion played a significant role, especially through the work of Mike Robinson, formerly a student of Pask and colleague of de Zeeuw. Understandings of how we communicate are central to cooperation, all the more so when communicating at a distance (see, *Designing Social Systems; A Systems Design of the Future; Cybernetics and Communication*).

5.2.2 Learning and Cognition

Gordon Pask once defined the human being as a "machine for learning." Learning is one of the more obvious cognitive behaviors. From early days, cyberneticians were interested in teaching machines, offering information in efficient ways to students. Pask may be considered the father of the resulting field, Computer Aided Learning (CAL), having in the early 1950s invented the Self-Adaptive Keyboard Instructor "SAKI" for training keyboard operators: the world's first self-adaptive, and therefore learning, computer program. (Pask worked with extremely talented and creative programmers, including Robin McKinnon-Wood, Dionyssius Kallikourdis, Paul Pangaro, and Gert Hulstein.)

Note that Pask referred to learning, whereas CAL rapidly became, in the hands of others, Computer Aided Teaching or Instruction. Teaching and Instruction are essentially first order Cybernetics— externally controlled activities. In second order Cybernetics, the obligation for learning is placed not on the teacher, but on the learner: hence CAL, where the learner regulates his own performance.

Pask did his Cybernetics against a background interest in CAL. He developed many learning environments (he came to call them teaching machines), remaining at the forefront of work in this area throughout his life. His theorizing is directly traceable to his practice.

Pask's work extended beyond conversation as the mechanism for exchanging and

testing individual understandings to an analysis of the necessary structural properties of a subject matter to be learnt; testing; and the accommodation of different ways of looking at what is to be learnt (learning styles). Learning is closely related to knowledge and therefore studies of it are necessarily epistemological: as Pask confirmed his interest in the learner, he came to consider not knowledge but knowing (under pressure from von Glasersfeld and myself). This consideration of the verb rather than the noun has similarities to the consideration of the process of living rather than the fact of life, characterizing the autopoietic system.

These attitudes and models have proved a rich basis for developments in both teaching and learning theory and Educational Technology. Pask was an advisory professor at the UK's Open University, which remains one of the largest and most successful enterprises of its type. Wherever one looks in work on education and its technology, Pask's influence is visible (if not always acknowledged). The work of Diana Laurillard, Noel Entwistle, and Bernard Scott (Pask's former collaborator in the development of Conversation Theory and the author of *Cybernetics and the Integration of Knowledge, Cybernetics and Communication* in this encyclopedia) is evidence enough. It extends beyond Pask's circle: for instance, Laurie Thomas's, Donald Schon's, and Joe Scandura's work can be interpreted as belonging here.

5.2.3 Math and Computation

Spencer Brown's "Laws of Form" has been cited as one of the major source texts that liberated the thinking characterizing second order Cybernetics (section 3.1). This is a text in logic, attempting to reach to where we can create a relationship with a world, and realize the structural consequences of this. In fact, much of the thinking in second order Cybernetics is essentially mathematical or computational (von Foerster is an outstanding mathematician. Pask and Varela were also pretty good).

The problems associated with self-reference and the generation of understanding have been explored in great depth by Louis Kauffman, whose writing on post-Spencer Brown distinction logics has created great clarity. He also contributes through his examination of the topology of mathematical knots, bringing together and intersecting mathematical spaces that may represent distinctions.

Lars Loefgren, one of the precursors of second order Cybernetics (section 3.1), works in the similar area of "Autology". He is interested in the occasions when at least partial self-reference is possible, and in an interpretation of (autological) systems through a complementaristic language.

Understandings deriving from second order Cybernetics, especially as embodied in "Constructivism" (see below) had also been brought to bear on the logic and design of computer programs by mathematicians such as Christiane Floyd. This undertaking can be related, at least in spirit of origination, to the work of Terry Winograd and Fernando Flores.

In the opinion of some, the largest application of all is in the everyday practice of computing familiar to so many. The development of a concern with the computer interface, with at least token acknowledgement of the importance of conversation, of the idea of play with and between man and machine, are testament. But the greatest

testament is that strange, almost formless connection of the vastest complexity, the internet, which follows and realizes second order Cybernetics principles in so many ways: its essential autonomy, its ability to repair itself (by rerouting) and to make decisions, its involvement in dialogue (when we browse), its ability to respond and adapt (both with and without human intervention). When we use the internet we begin to shift from the notion of data collection to the construction of our own knowledge (our knowing). Our awareness of the world in the manner described by second order Cybernetics can be said to emerge from what was, initially, a first order device intended to facilitate the coordinated transmission of data.

In this manner, the computer age we now live in is the era of second order Cybernetics.

5.2.4 Management

Cybernetics comes naturally to management. Management, regulation, and control are, in many respects, synonyms. Early on, cyberneticians (particularly Stafford Beer) realized they had something to offer the running of businesses, governments, and other bodies, challenging or complementing management science. Second order Cybernetics offers management the possibility of that current philosopher's stone, the reflexive, self-aware, learning organization.

Beer's position in management is similar to Pask's in cognition and learning. Although there have been other deeply influential cyberneticians working with management, only Beer has been a constant presence, always at the forefront of conceptual and practical development; and claiming a second order Cybernetics connection. Having produced his Viable Systems Model, at the time of the birth of second order Cybernetics he was working on real-time modeling of the Chilean economy for Salvador Allende (with Maturana, Varela, Flores, and von Foerster). This enormous project, to allow better real-time steering, and hence performance, of the economy was never fully tested, due to the CIA's terminal intervention.

Beer's work has inspired many theorists and practitioners. Amongst those most sympathetic to his efforts and who fit under the second order Cybernetics umbrella are Raul Espejo (another former colleague of Maturana and Varela) and Markus Schwaninger. Beer's more recent conversational framework and procedures, "Syntegrity" using Buckminster Fuller's geometries, have been used by Espejo and Schwaninger to create a map of Beer's central notions reflexively. This work has profoundly influenced the design of new media material such as that produced by Amaze, from Liverpool, UK (see, *The Geometry of Thinking*).

Coming from a different direction, but also working with notions based in second order Cybernetics, is the work of the Swede Graham Barnes. A psychotherapist by training, Barnes for years taught "Cybernetic Psychotherapy" in the former Yugoslavia. He has applied his therapeutic understandings, through the filter of second order Cybernetics, not only to conventional psychotherapeutic situations, but also to helping with corporate, national, and international societal problems, and especially the drive for peace. A dialectician inspired by Bateson, von Foerster, and Pask, he maintains that continuation of the conversation is the crucial factor.

Complementing these approaches is that of Mingers (see above) and Stuart

Umpleby, a von Foerster student who has done much, not only in bringing second order Cybernetics to managers, but also in enabling second order Cybernetics to attain greater visibility.

There is an increasing body of management theorists and consultants who, whether wittingly or not, are bringing ideas from second order Cybernetics to bear within management situations, and also to the whole study of management itself.

5.2.5 Design

Of the activities humans are involved in, design is at once mysterious and ambiguous—and, I would argue, basic. In the sense meant here, design is a circular, conversational process, normally with oneself, using some medium such as paper and pencil, leading to the creation of novel objects and/or concepts—a characterization due to Pask. Second order Cybernetics has made a significant contribution here, in both liberating and extending design computation so that it is not seen as merely the mechanization of the drawing board, and in providing models for active participation. The work of John Frazer in particular is constantly inventive and moving beyond the norms of product design.

I have also developed the analogy between second order Cybernetics and design so as to give mutual reinforcement to both. Design is the action; second order Cybernetics is the explanation. The importance of this understanding in an age of mechanistic problem-solving is, I have argued, that it leaves openings for novelty. Curiously, several protagonists of second order Cybernetics (including Klaus Krippendorf, Frank Galuszka, and the author) have also often worked in the arts and design.

6. A Note on Second Order Cybernetics and Constructivism 

Second order Cybernetics considers (rather than ignores) the observer, studying observing as opposed to observed systems, insisting the observer takes center stage.

A consequence is that all knowledge is seen as dependent on the observer's involvement. The observer contributes and, since it is impossible to access what we observe without being an observer, that which is observed is unclear. Is there an object in an external reality? If so, what can we know of it, since our knowing always depends on us, and we can never subtract our presence?

This is not a new "problem". Previous approaches to it have tended to either deny the problem and claim that "the real out there" is obvious; or, solipsistically, to deny anything other than individual sensation and understanding.

Constructivism is an attempt to move beyond this polarization. It is concerned with how stable concepts may arise from an observer's observing, and the nature of such concepts. It is closely allied to aspects of the developmental psychology of Jean Piaget, and the Personal Construct Theory of George Kelly, although it has a much older pedigree. It neither denies not avows mind-independent reality, which it sees as unknowable and, hence, inappropriate to make a decision on.

Since second order Cybernetics is intimately concerned with the observer's active

and accepted involvement in observing (and consequent acts, such as knowing), it is inevitable that common ground be found between it and Constructivism. The cybernetician Ernst von Glasersfeld understood this very early on, and has worked at showing the links, developing understandings of Constructivism, and making second order Cybernetics and Constructivism powerful philosophical partners.

