describe it, "as-if" our simple story was the very reality we need to deal with.

> "The only meaningful thing is the usefulness of the model […] When such a model is successful at explaining events, we tend to attribute to it, and to the elements and concepts that constitute it, the quality of reality or absolute truth." (Hawking & Mlodinow 2010: 7)

Empowered by such success, we overlook its context-dependence. But our very definition of success has been intimately tied to the boundaries and constraints (cf. Juarrero 1999) that we imposed so as to frame the situation. In other words, our choices about context help to determine the success or failures of our models.

« 14 » We must remember the lessons from Vaihinger: "The object of the world of ideas as a whole is not the portrayal of reality – this would be an utterly impossible task – but rather to provide us with an instrument for finding our way about more easily in this world" (Vaihinger 1924: 15). and of Rorty. Our simple story is the result of choices we each make and have made. We make those choices to "make sense" out of a situation, to help us in our way-finding and in our coping. We always have the option of making different choices. But, the reality with which we deal will be the one we choose to deal with.

« 15 » This is the realm of "pragmatic constructivism" (Lissack & Graber 2014). The "pragmatic" here refers to the process of how we go about explaining a situation to someone else and the process of how we reach an understanding of that situation ourselves. When simple perceptions are inadequate, the need for tools that enable better access to the "what, who, and how much" that one needs to know in order to act becomes painfully obvious. The pragmatic constructivist is happy to accept the scientific realists' models as a base that must then be modified to account for boundaries, constraints, and the manifold possibilities inherent in the interactions of large numbers of autonomous and semi-autonomous agents. Such modifications are rooted in the observer/actor's understanding of the situation at hand – an understanding that itself can be molded by the interactions it observes and participates in. Explaining is the ability to relate a narrative to the questioner, which, at a minimum, allows a "fit" between the question asked and the "attended to" context and, in depth in the form of acquired understanding, allows the explainee to apply such narrative to new contexts and new questions.

« 16 » When we are explicit that we are choosing the realities we deal with, the problems we recognize as problems, and the boundaries and constraints that enable solutions, we are not only accepting some form of constructivism, but we are also accepting that we each have a sense of responsibility regarding such choices. Cybernetics has served to produce great insight into how we might manage these responsibilities, including:

- the role of the observer (von Foerster 2003d),
- the law of requisite variety (Ashby 1958),
- the importance of the observer in cognition (Maturana & Varela 1980),
- the use of Black Boxes (Glanville 1982),
- the idea that all action is in some ways a conversation (Pask 1975a),
- the importance of recognizing that "true models" (in the Robert Rosen sense, cf. Lissack 2016) differ from descriptive representations,
- the importance of narratives (Clarke 2014).

These insights can be reduced to a fundamental essence: it is critical to ask and explore how context in its fullest meaning matters. Second-order cybernetics is at essence the science of exploring how context matters.

« 17 » Exploring how context matters is a second-order concept. It is the essence of everything written above. Indeed, it may be the essence of everything in this special issue of *Constructivist Foundations.* What is important is that "exploring how context matters" is not jargon, is not domain or intellectual foundation restricted language, is not hard to grasp. Exploring how context matters is a question that can be applied to every scientific exploration, every strategic business decision, every social issue, and nearly every personal choice. If we can focus our second-order cybernetics efforts on getting others to "explore how context matters," we can reintroduce a ubiquity to the cybernetic/constructivist endeavour.

« 18 » Umpleby (§82 and §84) poses a challenge to the second-order cybernetics community: find relevance or risk death. His list of issues where a second-order cybernetics approach may yield valued results is both lengthy and practicable. But Umpleby (like the other authors in this issue) has minimized our actual dilemma: if we continue to use jargon to which others cannot relate, we fail.

« 19 » Many other intellectual communities are doing work that falls within the domains of second-order cybernetics and what I prefer to call "pragmatic constructivism." We can bring members of these communities "into the fold" if we begin to use language that gives them meaning. Together we can co-construct a new science of context. Exploring how context matters is just a beginning.

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Received: 28 May 2016
Accepted: 31 May 2016

Beware False Dichotomies

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> Upshot • While I agree with most of the thrust of second-order cybernetics, I find the dichotomy of first- vs. second-order cybernetics conceptually and historically problematic because it implicitly conflates the cybernetics of nonhuman systems with realist conceptions of observer-free science. The dichotomy may be divisive and unhealthy for cybernetics by driving natural scientists and engineers out of the movement, thereby undermining the universality of its principles.

