Reconceiving Cybernetics in Light of Thomistic Realism

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Abstract

Since its origins in the early twentieth century as a transdisciplinary approach connecting the fields of electrical and computer engineering, mechanical engineering, dynamical systems theory, logic and discrete mathematical modeling, neuroscience, and other disciplines, cybernetics has greatly expanded in scope, addressing salient issues across the disciplinary spectrum, including the social sciences and the humanities. One of its most significant interactions has been with twentieth century philosophy. Contemporary second-order cybernetics research engages issues in cognitive science, epistemology, the philosophy of science, metaphysics, ethics, and other fields. Working from the perspective of Thomistic realism, as represented by Étienne H. Gilson and Stanley L. Jaki, this paper presents both a metaphysical and epistemological critique of cybernetics, as traditionally conceived, and attempts to recover some of its key insights and practices in light of new first principles.

Keywords: *Epistemology, Metaphysics, Realism, Thomism, Cybernetics, Constructivism, Philosophy of Science*

1. Introduction

Cybernetics is unquestionably one of the most important engineering movements of the twentieth century. The work of the early founders, such as the American mathematician, engineer, and philosopher, Norbert Wiener, established foundations for the emerging fields of control theory, communications, computing, and artificial intelligence (Wiener, 1965). The British psychiatrist, W. Ross Ashby, another pioneer in the field of cybernetics, developed the fundamental concepts of the homeostat, the law of requisite variety, the principle of self-organization, and the principle of regulatory models (Ashby, 1956). The Austrian-American physicist, electrical engineer, and philosopher, Heinz von Foerster's, seminal research made lasting contributions to self-organizing systems, bionics (i.e., the

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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) (von Foerster & Ashby, 1964).

In addition to the vast engineering and technological contributions of particular cyberneticists, the movement has also greatly enhanced interdisciplinary communication. Hugh Dubberly, the former Creative Director at Apple Computers, writes,

> Cybernetics offers a language (both vocabulary and frameworks) that enable scientists (and designers and others) from different domains of knowledge and practice to communicate—to describe the structural similarities of systems and to recognize patterns in information flows. This shared language is especially useful in analyzing, designing, and managing complex, adaptive systems, which are intertwined with many of today's wicked problems. (Dubberly, 2019)

With the emergence of the "cybernetics of observing systems," or second-order cybernetics, in the late 1960s and early 1970s, many cyberneticists shifted their focus to the social sciences, communication, and the humanities (Abramovitz & von Foerster, 1974; Mead, 1968; Pask et al., 1973). In particular, cyberneticists have considered issues related to cognitive science, epistemology, and the philosophy of science, with clear mutual influence. Von Foerster's new theory of knowledge has many striking parallels with the radical constructivism of Ernst von Glasersfeld. However, as the Israeli philosopher, Itay Shani, astutely observes,

> However historically prominent, it is nevertheless clear that constructivism, and in particular radical constructivism, remains a matter of dispute within systems theory. As systems theory developed, its methods, categories, and ontological landscape were adopted by many theorists and practitioners who pay little regard to constructivist epistemological considerations. Clearly, the ontology of systems theory has taken a life of its own, manifesting a high degree of autonomy from the constructivist epistemology cherished by dedicated cyberneticists. This raises a serious question, to wit, is radical constructivism an indispensable part of systems theory, or is it rather a dubious interpretation—however spiritedly pursued? Do second-order cyberneticists overstate their case? Have the skeptics failed to grasp the message? (Shani, 2019, p. 81)

We enter into this metaphysical and epistemological conversation and offer a critique of cybernetics' constructivist foundations as well as its origin in the conflation of nature and artifice. Our goal is to recover some of cybernetics' best insights and practices in light of new first principles rooted in Thomistic realism—the metaphysical thought of the thirteenth century Italian polymath, Thomas Aquinas, and its elaboration by later philosophers through to and especially in the twentieth century. According to the French philosopher, Joseph De Finance, “Realism, in the fundamental sense of the word, is the name given to every [philosophical] doctrine which acknowledges that things (persons or objects) have an *en-soi* [(being) in-itself] and does not reduce them to representations or constructs of the mind or ideas” (De Finance, 1994, p. 808).