7. Cybernetics, Second Order Cybernetics, and the Future

7.1 A Third Order Cybernetics?

If first order Cybernetics leads to second order Cybernetics, the question arises as to whether there might not be a third order Cybernetics, and if so, perhaps a fourth, et cetera?

Robert Valée has recently suggested that we should, indeed, consider a third order Cybernetics. His argument is that there is an ascent of orders: from observed to observing and from observing to acting. He proposes that third order Cybernetics is needed to turn Cybernetics from a subject that studies into one that can also do. In a sense, this is a reflection of the process base that is seen so consistently in Cybernetics. However, the questions remain, what happens when we consider observing as a type of action; and what happens when we move from third to fourth order, and, then, ever upwards and onwards?

Some 20 years ago I made a different observation. When we consider some system we can do so either in the familiar manner of a first order system such as traditional science idealizes, where we focus on the observed system; or we can do so in the circular manner that includes the observer. This is the familiar difference between the positions taken by first order Cybernetics and second order Cybernetics.

The question arises about differences in how we observe a system that is first or second order. If we talk about (observe) a second order system in the cool manner in which we are used to talking about such things, we might claim we are, in effect, creating a third order system, which we can, however, collapse into a first order one (because the observing is of the first order type, no matter what type the observed system is). If we talk about it in the manner of second order Cybernetics, we create a fourth order system, which can be collapsed to a second order system.

Thus, we may claim that we can make third, and fourth order systems as well as first and second, and presumably we could continue ad infinitum (much as we can with meta-levels), but we can always collapse these orders back into the first and second orders. (This process closely echoes Spencer Brown's condensation, in his Laws of Form.)

There may be reasons to add to the number of orders of Cybernetics, although neither I nor von Foerster—for similar reasons—see a reason for more than two. There is a significant difference between first and second order which was characterized at the start of this piece as akin to the difference in generality between Newton's and Einstein's mechanics. With more than two levels, there is the familiar danger of a potentially endless regression. However, when we appreciate collapsibility, this danger dissolves.

In fact, it seems to me that it would be better, nowadays, to talk only of Cybernetics, without orders: thus bringing the different approaches into a closer proximity. For we have seen that they are mutually dependant and mutually reinforcing. And the subject is always circular.

7.2 Second Order Cybernetics: a Vanishing Conscience?

One might describe the role of second order Cybernetics as the conscience of Cybernetics. That is, it attends to the subject's consistency, clarity and, to some extent appropriateness (is what Cybernetics is doing appropriate to, and in the spirit of, Cybernetics?), and our awareness of this.

One role of a conscience is the purist one: to protect integrity and identity. And this raises the question of what has become of Cybernetics.

Von Foerster's answer is that Cybernetics no longer exists as an autonomous subject. Cybernetics gave insights, those insights have been appropriated by other subjects so that there is no longer either the uniqueness or the coherence in them that would constitute a conventional subject area. Cybernetics is unnoticeable, ubiquitous, and all-pervasive, its concepts acquired by all disciplines—a realization of Mead's characterization of Cybernetics as a meta-language. There is, therefore, no future for Cybernetics, because there is no present in the sense that there is still a distinct subject. For there to be a future, Cybernetics will have to be reborn in some new incarnation (as happened earlier, some argue, with bionics). At the moment, according to this view, Cybernetics, whether of first, second, or n^{th} order, is dispersed like gas between stars. Its life is in and through other subject-areas, its insights so influential that they have been absorbed almost without trace or realization. In a recent interview with Christina Waters, von Foerster argued that this ubiquity is a positive achievement, the unnoticeableness an advantage in the take-up of the concepts (often unfamiliar and revolutionary) that second order Cybernetics has developed. He likens his view of Cybernetics to a dance: a continuing process in which we all exist and change, and through interaction, where we find ourselves reflected in the other.

While I concur that Cybernetics has largely disappeared, and also with the metaphor of a dance, in contrast to von Foerster I see second order Cybernetics as having the power to resuscitate and re-cohere the subject. I see Cybernetics as having been "stolen" but not as having been irreversibly absorbed, and I see the role of second order Cybernetics as crucial if Cybernetics is to survive. It is not that Cybernetics is either isolated or fixed, but rather that there is some persistence in being that is in, and of, itself (an identity, in the cybernetic understanding of the term). In some sense, I see second order Cybernetics as being the heart of, and hence crucially identified with, Cybernetics.

What is clear is that the notions that Cybernetics, and more especially second order Cybernetics, have developed have ever greater significance: witness the applied linguistic analyses of scientific publications already mentioned above.

The notions of second order Cybernetics need to be cherished through continuous and continuing development and clarification. It is doubtful this can be done peripherally, without a central focus. Approaches which have some similarity, such

as post-modernism, do not fit the bill, for they lack the rigor in extension that second order Cybernetics has, or has had.

7.3 Cyber this and Cyber that

The proliferation, since William Gibson coined the still subtle and perplexing concept of "CyberSpace" in his 1984 novel "Neuromancer", of appropriations of the prefix "cyber-" has lead some to take this as evidence for both von Foerster's and my views. Thus, the fact that there seems to be nothing to which the prefix cannot be attached would support the view that Cybernetics is everywhere, without really existing per se anymore. Or, this same fact might indicate that Cybernetics does still exist in a form from which it can be appropriated, and therefore the attempt to develop coherence and identity is crucial.

Neither of these views seems quite appropriate. It seems, rather, that the term "cyber-" is a fashion attachment added with little deep meaning. Frequently, that to which it is attached has little to do with Cybernetics in any understandable sense: or, if it has, then the view of Cybernetics is both very old (1950s vintage) and very restricted (usually to notions of machines and control theory, with overtones of an anti-human takeover by automation, automata, etc.), rather than the deeply human and humanitarian Cybernetics that is second order Cybernetics.

This would constitute no future for Cybernetics, and least of all for second order Cybernetics. If this is to be the future that cyberneticians aspire to, they might as well give up now. It is a formula for the moribund. Fortunately, second order Cybernetics can offer us far more than this.

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Second order Cybernetics is a study in which observes and actors take responsibility for their observations and actions. Therefore it goes without saying that, while I greatly enjoyed being on the receiving end of my colleagues' criticisms, all errors intentional, born of ignorance or opinion, or otherwise created are mine. I do not just accept them. I welcome them: all errors remain the responsibility of their owner!

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Glossary

Autopoiesis **:**The circularly organized processes of "self-creation" that characterize living systems, and, by extension, processes whose

products include the processes that produce them.

Black Box :A (fictional) construct applied by an observer at the location of some change in what is observed. The insertion of a Black Box allows a description to be developed for what might account for observed and yet-to-be observed changes, through the interaction of the observer and his Black Box. Many users of the Black Box forget its fictional nature, assuming this description is a mechanism/explanation, which, however, the Black Box can never reveal.

Circularity :The form of a process executed in an organization in which, after an indefinite (but usually small) number of steps the process ends up where it started (but often with a different value). Recursive systems are circularities, as is the understanding of control and of (conversational) communication explored in this article.

Communication:The act and means by which one system persuades another system to create an understanding (its own understanding).

Control :The act by which one (controller) system shapes the behavior of another (controlled) system, so that its behavior is more to the liking of the controller. However, investigation shows that control is circular and that controller and controlled are roles determined by an observer.

Conversation :A circular form of communication in which each participant constructs his own understanding. Checks on understandings between participants occur through re-presentation of individual understandings in a feedback loop. Conversation occurs between participants and is essentially interactive.

Cybernetics :"The study of circular causal, and feedback mechanisms in biological and social science" (Macy Conferences); later, "Communication and control in the animal and the machine" (Wiener's eponymous book).

Epistemology :What may be known, and how we can come to know this.

First order Cybernetics :"The study of observed systems" (von Foerster).

Interaction :Mutual responsiveness that may lead to novelty, in which no participant has formal control over the proceedings. Interaction occurs between participants, not because of any one of them. Conversation epitomizes interaction in progress.

Mutualism :The reciprocal arrangement by which what may be of one may be of the other.

Observation :What the observer determines to be the case. Observation is not necessarily visual.

Observer :The system that determines what is the case.

Recursion :Literally, backward movement, return:e.g. a process by which the response to a statement raises that statement again. Self-referential systems have this quality. An example of recursion is the round, "A dog came in the kitchen/ and stole a crust of bread/ then cook up with a ladle/ and beat him till he was dead// Then all the dogs came running/ and dug the dog a tomb/ and wrote upon the tomb stone/ for the eyes of dogs to come// "A dog came in…" (from Samuel Beckett's "Waiting for Godot"). All things that are applied to themselves, including the cybernetics of cybernetics, are

recursive.

Second order Cybernetics **:**"The study of observing systems" (von Foerster). Also, the study of cybernetics from a point of view informed by the understandings developed in cybernetics.

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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.

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