« 1 » I am in general agreement with Stuart Umpleby's thoughtful historical and conceptual review of second-order cybernetics, and do agree with him that widespread adoption of the epistemological stances of second-order cybernetics would constitute a fundamental revolution in how most scientists think about and do science. The proposed revolution involves a shift from realist ontology to constructivist epistemology, from realism to pragmatism, and from observer-free to observer-aware descriptions. That is all fine and good.

« 2 » Missing, however, from Umpleby's account (e.g., the Popper-von Foerster-Kuhn trichotomy in Table 1) is an acknowledgment of parallel paradigmatic realist-pragmatist debates that have played out in science and in the philosophy of science. The cyberneticists have not been the only ones to formulate alternatives to realism. And not all scientists are either naïve-realists or Popperian falsificationists. There have always been pragmatists and operationalists (e.g., Heinrich Hertz, Ernst Mach, Percy Bridgman, and Nils Bohr) who have regarded scientific models as provisional, observable-dependent, predictive models rather than as correspondences with some underlying absolute, knowable reality. In the debates over quantum mechanics and the foundations of physics debate, Bohr and others sought to explicitly include the observer in the predictive modeling process (Murdoch 1987). Similarly, in the philosophy of science, there are well-developed, full-blown pragmatist and radical constructivist alternatives to realism (Van Fraassen 1980; Munévar 1981; Glasersfeld 1995). A tactical question is whether second-order cybernetics is the best banner under which to advance this alternative understanding of science, or whether a broader front united with like-minded scientists and philosophers of science would be more effective.

« 3 » A second, related point is that normal practice in empirical science *does* to some degree take into account the methods and purposes of the observer. Although most individual scientists are not very reflective about their ontological and epistemological assumptions (in many fields, especially in biomedicine, discussion of "larger philosophical questions" is palpably maladaptive for securing funding), in practice empirical science does not automatically make the naïve realist assumption that what is being measured is completely well-characterized (i.e., the assumption "it is what we think it is"). With the exception of theoretical discussions and commentaries, every scientific paper has an introduction section where the observer's reasons for considering a phenomenon are presented and a methods section where the experimental procedures of the observer are spelled out to the extent that the observations made can be reliably replicated by others (i.e., intersubjectively verifiable). The removal of subjective biases and the striving for "objective" measurements and evaluations (as in Kandel quote, §22) is not to assert realist objectivity but to assure conditions for pragmatist intersubjective verifiability. By "objective," Kandel means not that the measurement is objectively true, but that, to the greatest extent possible, it is not being intentionally biased by the observer.

« 4 » The observer determines which measurements will be made and how they will be made, but the specific outcome of each measurement cannot be under the control of the observer if measurements are to be replicated by others (who have potentially different intentions). A realist says "say how it is," and Heinz von Foerster replies "it is how you say it" (§27 and Table 3), but a pragmatist-operationalist would say "you will see it this way, if you construct these lenses for observing it."

« 5 » The observer alone does not determine what he/she/it observes. Exactly what is observed is co-determined by the experimental preparations and measuring devices chosen by the observer (the observational frame) and how the measuring devices interact with their surrounds. We construct our own epistemic realities to the extent that we choose how to view the world (the nature of the measurements made), but beyond this, we do not control specifically how the world will appear to us (the outcomes of those measurements) once the choice is made. If we did control specific outcomes, there would be no reduction of uncertainty for the observer (in Ashby's sense). It would also mean that observers with different intentions would not be able to use each other's data in building models and theories.

« 6 » Even the most reductionistic molecular biologists, who tend to eschew philosophical considerations entirely, are keenly aware that interpretation of a given body of data depends critically on exactly how the system was prepared and the measurements made. They understand that they do not know exactly what is being measured in their assays. A great deal of time and mental effort is spent *not* taking data at face value, and acknowledging that different observational frames, even if they are supposedly measuring similar or related things, are not necessarily commensurable. Rather than caricaturing most normal scientists as unsophisticated naïve realists, it may be more persuasive to emphasize those parts of scientific practice that do explicitly take the observer into account, thereby showing that many aspects of the new perspective are already valuable parts of current practice.

« 7 » "Second-order cybernetics" is often contrasted with "first-order cybernetics" along various dimensions of difference. Many can be seen in my Table 1, which includes distinctions from Umpleby's Tables 1–4 and additional ones from recent related discussions with Umpleby and other cyberneticists. These are not repeated verbatim, so they reflect my understanding of the distinctions. They also include some ideas from Eric Dent, Umpleby's former graduate student and collaborator.