Philosophical realism is the noetic and ontological foundation for all human knowledge, especially scientific investigations. As the Spanish physicist and philosopher, Mariano Artigas, points out,

> [T]he philosophical realism required to validate the knowledge of experimental science is already implicit in scientific activity, since the central role played by experimental control is incompatible with idealist, empiricist, or skeptical approaches. (Artigas, 2006, p. 150)

In other words, the objectivity of the scientific method implies a realist ontology. In order to show how this pertains to cybernetics, we bring to bear the insights of two twentieth century Thomists: the French philosopher and historian of philosophy, Étienne H. Gilson (1884-1978), and the Hungarian-American physicist, philosopher, and historian of science, Stanley L. Jaki (1924-2009). Gilson, who is our main focus, is well known for recovering a Thomistic metaphysics that prioritizes the act of being (*esse*) to serve as the foundation for a realist method which rigorously avoids the modern idealist conflation of human thought and being as such (Gilson, 2011, 2012). But Jaki must also be mentioned here, as his sustained application of Gilson’s method in relation to modern science serves as a precedent and inspiration for our own assessment of constructivist cybernetics (Haffner, 2009; Jaki, 2002; Relja, 2008). We now offer some historical and philosophical context to the emergence of the constructivist epistemology in relation to the distinct approach of realism.

2. Historical-Philosophical Context

The eighteenth-century Prussian philosopher, Immanuel Kant, attempted to unite the post-Cartesian schools of Continental rationalism and British empiricism with his own synthesis. He sought to develop a transcendental theory of knowledge. Kant distinguished between the extra-mental thing, i.e., noumenon, and the impression it makes on the knower, i.e., phenomenon. He posited that *das Ding an sich* (the thing-in-itself) is unattainable because one can only know it as conditioned by the transcendental conditions of one’s cognitive faculties. Kant acknowledged that one cannot envision anything outside of the *a priori* conditions of time and space, yet asserted that the noumena are strangely neither spatial nor temporal (Kant, 2007, p. part I, bk. II, chap. 3). Hence, Kant adopts agnosticism toward being in itself, while embracing Newtonian mechanism as a description of the transcendentally constituted phenomenal realm.

The modern Kant scholar, Hans Vaihinger's, 1911 book, *Die Philosophie des Als Ob* (published in English as *The Philosophy of "As if": A System of the Theoretical, Practical and Religious Fictions of Mankind*) is a foundational text for the constructivist philosophy closely aligned with contemporary second-order cybernetics. Vaihinger accepted the Kantian premise that knowledge is limited to phenomena and one can never reach noumena. One only has access to one's own mental constructions. Therefore, one must assume that these mental constructions match reality. Hence, Vaihinger asserts that humans behave "as if" the world matches our mental models (Vaihinger, 1911).

In summarizing the historical development of "constructivism," one must also acknowledge the influence of the American philosopher of science, Thomas Kuhn, whose *The Structure of Scientific Revolutions* (1962) is perhaps one of the most cited academic books of all time. It is is interpreted by many as the classic statement of epistemological and ontological constructivism. For example, Kuhn writes,

> In a sense I am unable to explicate further, the proponents of competing paradigms practice their trades in different worlds. One contains constrained bodies that fall slowly, the other pendulums that repeat their motions again and again. In one, solutions are compounds, in the other mixtures. One is embedded in a flat, the other in a curved, matrix of space. Practicing in different worlds, the two groups of scientists see different things when they look from the same point in the same direction. (Kuhn, 2012, p. 149)

Interestingly, according to the British philosopher of science, Alexander Bird, Kuhn denied any constructivist connotation to his remarks. He did not accept the position "that the way the world literally is depends on which scientific theory is currently accepted" (Bird, 2018). Yet, drawing on the work of (Hoyningen-Huene, 1990), (Bird, 2018) writes, "The important difference between Kant and Kuhn is that Kuhn takes the general form of phenomena not to be fixed but changeable." Even if Kuhn denied the label of "constructivism," his notion that scientific revolutions alter the phenomenal world does clearly remove the limit of a permanent knowledge paradigm, freeing Kantian epistemology in particular from its *a priori* commitment to a Newtonian conception of space-time.

