Cybernetics of Observing Systems and Lonergan's Generalized Empirical Method

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ABSTRACT

Cybernetics is inherently interdisciplinary and reflexive; second-order cybernetics stresses reflective interaction of knowledge and action with the observer. The same themes are central to the work of the twentieth century philosopher and theologian, Bernard Lonergan, SJ, and his Generalized Empirical Method. In reading both, one is struck by the resonances and interplay between the two perspectives, especially as applies to the scientist/observer interacting with and reflecting on their disciplines. In this short overview, we present the case that the similarities and differences add value to the study both of the work of Lonergan and of second-order cybernetics, and that Lonergan can be seen in part as an early and illuminating figure for understanding and reflecting upon second-order cybernetics itself.

Keywords: Cybernetics, Bernard Lonergan, Generalized Empirical Method, Cognitional Theory.

1. INTRODUCTION

In reading the works of twentieth century philosopher and theologian, Bernard Lonergan, SJ, one may find echoes or even anticipation of major themes of second-order cybernetics [SOC]. Most important may be

- An emphasis on the process of knowledge and cognition, including a re-examination of the Thomistic experience-understanding-judgment view of human knowing, with the insistence on understanding the role of the observer as a key to valid knowledge;
- A call for method, accepted and employed, in theology and philosophy, comparing the scientific method on the one hand, and the structures of mathematics on the other, resulting in his Generalized Empirical Method;
- A need for reflection (Insight) in philosophy, science, mathematics, and social science;
- And an integration of the social, natural, and formal sciences into his work, sometimes as a topic or perspective, sometimes as a tool, and sometimes by analogy.

In this article, we present the view that Lonergan should be considered as a key figure in the development of, and for the modern understanding of, second-order cybernetics. We first review the development and major ideas in that field, then consider Lonergan, his work, and his approach, and in particular its interactions and implications for knowledge, cognition, learning, and insight, both in general, and for the formulation and examination of research models and approaches.

We then consider separately the views from both perspectives of the natural and biological sciences, the mathematical sciences, the social sciences, philosophy, and theology. We seek to codify the overlaps, contrasts, and interactions of the approach of Lonergan with that of second-order cybernetics. We present a perspective integrating Lonergan's views with cybernetics, while considering differences and conflicts, and then consider some broadly applicable (and some more narrowly applicable) lessons. Finally, we present our conclusions and suggest paths for using and further exploring this connection.

2. CYBERNETICS

First Order Cybernetics

The term "cybernetics" comes from the Greek word, κυβερνήτης (*kybernētēs*), meaning steersman, governor, pilot, or rudder. The American mathematician, Norbert Wiener, first utilized the term *cybernetics* in his 1948 book on the study of control and communication in the animal and the machine [1]. This seminal work established foundations for what would become control theory, analog computing, artificial intelligence, neuroscience, and communication theory. The MIT professor also made lasting contributions to the mathematical theory of Brownian motion and the foundations of signal processing. Wiener's research on probability theory provided the basis for Claude Shannon's development of information theory [2].

The British psychiatrist, W. Ross Ashby, was another pioneer in the field of cybernetics. He developed the fundamental concepts of the homeostat, the law of requisite variety, the principle of self-organization, and the principle of regulatory models [3]. The Hungarian-American mathematician, physicist, computer scientist, John von Neumann, also made a contribution to cybernetics when he developed what are now referred to as Von Neumann cellular automata (CA). The purpose of his CA was to provide insight into the logical requirements for machine self-replication, eventually utilized in von Neumann's universal constructor (i.e., a self-replicating machine in a CA environment) [4].

First Order (Engineering) Cybernetics survives as an interdisciplinary field focusing on the design, analysis, and control of dynamic systems at universities in countries such as Norway, the UK, and Russia. Through the IEEE Systems, Man, and Cybernetics Society and a few other learned societies, cybernetics research continues in the USA, albeit not nearly as pervasively as its founders would have hoped [5]. The field has largely deliquesced into computer science, decision and control engineering, artificial intelligence and (more recently) data science, robotics, and bioengineering.