« 8 » The commonly cited distinctions in the table relate to the dominant subject matter, philosophical stances, aims, and methods of the two proposed forms or modes of cybernetics.

« 9 » Although this dichotomy of distinctions may fairly characterize second-order cybernetics, I think it seriously misrepresents the concepts and practices that most people would tend to label as first-order cybernetics. For example, three major artefacts of the early period of cybernetics – Ross Ashby's adaptive homeostat, Grey Walter's autonomous robotic tortoise, and Gordon Pask's self-organizing electrochemical device – do not fit well into the caricature of first-order cybernetic devices as deterministic, controlled, predictable, or even well-defined (Cariani 1993, 2009; de Latil 1956; Pickering 2010). The major proponents in the early phase (e.g., Norbert Wiener, McCulloch, Ashby, Walter, Pask, Stafford Beer, von Foerster) held pragmatist, not realist, epistemologies heavily informed by neuroscientific and psychological perspectives.

« 10 » The dichotomy of first- vs. second-order cybernetics too easily lapses into a historical break (early vs. late cybernetics), a difference between nonhuman (natural sciences and engineering of artefacts) and

Dimension	First-order	Second-order
Commonly cited distinctions		
Approach	Reductionism	Holism
Method	Analysis	Synthesis
Primitives	Entities	Relations
Processes	Deterministic	Probabilistic
Relation to designer	Controlled	Autonomous
Relation to designer	Designed	Self-organized
Embeddedness	Context free	Context dependent
Role of observer	Observer-free	Observer-dependent
Position of observer	Outside observed system	Embedded in observed system
Theory dependence	Theory-free phenomena	Theory-determined phenomena
Metaphysics	Ontology	Epistemology
Working framework	Naïve or critical realism	Pragmatism, radical constructivism
Aim	Understanding (prediction)	Action (intervention)
Definition	Clarity, operational definitions	Ambiguity as opportunity
Subjects	Inanimate objects (nonhuman)	Thinking participants (human)
Reflexivity	Unreflexive	Reflexive
Medium of interaction	Physical	Language
Mode of interaction	Communication	Conversation
Common conceptual rubrics		
Historical period	Early cybernetics (1930–1975)	Late cybernetics (1975–present)
Target systems	Artificial devices	Human systems
Disciplines	Engineering & natural sciences, medicine (bionics)	Social, psychological, therapeutic arts & sciences, management, arts, organizational & social change
My perspective		
Purposive systems (systems with embedded goals)	Study, design, construction and use of purposive systems (natural and/or artificial)	Study, design, construction and use of interactions between purposive systems (natural and/or artificial)

Table 1 • Some dimensions of the proposed first-order/second-order cybernetics transition.

human systems (socio-psychological interventions), and a disciplinary divide (hard scientists and engineers vs. soft social and psychological scientists and human systems people). Do we want to divide cybernetics along these lines? Perhaps the distinction can be coherently construed as a historical transition from one kind of research to another. But, if so, we should avoid the error of thinking that the first wave of cybernetics was epistemologically less sophisticated, either because they came earlier or because many of them studied and designed feedback control systems or because many of them were biologists and neuroscientists. If a revolutionary flag is to be raised, the distinction should instead be made between an observer-aware second-order cybernetics and traditional, realist conceptions of science and engineering. There is no need to use the distinction to divide cybernetics itself.

« 11 » I do agree that a historical and sociological transition can be identified in the cybernetics movement, but this is not so much a revolution of ideas but a shift in who continued to work explicitly under the banner of cybernetics and what kinds of systems they studied ("first-order" and "second-order" are misleading labels for this kind of transition because they imply an essential, conceptual distinction rather than a sociological one). During the 1950s and 1960s, there had been a series of scientific conferences and technical publications related to cybernetics, self-organizing systems, and bionics, but by the late 1960s, these had ceased entirely. It appears that government funding for the cybernetics of natural and artificial systems dried up, causing scientists and engineers to leave the field. The center of gravity of the field then shifted to the cybernetics of human systems.

« 12 » In part, the loss of funding can be attributed to the Mansfield Amendment (Umpleby 2003). But perhaps more importantly, by the late 1960s, proponents of computational approaches to artificial intelligence had also achieved control over the major sources of American defense funding (ARPA, ONR) and did not hesitate to defund competing research programs. Funding for research in cybernetics, neural networks, trainable machines, bionics, and self-organizing systems all abruptly came to a halt. Many people attribute the cutoff of funding for research on neural networks directly to the influence of Marvin Minsky on funding decisions (Dreyfus & Dreyfus 1988; Boden 2006). In conversations with his colleagues and students, I have learned that von Foerster expressed similar beliefs about why funding for his Biological Computation Laboratory had dried up. More light needs to be shed on this history.