The term "radical constructivism" was later coined by the German-American psychologist and philosopher, Ernst von Glasersfeld, in 1974. Influenced by Hans Vaihinger, Giambattista Vico, Jean Piaget, George Berkeley, and others, von Glasersfeld argued that any constructivism has to be complete, i.e., radical. One of his fears was that his Kantian epistemology could degenerate into some kind of nuanced realism. An axiom of radical constructivism is that all knowledge is constructed, rather than perceived through senses. Von Glasersfeld did not intend to formulate a metaphysics in the strict sense, as he did not make claims about the nature of extra-mental reality. In his book, *Radical Constructivism: A Way of Knowing and Learning*, he presents an in-depth explanation for his theory of knowing. Von Glasersfeld's stated goal was to provide a pragmatic approach to questions about reality, truth, language, and human understanding (von Glasersfeld, 1995).

Yet, we shall argue that this constructivist epistemology, indeed any epistemology, also implies an ontology. The British physicist and philosopher, Andy Pickering, accordingly refers to cybernetics as an "ontology of becoming" (Pickering, 2010). Building on this concept, the American philosopher of science, Peter Asaro, describes cybernetic metaphysics as a rejection of a cosmos composed of matter and energy as well as one made up of ideas, words, and symbols. The preferred cybernetic perspective is that the world is made up of feedback loops of information. According to Asaro, cyberneticists place great emphasis on the *dynamic* nature of information (Asaro, 2010). But the question remains: What provides purposive direction and intelligibility to this cybernetic dynamism? It seems that for von Glasersfeld, von Foerster, and constructivist cyberneticists, it is the pragmatic mind (or minds?) that bestows purpose and meaning by using available information to achieve its own stasis.

In a chapter for the *UNESCO Encyclopedia* section on System Science and Cybernetics entitled "Cybernetics and the Theory of Knowledge," von Glasersfeld explicates his epistemology. It is helpful to quote him *in extenso*:

> The epistemological position of radical constructivism is primarily based on the logical consideration that observers necessarily conceptualize what they observe in terms of concepts that are of their own making (as Kant said, according to reason's own design); but the fact that the "data" of vision, hearing, touch, smell, and taste are (from the neurophysiologist's point of view) all indistinguishable is a welcome empirical corroboration of the perceiver's autonomous constructive activity. The constructivist theory of knowing, one of the cornerstones of second-order cybernetics, can be briefly summarized in the principles:
>
> 1. Knowledge is the result of a cognitive agent's active construction.
> 2. Its purpose is not the representation of an external reality, but the generation and maintenance of the organism's equilibrium.
> 3. The value of knowledge cannot be tested by comparison with such an independent reality but must be established by its viability in the world of experience. (von Glasersfeld, 2002)

The Italian philosopher and psychologist, Simone Cheli, observes that "radical constructivism, in the tight sense articulated by von Glasersfeld, shows many commonalities with von Foerster's second-order cybernetics" (Cheli, 2018). One of von Foerster's famous expressions was "*Was wir als Wirklichkeit wahrnehmen, ist unsere Erfindung*" (The world, as we perceive it, is our own invention) (Riegler, 2018).

To philosophical realists dating back to Plato, the apparent philosophical problem here is that of relativism: lacking a universal standard beyond itself, the particular mind's unimpeded constructive power becomes the standard of "truth" and "goodness." To this extent, being itself cannot be known, enjoyed, and shared in common by all rational beings, since what exists at bottom are (essentially untrustworthy) appearances, manipulated according to the arbitrary purposes of the subjective will.

Von Foerster, however, thought that the realist view was itself problematic, namely, in that it naively presented objective beings as existing in themselves, prior to and apart from human knowing—when in fact, phenomena are never known, except by way of the mind's own dynamic self-regulation. A motivation for his second-order cybernetics was to formulate a radically reflexive form of science that critically engaged what he saw as the illusion of objectivity and the problems of a realist epistemology. In his 1981 book entitled *Observing Systems*, von Foerster offered his insights into topics in cognitive science, artificial intelligence, epistemology, ethics, and other fields (von Foerster, 1981). That same year, the "Declaration of the American Society for Cybernetics," composed by von Glasersfeld, described the second-order cybernetic epistemic quest as attempting to formulate "a theory of knowledge construction that successfully avoids both the absurdities of solipsism and the fatal contradictions of Realism" (von Glasersfeld, 1992, p. 3).

But even if constructivists like von Foerster and von Glasersfeld admit the existence of phenomena emerging from beyond the mind (thus refuting solipsism—the belief that knowledge of anything outside one's own mind is at best "unsure"), they still have not attained a universal standard for common knowledge and shared purpose, transcending the self-interested constructions of particular knowers. As both Plato and Aristotle already saw, phenomena remain no more than superficial appearances, subject to arbitrary control—unless, that is, they are the appearances of *universally intelligible being*.

Gilson's scholarship in the history of philosophy shows how metaphysical realism continues to resist the pitfalls of the modern philosophies that have attempted to replace it (Gilson, 1999). Indeed, the history of modern philosophy, moving from Kant's idealism to Nietzsche's post-modern relativism, suggests that Gilson is right: by making the human mind the standard of being, rather than vice versa, modern philosophy fails to resist relativism and arbitrary constructivism. Gilson, moreover, refutes the cliché that all forms of realism "naively" or "crudely" presume the existence of objective beings "out there," separate from the activity of the mind. Thomistic realism, for its part, adds to the classical realism of Plato and Aristotle a deeper awareness of both the fundamental role of the creative mind and the absolute primacy of actual existence (*esse*) (Gilson, 1952).

By fully prioritizing concrete *actuality*, Thomism thoroughly resists the human mind's arbitrary projection of its own purposes and images into nature and therefore safeguards the rationality of empirical science:

> In reaction to the idealist tendency to attribute constitutive powers to mere thought, Thomist realists have attempted definitively to reject idealism by setting their philosophical foundations upon being, rather than upon consciousness, by taking metaphysics rather than epistemology as their point of departure, by grounding their epistemologies not rationalistically in mere thought, but realistically in the empirical givenness of things, and the immediacy of the senses. (St. Amour, 2005, pp. 589–590)

Jaki concurs, writing,

> [T]hat even the fact, let alone the nature, of external reality, however ordinary, cannot be proven by mere logic or mathematical formulas does not make one's immediate registering of external reality a less than fully rational process. To know the existence of things is in fact the very first step in reasoning. Any critical knowledge or philosophy which does not accept this will remain a mere criticism of criticism and not a criticism of the external reality one registers, and not even one's own registering it. (Jaki, 1993, pp. 108–109)

In beginning with the givenness of things as mediated by the senses, Thomistic realism does not thereby discount the constructive activity of the mind; rather, it views the latter as a creative response to the prior givenness of being.

3. Knowledge as a Response to Natural Form according to Thomistic Realism

Pace von Foerster, Thomistic realism accepts that the truth of being—its actual intelligibility—requires that it be actively known by a mind—foremost, the infinite mind of the eternal Creator (Gilson, 1994, pp. 207–235). For Aquinas, the Creator thinks all of creation into existence out of nothing, drawing only from his own perfectly intelligent and intelligible Being. This must be so, he argues, if scientific rationality is to be upheld. For apart from the creative truth of the divine Mind, the empirical order of the cosmos would be, instead, a passing illusion founded on a more basic chaos. According to Aquinas, God's free creation flows from the knowledge of His own infinitely intelligible being, which He can share, in His supreme goodness, with countless finite beings. Thus, Aquinas could agree with radical constructivists, that if a being were never known by a mind, it would not be "real."

As regards our human knowledge, this means that the intelligible natures, which we grasp as intelligible "essences" (*essentia*), are participations in God's own creative mind. By contrast to von Foerster, Thomism holds to the ontological priority of being (i.e., existence determined by natural forms) in relation to finite minds. As Aquinas famously explains in *De Veritate*, truth is a correspondence between actual being and the knowing mind (Aquinas, 1954, q. 1). Since the truth of being terminates in the mind, any finite instance of truth obviously requires a knowing mind. And yet, it is always the truth *of a given being*. The fact that the human mind awakens to consciousness in relation to an already existing order of beings shows that actual being precedes human knowing and is its primary object. Concrete beings ontologically precede the human mind's grasp of them, since the mind obviously does not bring them into existence out of nothing. Natural beings, each composed of a dynamic form and consigned matter, are themselves transcendent standards of human knowledge, since they are potentially knowable by *all knowing minds in common*, not excluding their distinct perspectives. The notion of "form" here signifies the intelligible identity or "whole" of a particular being, transcending the displacement of its matter over time (Gilson, 1994, p. 174). By grasping the form of a being in a particular event of knowledge, the knower actualizes that being's intelligible essence in a new perspective; but it does not thereby actualize the form of the being itself, which already exists.

In the view of Thomistic realism, human artifice, which constructs purposive mechanism, is always a response to prior natural forms, given to the human mind from beyond it. "Nature" here signifies an intrinsic principle of teleological motion, such as that found in any plant or animal (Gilson, 1994, p. 184). Natural forms like dogs or trees are intrinsically intelligible, such that the mind can grasp them as beings in themselves and for others. All natural forms are both self-contained, teleological unities (as actual beings) and related to human minds (as intelligible essences). On the other hand, artifacts have their unity and purpose imposed upon them by external human agency. Although a machine's parts are externally related, it receives a unified purpose through a constructed design. The existing world, with its natural facts, is first given to the human mind through sensation, intuition of forms, and judgments of existence; and only in consequence of this factual givenness can we humans use nature to craft and design artifacts according to our own creative purposes (Murphy, 2004).

Accordingly, Gilson's critique of Kantian idealism rejects any notion that the world of our experience is a world arbitrarily constructed by the mind. He writes,

> It is a characteristic of thought to be faced by what is opaque; as soon as that wall of opaqueness becomes translucent, there is always a similar one behind it; and this barrier, which thought strikes against with such a beneficial and fruitful impact, appears to it as the very opposite of a free decree or law of the spirit. The way things actually occur suggests that, by means of science, thought progressively assimilates what is intelligible in a world given to it from without, not that it creates both the intelligibility and existence of that world. (Gilson, 2011, p. 112)

As Gilson here observes, humanity's scientific knowledge is ever progressing through further clarification of given facts (or, as modern science might phrase it, through formulating, testing, refining, and clarifying a sequence of models ever more closely approximating reality). Should one interpret this progress in idealistic terms, the apparently un-limited dynamism of knowing itself becomes primary. Relativism is thus close at hand, in that it falls upon particular knowers to arbitrarily determine the purposive direction of such "progress." On the other hand, if one locates the basic source of scientific progress in the inexhaustible intelligibility of actual being itself, finite minds can thus be understood as creative participants in the truth of being.

Thomistic realism takes precisely this path: while avoiding a "naïve" realism that would ignore the essential, creative role of the mind, it nonetheless affirms a universal standard of knowledge in the actual order of being, prior to human activity. It thus safeguards the authentic intelligibility of natural phenomena, as discerned by the scientific community over time. As regards method, this implies that scientists, including cyberneticists, must not conflate human artifice with prior orders of being, particularly that of nature, lest they sunder the intelligibility of natural beings to the "constructive" will of particular scientists. Our next section applies this methodical principle to first-order cybernetics.

4. A Problematic Tendency in First-Order Cybernetics: The Conflation of Organisms and Feedback Mechanisms

According to Gilson, Kant's most basic error was to prioritize a Newtonian conception of the cosmos, composed of externally related forces and parts interacting in absolute space (Gilson, 1999, pp. 179–198). If mechanistic physics is ontologically basic, as it was for Newton, purposive form becomes something imposed on nature by the willing mind. Although Kant's system is far too sophisticated to summarize here, it is fair to say that natural form, for him, is akin to a purposive mechanism ("teleo-mechanism") projected into nature by the *a priori* structures of understanding. Following Newton, Kant subtly conflates nature and artifice, that is, by draining the former of intrinsic teleological motion and then locating the source of its apparent unity and purpose in the structures of the human mind.

As traditionally articulated by Wiener and Ashby, first-order cybernetics has likewise tended to conflate nature and artifice. It conceives organisms and complex machines as dynamic systems of the same kind (Drack & Pouvreau, 2015, pp. 526–530). Regardless of whether cybernetics studies a natural or artificial being, its systems are always models organized by the following components:

1. The dynamic equilibrium (and entropy) of interacting parts;
2. From among these parts, at least one detecting mechanism that measures inputs;
3. A feedback loop between the detecting mechanism and the other parts;
4. An external human agent who generates inputs and observes their effects; and
5. Underlying physical laws, which are conditions common to #1-4.

Although cybernetics' original emphasis on "dynamism" makes it seem as if it moves beyond the ontological mechanism of Newton, it actually utilizes the analogy of mechanical feedback to extend mechanism into the organic realm. What is most basically "real" in the ontology of first-order cybernetics, as traditionally conceived, is the force of entropy, on the one hand, and the mechanical systems, constituted in relation to external human minds, that resist entropy through detection and feedback, on the other hand. Indeed, in the thought of both Ashby and Wiener, the externally related parts of any system receive their "self"-regulating equilibrium, not from the system itself, but rather from the interaction of inputs, detection mechanism, and feedback loop—as devised and conceived by a human observer. The mind of the cyberneticist observes external systems by means of artificial inputs and conceives them by analogy to the machines they construct. Should the observer-engineer remain consistently aware that the unified, interior dynamism of every nature is irreducible to parts, inputs, and their interactions, this analogy between life and self-regulating machines could allow one to enhance life by imitating it. However, as the German-American philosopher, Hans Jonas, has pointed out, when the being of an organism or groups of them is itself conceived according to the pattern of a self-regulating machine, it is thereby drained of its own teleological form and made subject to human designs (Jonas, 2001, pp. 108–134; Tibaldeo, 2008).

5. The Problems of Constructivist Cybernetics: In Summary

It thus seems that the radical constructivism of second-order cybernetics logically follows from the tendency in first-order cybernetics to conflate nature and artifice. Just as Newton's ontological mechanism lead to Kant's idealism, so too does the dynamically mechanistic ontology of first-order cybernetics lead to the radical constructivism of second-order cybernetics. Already in the "first-order," knowledge is constructed by an "observer" who, in fact, imposes artificial purpose upon the mechanically related parts and processes of "nature." Constructivism is tacitly present in first-order cybernetics; but second-order cybernetics makes it explicit. As a whole, cybernetics has (at least implicitly) tended to view "reality" as a "system" of constructing minds and self-regulating machines, interacting with inherently purposeless physical processes. The self-regulating purpose of all systems is to resist entropy and maintain their own equilibrium for as long as possible.

According to the principles of second-order cybernetics, our discrete minds are both constructed and constructing. In one sense, the self-interested power of particular minds drives this dynamic process, as it attempts to control and direct a-telic forces; in another sense, all minds are ultimately dominated by the indifferent (i.e., mechanical) processes of entropy and evolution. Second-order cybernetics' overarching evolutionary, specifically Darwinian ontology becomes apparent, e.g., in (Scott, 2004, p. 1375). On the one hand, then, cybernetics is a recursive system, defined by the cyberneticists' own constructive knowing; on the other hand, it is just one more pragmatic adaptation in the a-telic process of evolution. This ontology is clearly present, for example, in the German cognitive scientist, Tom Froese's, proposal that cybernetics recovers its foundations in *systems biology*, on the one hand, and an *existential phenomenology* of lived experience, on the other hand (Froese, 2010, p. 83). For while the latter remains essentially subjectivist, the former remains in thrall to a foundational evolutionary paradigm. The cybernetic "system" that prevails at any given moment, within the broader sweep of evolution, is the particular system that can best dominate all other systems.

A similar ontology is present in social scientist, Maria Jakubik's, cybernetic theory of the human intellect. She rightly conceives of the human intellect as a dynamically creative process vis-à-vis its evolving social and physical context. However, she fails to affirm the priority of being *per se*, over both the intellect and its context, when she writes that, the "human intellect forms its context, and at the same time it is formed by it" (Jakubik, 2020, p. 67). If neither exists with its own being and irreducible interiority, then it may be that both the intellect and society (or the world) are essentially manipulating and manipulable processes. Indeed, Jakubik accepts that artificial intelligence may be a genuine imitation of the human intellectual process, which suggests that the latter in turn can be externally—perhaps even exhaustively—programmed, like the AI made in its image. In sum, in the second-order cybernetics of both Froese and Jakubik, the mind does not know the inner depths of reality in itself; rather, one knows ever-shifting, arbitrary constructions and their brute physical conditions.

Based exclusively on its own terms, then, the putative modeling of second-order cybernetics may not be what it seems; for no appearance in this system is really trustworthy. As we have argued, this "cybernetic ontology" is problematic for science in general, because it fails to safeguard the permanent and universal intelligibility of empirical observation and description by the scientific community, as it gains in knowledge over time. Ethical and political problems become apparent when one considers that, on this view, constructing minds are not ordered by any good—or toward any purpose—beyond their own constructive knowing. The dynamics of "nature" are only conditions for constructing systems. As components of "social cybernetics," humans themselves become subject to the construction of other human minds.

This risk is particularly evident in the field of education (Liguš et al., 2011). The Brazilian social scientists, Tiago Quiroga and Cláudia Sanz, articulate a well-founded concern with regard to cybernetic educational theory's emphasis on "control," although it should be noted that an equally valid cybernetic theory of education could instead be based on communication and coordination. They argue that educational theories founded on information rooted in a principle of meaninglessness expands a type of social order where the rules are about control in and of itself. In this light, Quiroga and Sanz propose the German philosopher and social scientist, Wilhelm Dilthey's, concept of lived experience and apply it to education as an alternative to Warren Weaver, Claude Shannon, and Norbert Weiner's cybernetic perspective (Quiroga & Sanz, 2015). Whether or not Dilthey's concept is itself an adequate ground for education, this attempt to overcome the moral relativism of constructionism remains salutary. In the Catholic intellectual tradition carried on by Thomistic realism, education ought to be rooted in a view of the human person as a unique, free, and relational being.

The consequences of radical constructivism on the philosophy of science must also be acknowledged. In the context of a discussion on cosmology, Jaki observes that regrettably in post-Kantian philosophy, even the very "universe" is often reduced to a mere word, if it is employed at all. While not directly addressing the radical constructivist school, he does critically engage related idealist philosophies, some with very evident constructivist aspects, that he regards as having a detrimental effect on science. He writes,

> The word "universe" had no place in the positivism of Auguste Comte and of J.S. Mill. The pluralistic universe of W. James's pragmatism is just as illogical as is the universe within Dewey empiricism. There is no room for the universe in existentialism and in phenomenology. Whatever else the universe may be, it is not a phenomenon. And insofar as the universe means coherence, it is irreconcilable with the radical separation among all events as postulated by Sartre. It should be no surprise that deconstructionists can at most repeat Kant's false arguments about the universe. As if to prove how far they are behind

> times, they are the least willing to construct a philosophy about the universe in this age of scientific cosmology. (Jaki, 1992) †

Jaki also notices that the "universe" in Berkeleyan and Hegelian idealism is reduced to a mental entity. The Dutch mathematician, Willem de Sitter, in the context of discussing the formal construction of scientific laws as the sole true reality, states that the universe is a mere mathematical formula (de Sitter, 1932, pp. 133–134)—which nonetheless postulates an underlying (if ideal or conceptual) reality. Clearly, much is at stake with the widespread, often uncritical adoption of the Kantian, constructivist paradigm which does not acknowledge that the universe is a contingent yet intelligibly ordered totality of things.

6. Reconceiving Cybernetic Practices and Aims according to Thomistic Realism

The above critique shows that cybernetics to date errs, first, in failing to distinguish between pre-given natural forms and complex machines and, second, in therefore conceiving knowledge as construction. However, if we place cybernetics within the prior context of a realist metaphysics and natural philosophy, some of its best insights and most useful practices may be retained and reconceived in a richer way. Thomistic realism claims that nature precedes artifice in the order of being and knowing.

As Jaki eloquently puts it, Thomistic realism begins with the acknowledgement that "it is natural for man to be in a cognitive unity with nature" (Jaki, 2005, p. 37). Nonetheless, artifice imitates nature and realizes its hidden potencies. Cybernetics may succeed in precisely this respect—and to a uniquely high degree—insofar as its constructions imitate nature's own dynamisms. Yet it must be extremely careful to always aim to enhance the inherent truth and goodness of nature itself—not to usurp it by displacing it—since pre-given nature intrinsically orders all being, including free human beings, towards shared truth and goodness.

Still, second-order cybernetics is partially correct in emphasizing the constitutive role of the knowing subject in all events of truth: when the mind knows nature, it enables it to fulfill its purpose of being intelligible. What it aims to know is reality: minds in relation to nature. But reality by definition is not a constructed "system"—for the latter is a manipulable appearance by definition. Reality, on the other hand, is a differentiated, indeed communal, order of natural beings—an order which gives itself to humans to be known and consequently sets our mind free to enrich it. This, indeed, is the task of a renewed cybernetics—to enrich reality. Its unique role should be to develop complex machines and systems, in imitation of organic nature, that set natural forms and human persons free to be more fully themselves.

† This excerpt from Jaki's unpublished lecture can be found in (Pham, 1995).

Engineering cybernetics has served and can continue to serve the flourishing of humanity and nature. Advances in control engineering of mechatronic, chemical, and biological systems has tremendous potential, e.g., self-regulating dam / fishway systems that respond to complex changes in the environment (Bureau of Reclamation Research and Development Office, 2015). Cybernetic principles continue to inspire advances in biomedical engineering, e.g., artificial organs such as the heart (Mohacsi & Leprince, 2014). The important field of systems engineering continues to benefit from cybernetic insights on how to design, integrate, and manage complex systems over their life cycles (Laracy, 2017).

First-order cybernetics should thus be conceived as a practical science, a form of engineering, whose purposes are determined by the prior and more basic sciences of metaphysics and natural philosophy. Stated more concretely, cybernetic engineering should serve the flourishing of free human persons, the natural cosmos, and indeed the whole of being—not vice versa. Basing cybernetics in a realist metaphysics ensures this by affirming the intrinsic *telos* of each being, especially of each human being—whose unique task it is to know and enrich the gift of nature, together with other humans.

Second-order cybernetics also provides useful models for creating, understanding, and optimizing communities of interest, learning, and practice. It can make major contributions to interdisciplinary fields including environmental and sustainability studies. Cybernetics also complements other models in understanding business and economic systems. Second-order cybernetics, as we will argue in a future paper, also provides a useful model for understanding trends in the practice of software engineering and of data science. Given the cybernetic community's interest in interdisciplinary communication, we hope that they will be open to this beneficial interaction with the distinct field of Thomistic metaphysics.

7. Future Work

Looking ahead, with regard to method, there should be closer study of the proper subject of cybernetics and how it relates to other closely related disciplines. Our main task in this paper was to reorient cybernetics in light of new first principles; but only at the end do we explicitly recover its specific purpose. Focusing in particular on first-order cybernetics, future scholarship should shift toward the concrete, practical direction, without losing sight of the purpose of safeguarding and fostering human nature and the cosmos.

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