Second Order Cybernetics

The Austrian-American physicist, electrical engineer, and philosopher, Heinz von Förster, is widely acknowledged as the father of second-order cybernetics. He founded the Biological Computer Laboratory (BCL), a research institute of the Department of Electrical Engineering at the University of Illinois in Urbana-Champaign. The BCL was a productive research community from 1958 until 1976 when von Förster retired. The focus of the research at the BCL was on self-organizing systems, bionics (i.e., the application of biological methods and systems found in nature to the study and design of engineering systems), and bio-inspired computing (i.e., analyzing, formalizing, and implementing biological processes using computers). See [6].

The American computer engineer and management scientist, Jay Wright Forrester, continued to develop second-order cybernetics with an emphasis on the modelling and simulation of complex systems. Forrester founded the System Dynamics research group at MIT which focused on the study of the non-linear behavior of complex systems over time using stocks, flows, internal feedback loops, table functions, and time delays. His first application domain was analyzing industrial business cycles [7].

Another significant figure in this space is the Austrian biologist, Karl Ludwig von Bertalanffy, who developed the field of general systems theory (GST). GST offered a universal theory of systems with applications in numerous domains. It emphasizes holism over reductionism and organism over mechanism [8]. Manfred Drack and David Pouvreau point out however that Bertalanffy had an "ambivalent relationship" with the traditional cybernetic community and preferred to emphasize the distinctions between the two approaches [9].

Lonergan was certainly aware of Bertalanffy's work. In *Method in Theology*, he favorably cites his 1968 book *General Systems Theory*. Like cyberneticists, Lonergan was concerned about reductionism in the sciences. He observes that reductionism was particularly evident in the human sciences. Lonergan writes,

> Reductionists extend the methods of natural science to the study of man. Their results, accordingly, are valid only in so far as a man resembles a robot or a rat and, while such resemblance does exist, exclusive attention to it gives a grossly mutilated and distorted view. General system theory rejects reductionism in all its forms, but it still is aware of its unsolved problems [10].

A traditional electrical engineer interested in complex systems (or "first-order" cyberneticist) studies a system as if it were a passive, objectively given entity. On the other hand, a "second-order" cyberneticist, often studying an organism or social system, acknowledges that the system under study is an agent in its own right, interacting with the observer. However, it should be noted that there was no "schism" between the two "orders," at least early on. Heinz von Förster, for example, was also involved in the development of first-order cybernetics in the 1950s.

Von Förster attributes the origin of second-order cybernetics to the quest to develop a model of the human mind [11]:

> [A] brain is required to write a theory of a brain. From this follows that a theory of the brain, that has any aspirations for completeness, has to account for the writing of this theory. And even more fascinating, the writer of this theory has to account for her or himself. Translated into the domain of cybernetics; the cybernetician, by entering his own domain, has to account for his or her own activity. Cybernetics then becomes cybernetics of cybernetics, or *second-order cybernetics*.

The Anglo-Irish cyberneticist, Ranulph Glanville, president of the American Society for Cybernetics, 2009-2014, and a leading light in the "second wave of second-order cybernetics," combined a multidisciplinary and interdisciplinary perspective with a view of design as the creation of novelty as much as, or more than, problem solving, and saw design and cybernetics as opposite sides of the same coin [12]. He stressed the feedback-loop interaction of observer and system, and of action and understanding, and applied these philosophical perspectives to science studies, understanding scientific explanations as an interaction between nature and the observer.

Stuart Umpleby is another significant, contemporary second-order cyberneticist, or “cybernetician,” as he prefers. Umpleby is professor emeritus in the Department of Management and Director of the Research Program in Social and Organizational Learning in the School of Business at the George Washington University. As an undergraduate electrical engineering major at the University of Illinois, Umpleby studied cybernetics with von Förster and Ashby in the Biological Computer Laboratory. Umpleby has been a strong promoter of second-order cybernetics, biological cybernetics, and social cybernetics. His scholarship has also advanced the fields of philosophy of science and management methods. Like Glanville, Umpleby served as president of the American Society for Cybernetics [13].

In general, second-order cyberneticists tend to emphasize topics in epistemology and ethics. In their study of complex systems, they often focus on the qualities of autonomy, self-consistency, self-referentiality, self-organization, and the interaction of system and observer.

3. BERNARD LONERGAN

Bernard Lonergan, SJ was a twentieth century Canadian Jesuit philosopher and theologian whose work spanned the subfields of these disciplines while also incorporating and influencing work in the social and natural sciences. In his seminal work, *Insight*, Lonergan holds that a very common and basic supervening act of understanding is operative throughout and critical for all cognitional activity, and views learning as a structured interweaving of experience, understanding, and judging.

Turning our attention to this act allows us to understand some of the truths of particular fields of inquiry but more importantly it allows us to understand the dynamic process of understanding in general. Lonergan famously writes “thoroughly understand what it is to understand, and not only will you understand the broad lines of all there is to be understood but also you will possess a fixed base, an invariant pattern, opening upon all further developments of understanding.” [14] This allows us to recognize the systematic unity of all cognition and prescribes for us an approach that can be employed for particular inquiries but also internalized as a disposition towards all possible knowledge. What results is what Lonergan calls the Generalized Empirical Method (GEM). This method can be understood as taking an empirical, scientific approach to the experiences, insights, and judgments of consciousness. As such it

> consists in determining patterns of intelligible relations that unite the data [of consciousness] explanatorily… However, generalized method has to be able to deal, at least comprehensively, not only with the data within a single consciousness but also with the relations between different conscious subjects, between conscious subjects and their milieu or environment, and between consciousness and its neural basis [15].

Because the data of the consciousness of the knower necessarily falls within the scope of inquiry, such method also gives rise to an ethical dimension that Lonergan calls self-appropriation.

Mathematics offers evidence of the necessity of this reflective process even in the most formal *a priori* domains. Mathematical formalizations cannot be separated from the process through which they are formalized and this involves “gradually acquiring the insights that are necessary to understand mathematical problems, to follow mathematical arguments, to work out mathematical solutions. This acquisition occurs in a succession of higher viewpoints.” [16] The insights of higher-level mathematics are conditioned by the insights, experiences, and judgments of lower-level mathematics. A mathematician can generate analytic propositions seemingly at will that tend towards completeness, generality, and ideality. Such propositions, however, must be conjoined with data and consistency constraints that the formal element then structures, even if these exist only in some conceptual universe. Thus, even pure mathematics cannot merely begin with certain analytic propositions and run rampant. Rather there is a procedure of deductive inference that serves as a process of checking.

4. LONERGAN AND CYBERNETICS

Lonergan’s cognitional theory aligns with the aims of second order cybernetics, because it is fundamentally reflective and systematic. While insight is the lynchpin, the system is structured by a kind of feedback loop formed through experiencing, understanding, and judging. Understanding and judging condition and form the knower’s experience which leads to other insights and further understanding and judging. This loop is inseparable from the knower who experiences, understands, and judges. “So far I have been talking about events as if there were nobody there; but there is someone who senses, imagines, inquires, understands, formulates his understanding, asks whether it is so, grasps the sufficiency of the evidence, and makes the judgment.” [17] For Lonergan, the reflective moment of understanding this cognitional process also changes what we can understand. That is, the epistemological awareness is crucial for further metaphysical content. This situates us as knowers within the functional unity we seek to know: being. An example often used to demonstrate the supervening nature of insights asks us to consider the next entry in the series OTTFFSS. The realization of the correct answer is not a result of further information or rearranging the entries. It is a “Eureka” about the relationship among the entries. This realization requires awareness of the knower because the intelligible relationship has to do with what the knower is seeking. As such it calls for a kind of thinking about thinking that influences thinking.

So Lonergan's cognitional theory is not only to be understood as systematic but also as seeking systematicity. In this way, he is seeking understanding on a systematic level yet within that system and thus interacting with it. In part, Lonergan sees himself as bringing this systematicity, which has been successful in mathematics and physics to philosophical and theological cognition:

> A single insight yields a conception, a definition, an object of thought; but from a cluster of insights, you build up a system of definitions, axioms, postulates and deductions…By way of contrast, St. Thomas' *Summa Theologiæ* and his *Summa contra Gentiles* are not simply systems. While those works do hold together, his method is not that of setting down definitions, axioms, and postulates, and then deducing. In fact, that is just what he does not do [18].

Though second order cyberneticists can find commonality with Lonergan, there are clear moments of departure. One such moment concerns the turn to second order. For Lonergan, the cognitional structure presumes that the knower is situated within being. This kind of Aristotelian empiricism does not hope or suppose that it would be better to inquire into being from outside it. That perspective outside of being is one Lonergan rejects as necessary for the kind of objectivity that is concerned with impartiality. Impartiality is possible by refining our attention to generalized empirical method, not by bypassing it altogether.

A second point of departure might be in the notion or conception of structure. Within cybernetics, the structure of the system has to be understood as abstracting something from the object of investigation. This abstraction can of course come without an evaluative judgment about the relative significance of what is abstracted out or with a judgment that deems that which has been abstracted as irrelevant or unimportant. But for Lonergan, structure is decidedly more ontologically pervasive. Insofar as something is, it is intelligible. Insofar as it is intelligible, it is structured. In this strong sense, there are no accidents for Lonergan. Systematicity permeates all of being and the knower's attention to it is not a matter of abstraction but rather an admission of the isomorphism between being and our unrestricted desire to know.

5. SCIENTIFIC DISCIPLINES FROM THE TWO PERSPECTIVES

Science is an interaction among nature, the professional and academic community, and the individual scientist. Science evolves through the understanding and judgment of individual scientists, leading to modeling, theory formation, and interpretation, interacting both with experiment and the scientific community. The roles of the three, and in particular the relevant domains and attributes of nature, and the balance among the three, change as one traverses the spectrum from social science and economics through the biological sciences to the natural sciences, ending with the formal sciences—mathematics, logic, and theoretical computer science.

The dependence of the conclusions of the social sciences (including economics), not only on interaction with the subjects, but also with the observer scientist, is now well-accepted. But both SOC and Lonergan view observer interaction as key in the biological and natural sciences as well. Most second-order cyberneticists, on the other hand, don't devote much attention to the formal sciences, nor see them as having any special role. Lonergan, on the other hand, looks very much to logic and mathematics. One reason Lonergan pays special attention to the formal sciences is to draw out the nature and significance of the empirical method.

What is empirical about the generalized empirical method is not that it takes for granted a material existence that gives rise to our ideas about the external world. This view can be forcefully rejected by many formal sciences. Lonergan rather takes as a given the data of consciousness, the content of our insights, experiences, and judgments. These data are within the knower, and as such are present in the cognition of all inquiry. As such, the formal sciences do not occupy a special epistemological position but serve a useful epistemological role. The privileged science for Lonergan is metaphysics because questions of meaning in general, and in particular a technique for determining and integrating meaning, require metaphysical equivalence. In this sense, Lonergan is pointing to the same notions as Horne [19] concerning the integration of *episteme* and *techne* but he situates those concerns within metaphysics. Lonergan seems to have accepted the twentieth century terminology of logic as mere sets of rules for thinking.

With respect to a rational process of human understanding, it is not unreasonable that, in much of the formal sciences, and with clearly mechanistic aspects of the natural sciences and engineering, the system can be fruitfully studied without including the observer or knower. But this excludes much of human life and intellectual activity: philosophy, theology, ethics, the social sciences and economics, the arts and humanities, health and medicine, most of cognitive science and artificial intelligence, and even most software engineering—or in fact, almost any system involving a thinking, choosing person. Lonergan would stipulate (and we concur) that in those domains, a systemic and systematic process of understanding must necessarily involve the knower and the knower's interaction with the system being studied.

6. LONERGAN AS A SECOND-ORDER CYBERNETICIST

In Lonergan's Generalized Empirical Method (GEM), a person engages in a discursive process between apprehension, insight, and judgment. Lonergan's notion of *insight* is the crucial link between simply perceiving data and true understanding. It is one thing to notice something and it is completely another to genuinely understand it. The GEM also includes the important processes of attention, imagination, and memory. Ultimately, the GEM should lead to decision and action.

Here we see a clear parallel with the cybernetic notions of observation, feedback/communication, and control of a dynamic system. Lonergan does not treat the process of human cognition as a static object simply to be observed. He acknowledges the dynamicity of the human mind and the importance of self-appropriation. His concern is not knowledge of an "abstract self." He hopes to lead a person in an experience of one's self-consciousness taking possession of itself.

An important aspect of cybernetics is the science of observing and describing dynamics as well as interacting in engineering and biological processes. Lonergan engages in an analogous quest for the human intellect in his development of the GEM. Both Lonergan and the second-order cyberneticist would certainly agree that science always involves the scientist.

Differences certainly exist between the work of Lonergan and most second-order cyberneticists. As a priest and professor of dogmatic theology at the Pontifical Gregorian University in Rome, Catholic theology was Lonergan's principle application domain. Unlike many cyberneticists, but closer to the second-wave practitioners [12, 20], Lonergan's main concern was not with artificial intelligence, autonomous craft, bionics, or cyborgs (i.e., beings with both organic and biomechatronic components), but rather with metaphysics and epistemology, with human beings as reasoning agents, and the role of reasoning in understanding the divine.

Lonergan also has, as noted above, a very different view of both the nature and the role of logic and mathematics. For him, these are, in addition to structures for formal deduction, models of conceptual reasoning and an epitome of the role of intuition. In contrast, the proponents of second-order cybernetics are on the whole less interested in the role or process of mathematical inquiry —the early second-order cyberneticists following their first-order predecessors (with the notable exception of Wiener) in tending to continue seeing mathematics primarily as an adjunct to science and engineering, and those in the second wave focusing on the biological and social sciences, and on design as a cognitive process, with mathematics as part of the analogy toolkit and infrastructure.

7. CONCLUSIONS

There are strong similarities in perspective and approach between Bernard Lonergan and the contemporary founders and later researchers in second-order cybernetics. These argue that considering Lonergan in the context of second-order cybernetics, and perhaps even viewing him as one of its (though perhaps not well known) founders, provides useful insights on both its development and its continued value for the philosophy of both science (broadly understood) and cognition, and for the study of science itself.

On the other hand, there are significant differences. The priority given by Lonergan to epistemology and metaphysics distinguishes him from most in the field of SOC. As a priest-philosopher and theologian, questions of meaning in general, and in particular a technique for determining and integrating meaning, both for its own sake and to deal with important questions, were also significant concerns for Lonergan. For example, the American priest and theologian, John Cush, writes,

> Lonergan witnessed the effects of the Great Depression as friends of his family experienced unemployment and even hunger. This was a life-changing experience for Lonergan, and caused him to orient his natural interests in epistemology in a social-ethical direction, including the study of economics [21].

As mentioned above, it is known that Lonergan was aware of and at least to some extent approved of the work of von Bertalanffy, if not of later developments in SOC. However, Lonergan appears not to be as well known, neither to his contemporaries in the SOC community [22], nor to the current SOC community.

An extensive review of the Lonergan corpus has revealed only one reference to cybernetics, beyond the reference to von Bertalanffy cited above. Lonergan refers to the collaboration of the American sociologists, Talcott Parsons and Robert Bellah, in advancing the "cybernetics of the social action system." [23] Bellah was a highly respected sociologist of religion at the University of California, Berkeley. Talcott was a Harvard professor, well known for his social action theory and structural functionalism. He was also the founding chairman of the Department of Social Relations for Interdisciplinary Social Science Studies, a collaboration among three of the social science departments at Harvard University (anthropology, psychology, and sociology) in 1946.

Parsons was very interested in the emerging fields of systems theory and cybernetics (especially Norbert Weiner's contributions), and their applicability to social and behavioral sciences. Utilizing systems thinking, he developed the concept of "open systems" in social and behavioral science, i.e., systems implanted in a setting with other systems. At the highest level is "the action system," interconnected human activity, set in in a physical-organic environment [24].

We have found that while contemporary SOC scholars are generally unfamiliar with Bernard Lonergan, they quickly become very enthusiastic about his philosophy. In our interactions with Lonergan scholars, we have learned that while generally unfamiliar with cybernetics, they are similarly intrigued once they are introduced.

Lonergan's GEM, similar to second-order cybernetics, is very conducive to interdisciplinary communication. This places him in the company of Ian G. Barbour [25, 26] and Charles S. Peirce [27, 28, 29], among others. Both Barbour and Peirce have strong interdisciplinary emphases and theories of knowledge, and the study of their work may similarly generate insights and approaches useful in SOC. Conversely, connecting Lonergan to Peirce offers another perspective linking Lonergan's GEM to non-monotonic, abductive reasoning as used in artificial intelligence and data science. In future work, we hope to examine connections between SOC and the metaphysical, epistemological, and/or semiotic systems that they have developed.

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