« 13 » There is also the question of whether the dichotomy divides cybernetics in such a way that undermines the maintenance of diversity (perspectival variety) within the cybernetics movement. Projection of realist and reductionist (purportedly first-order) beliefs onto engineers working on artificial systems or scientists studying natural systems has the effect of discouraging their participation in the cybernetics movement. It is probably unhealthy for the movement to nourish an identity politics of who is second-order or whether a given person's perspective is sufficiently second-order (i.e., "politically correct"). As a neuroscientist and theoretician, I constantly wonder about myself and exactly where I stand vis-à-vis the tenets of second-order cybernetics.

« 14 » We need an inclusive big tent rather than a divisive faction fight. I think the cybernetics movement will be enriched if it brings in participants from *all* fields that deal in some significant way with purposive systems (Table 1, bottom row), i.e., those systems that have internal goals that they pursue (Ackoff & Emery 1972). These include fields of endeavor that deal with the broad range of purposive artificial, natural, and social systems: engineering, natural sciences, neural & psychological sciences, social sciences, therapy, management & policy sciences, the arts, and movements for social change.

« 15 » There will be those who deal with how such systems are organized so as to effectively pursue their goals (first-order), and others who deal with how such self-directed systems interact with other such systems (second-order) to cooperate, compete, and converse. Somehow we will all get along and learn from each other.

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Received: 11 June 2016
Accepted: 16 June 2016

Second-Order Cybernetics Needs a Unifying Methodology

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> Upshot • Theory without a strong methodology is stranded in philosophy. Principles devolved from theory can be applied to situations in the arena of practice in many ways; however, a continually improving science must refine its theories with feedback from data drawn from the use of continually improving sets of codified methodologies. Second-order cybernetics is contingent upon sense-making within sapient systems. A perspective on cognitive science points toward the requirements for an enabling sense-making methodology for second-order cybernetic science.

Introduction

« 1 » In his target article, Stuart Umpleby's current review of the evolution of the epistemology of second-order cybernetics draws our attention first to a neurophysiological (neuropsychological; cognitive neuroscience) consideration of the sensory system. Sensory-input, the first step in sense-making, is both organically selective and autonomously filtered. Meaning, which is the substrate of cognition, is individually derived from direct and vicarious experiences via the senses. Our shared understandings are meanings that have become socialized through communication. And communication again involves selective and filtered sensory channels. Sensing and sense-making is, Umpleby asserts, the foundation of second order science … and for all other sciences too. The specific relevance of sense-making to the practice of second-order cybernetics is asserted to be based upon a (r)evolution in the construction of social meaning and a concurrent enhancement of action taken within living systems.

« 2 » The revolution is stated as an altered perspective. The cybernetic scientist is immersed within the system with the inference that being positioned within a system will alter the experience of the experimental observations that the scientist gathers. Implicit in this expectation is the belief that the scientist's way of seeing and interpreting observations into meaning changes as a function of the altered observational perspective. This theme warrants considerable exploration given that sense-making (and higher meaning-making) have autonomous features forged by formative experiences beyond voluntary control as well as reflective features that are more obviously and directly under voluntary control. The point that I am exploring here relates to autonomous features of a researcher's sense-making capacity that may be resistant to un-learning and re-learning without specific methodological support.

Expanding the research arena

« 3 » A fundamental feature of an observer's immersion within a sapient living system relates to the exchange of emerging understandings with and among actors in that system. When sense-making is a collective, subjective process (rather than solitary, objective work), the product of the sense-making is co-constructed. The second-order cybernetic researcher cannot be viewed simply as a cultural anthropologist artfully hidden behind a one-way mirror positioned in the center of an interactive sapient system; the cybernetic researcher is interacting directly and is being directly influenced by interactions. The researcher also cannot afford simply to be an arbitrator for collisions among differing theories of how things work in the system under study. Interdisciplinary perspective is not a matter of theoretical reconciliations, but rather it is a co-construction of new theory through the reconfiguration of meaning drawn from joint consideration of primary observations. This recombination can be considered as homologous to the synthesis of new chemical entities through reactions that facilitate recombination of elements into new coherent wholes. This letting go and rebuilding cycle can be particularly painful for researchers who cling strongly to favored theories.

« 4 » Input that is intentionally drawn from interactive recombination of ideas from a community of actors changes expectations of what constitutes a scientific finding. The finding is a complex function of: