

Author's Response: Identifying a Philosophy and Methods for Second- Order Science

Stuart A. Umpleby

> Upshot • The work that scientists do, particularly social scientists, is currently constrained by their conception of science. Expanding the conception of science would lead to more innovative work and more rapid social progress.

« 1 » I shall reply to the comments on my target article in approximately the same order as the themes in that article. Two points that will recur are that understanding human purpose is important and multiple perspectives are useful. Also, I shall expand the section on methods.

Epistemology and ontology

« 2 » Regarding the epistemological triangle in Figure 1, the underlying questions in the comments seemed to be: Is one epistemology correct and the others incorrect? Or can all three be in some sense correct? **Mark Notturmo** (§11) defines epistemology as an attempt to answer such questions as “What is knowledge?” He argues that the sides of the triangle are not different epistemologies but different foci of study. That is one interpretation. Perhaps because I am interested in cultural differences, I would say that people can have different purposes for studying knowledge and that these purposes lead them to create different epistemologies. **Notturmo** seems to be claiming that his purpose in studying knowledge is the best or most important purpose for studying knowledge. My interpretation is that it is interesting that there are several epistemologies. So, for me, it is intriguing to understand where they come from and what their implications are.

« 3 » **Notturmo** (§11) claims that “everything is what it is.” That is the ontological view of the world. What I perceive is that people differ in their views about “what is.” I suggest that the three epistemologies – realist, constructivist, and pragmatist – are rooted in different purposes. Realists seek to create accurate, universal descriptions of the world. Pragmatists tend to be ori-

ented toward specific, often economic goals. Knowledge is either effective or ineffective. Constructivists view the creation of knowledge as a series of choices of interpretations of experiences. The creation of knowledge is viewed as a means to the ends of survival and adaptation and the living of a good life.

« 4 » I find all three epistemologies to be useful. On any day I may use all three. When talking with a carpenter or plumber about a household repair, any epistemology other than realism simply causes confusion. The hot water source is either connected to the hot water faucet or it is not. When speaking with a business person, pragmatism is the appropriate epistemology. A product or service may seem ideal, but if customers do not buy it, it fails. Constructivism is helpful when communication is difficult, for example when discussing a contentious political issue. Then it is helpful to ask for the sources of information, the stories in the press, the history of the region or issue, the experiences of the other person and the conclusions drawn from those experiences. I view constructivism as more versatile, more respectful, and more grounded (in philosophy, psychology, and biology) than the other epistemologies. Hence, it is more suited to second-order science.

Four models used in science

« 5 » Regarding the four models used in science, **Jixuan Hu** (§§5–7) suggests some additional models that he believes are important. I agree with all his suggested amendments. My intent was not to create a comprehensive inventory of models but to call attention to the need for more complex models in the social sciences. For example, a simple linear causal model can be used to test a policy or a reform program by asking whether the policy produces the results desired. It may for a time, but its effectiveness may diminish as people change their thinking and behavior. And a policy that works in one country or community may not work in another. Searching for linear causal models, which is a very common practice in the social sciences, is based on the assumption that a statistically valid relationship, once found, will persist. But social systems are different from natural systems. The elements of social systems, human beings, sometimes change their minds.

« 6 » **Hu** (§10) is correct that George Soros's model of reflexivity has only slowly been recognized as important. However, according to the web site of the *Journal of Economic Methodology*, Soros's latest article (Soros 2013) is the “most read article” of that journal,¹ which is an indication that there has been progress lately.

« 7 » The model of reflexivity, as described by Soros, assumes that a society is composed of thinking and acting individuals and organizations. These people are engaged in “reflective practice” (Schon 1995). Attempting to understand social systems using a reflexive model is likely to be successful when competing with people using a model that does not have “requisite variety” (Ashby 1952). Second-order science adds two dimensions to first order science – attention to the observer and consideration of the effects of previous theories (or “re-entry” as referred to by the editors of this special issue, see Müller & Riegler 2014). I recommend that social scientists use a reflexive model when studying social systems.

« 8 » **John Stewart** (§§1f) questions whether science is or should be value neutral. If we started from the assumptions that human beings are purposeful systems and that they create science as an aid in achieving purposes, then we would view science as not value free, since scientists select problems to work on that seem important to them. Also, the methods and descriptions that they use are influenced by experiences in a social environment. It can be argued that the idea that science can be or should be value free arises from the belief that scientific statements should be objective. But the topics of research were selected. Second-order science would make **Stewart's** suggestion (§4) – that the values used to guide the research should become an object of discussion – a part of science.

« 9 » So, discussing the choices that scientists make would support **Stewart's** focus on the responsibilities of scientists. Presently, scientists claim their work is objective and value neutral because they are using a particular conception of science – that science is the search for objective, uni-

1 | On 7 November 2014 the journal site reported more than 25,000 article views.

versal principles. An alternative conception is that science is a purposeful activity undertaken to achieve the scientist's goals and that science can be evaluated by whether the goals are successfully achieved. Second-order science would alter the conception of science so that the values that guide the research are considered part of the research. The current conception among practicing scientists of how to do science constrains the questions that scientists think are legitimate. If scientists thought that it was acceptable to pay attention to the observer and to the consequences of scientific theories, more scientists would broaden their work accordingly, and the results would be closer to the outcomes that **Stewart** and I both hope will occur.

Ideas, groups, events, and variables

«10» **Bernd Hornung** (§8) states that more needs to be said about the four basic elements for describing systems – ideas, groups, events, and variables. He suggests there are different levels. In Medvedeva & Umpleby (2004), it was suggested that two levels – thought and action – are involved. For example, a researcher studies a social system described in terms of variables, and formulates a suggestion for a reform program (idea). That idea must then be taken, often by another person, perhaps a politician or an entrepreneur, and “sold” to a group that will support it, perhaps other politicians or investors. Assuming sufficient support can be found, an event such as passing a bill or founding a company may occur. After a time, the new social arrangement (e.g., a government program or a new company) can be evaluated in terms of variables. So, in general I agree with **Hornung**: variables and ideas occur at the conceptual level. Groups and events occur within society and involve human behavior.

«11» I also agree with **Hu** (§§14–16) that the four basic elements can be thought of as four different levels of analysis. However, my purpose in pointing to the four basic elements was to indicate how the current disciplines narrow our perceptions. The current situation is somewhat like having groups of specialists that each view situations through red, green, and blue filters.

Each has somewhat different experiences and uses a different professional language. But only by using all three can a full color picture be seen. Surprisingly, even though we know that societies are complex, we rarely question the appropriateness of our over-specialized disciplinary perspectives.

«12» In §12, **Notturmo** wonders why social scientists should study what is happening, why they should analyze it, and what might lead them to propose a new course of action. One answer is to improve society or some process in society. Quality improvement methods involve a now well-developed set of methods that are very similar to Karl Popper's (1972) tetradic schema. The principle difference is that rational criticism is replaced by experimentation. A process is defined. Those who work in the process brainstorm possible improvements to it. One proposed change is selected and implemented in one production line. If there is improvement (e.g., reduced cycle time, lower error rate, and/or increased customer satisfaction), the change is tested further. If it continues to be productive, it is implemented throughout the organization. If the change does not result in improvement, a second proposed change is tried. This method of continuous improvement has been so successful it is now being used on processes in organizations around the world to improve the quality of products and services. It is now standard management practice in organizations. Interestingly, continuous improvement methods are not commonly taught in schools of business, which still offer courses in traditional fields such as accounting, marketing, and finance. In the US, only the most basic philosophy of science is taught in business schools and social science departments, even at the doctoral level.

«13» The idea of describing social systems in terms of ideas, groups, events, and variables is similar to the continuous improvement model described in the previous paragraph, but it was formulated to guide work on larger issues such as social reforms. By describing a social system in terms of ideas, groups, events, and variables, one creates a reflexive description of the social system. One must think about actors, their ideas, their actions, and the consequences of their ideas and actions.

Including the observer in what is observed

«14» Many commentators addressed one of the core ideas of second-order science, i.e., the inclusion of the observer in science.

«15» Scientists are using the same methods for social systems that were developed for physical systems. They are trying to use methods based on assumptions that do not fit the social sciences. Relaxing these assumptions will lead to an expanded set of methods and inquiries. However, using the correspondence principle (see my §31) to show the differences between the natural and the social sciences is not sufficient. It is also necessary to adopt the model of reflexivity as developed by Soros (2013). Reflexivity can occur only when there is a subjective aspect (i.e., observation and interpretation). Hence, “reflexivity serves as a criterion of demarcation between social and natural phenomena” (ibid: 313). This does not mean that second-order science and paying attention to the observer are not important for the natural sciences as well. However, the effect on the social sciences will be greater than the effect on the natural sciences.

«16» **Notturmo** (§§3–5) claims that philosophers of science are aware that the characteristics of observers may affect their observations and that theories of social systems can alter those systems. However, most practicing scientists operate on the assumptions that objective science requires minimizing observer effects and that scientific theories, using physical science as an example, do not change the behavior of the systems described.

«17» Anthropology and sociology are probably the two fields most aware of the importance of the observer. **Mary Catherine Bateson** (§1) is certainly correct that second-order science has roots going back further than the work of von Foerster. Her parents, the anthropologists Gregory Bateson and Margaret Mead were a great influence on him, and all three worked together during the Macy Foundation conferences in the late 1940s and early 1950s. And **Eva Buchinger** (§§3–6) provides references to important sociological treatises that emphasized the interaction of the researcher with the system being studied.

« 18 » **Stewart** (§6) and **Notturmo** (§§6–8) suggest that second-order science could lead to third-order science. Such a progression is not needed. If first-order science entails making descriptions of one's experiences, second-order science entails reflecting on the process of making those descriptions – that is, the assumptions and theories one brought to the task. Reflection can involve examination of one's beliefs and doubts about those beliefs. What is important is to reflect on what one believes and why one believes it, on what one knows and how one knows it. Heinz von Foerster (1991) also claimed that a third-order cybernetics was not necessary, that nothing new would be added.

Methods and theories

« 19 » In my target article I was rather parsimonious with regard to suggesting a concrete set of methods and strategies, see, in particular, **Hornung's** criticism (§§1, 2, 9). Let me use this opportunity to amend my ideas based on the commentaries my article received.

« 20 » In §3 **Hornung** refers to methods of empirical research. When I used the term "methods" in Figure 2, I was referring to management methods, for example a method for leading a group of people through a planning exercise. This is a kind of research in that the members of the group learn what other members of the group think about problems and effective strategies, but it is action-oriented research rather than academic research. The purpose of the activity is to make the behavior of a group of people more effective, not to add to the academic literature, although occasionally academic papers may result as methods are improved.²

« 21 » **Hornung** (§4) anticipates that the development of methods suitable for second-order cybernetics, beyond the reach of first-order theories and methods, is a challenging task. Actually, many useful methods have already been developed and are being used in the field of management (see §17 in my target article). However, most management scholars are looking for theories (first-order science) and do not recognize man-

agement methods as a more suitable form of knowledge. That is the message underlying Figure 2.

« 22 » In the social sciences, a number of efforts have been made to include observers in what is observed. Ian Mitroff and Vaughn Blankenship (1972) proposed a methodology for a holistic experiment that required that any simulation should include human players, not just be a computer simulation, and required several different types of psychological observers to be involved. In the book *Beyond Method* edited by Gareth Morgan (1983), the authors provide brief biographical sketches and explain why they undertook their research. The purpose is to reveal the psychological, social, and political context of the research. The process improvement methods described in §12 above involve an on-going series of experiments in which the participants in a process improve the process.

« 23 » What is missing in the field of management methods is an overarching theory and a connection to the philosophical literature. Actually, a theory exists in the form of cybernetics, a general theory of control and communication. And a connection to philosophy is provided by second-order cybernetics. But so far this work has attracted little attention in schools of business. Two exceptions are the University of St. Gallen in Switzerland and the University of Hull in England. Reflexive thinking in economics has a home at the Institute for New Economic Thinking at Oxford University in England. Perhaps the ideal institute to serve as a home for second-order science would be the Horizons College described by John Warfield in 1996 in his *Wandwaver Solution*.³ The Horizons College would work on future-oriented, design-oriented problems. It would have its own faculty and would draw on faculty members from other parts of the university as their expertise is needed. The core curriculum would be systems science and cybernetics. So far the idea has not been implemented by any university, but perhaps one day it will be.

« 24 » I disagree with **Notturmo** (§§1, 3) when he claims that social science theories are applied in the same way that physical

science theories are applied. Physical science theories are applied in science and engineering by highly educated professionals. Social science theories are often adopted by political leaders in pursuit of their ambitions. As John Maynard Keynes pointed out, both politicians and the public frequently do not know the origin of the ideas they are advocating or supporting:

“The ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly understood. Indeed, the world is ruled by little else. Practical men, who believe themselves to be quite exempt from any intellectual influence, are usually the slaves of some defunct economist.” (Keynes 1936: chapter 24)

Furthermore, physical objects do not change their behavior when theories change. However, the elements of social systems act according to their beliefs and values, which can be changed by an appealing argument. In social systems, deliberate, skilled application of a theory is not required for a theory to have an effect.

« 25 » **Notturmo** (§9) maintains that a scientific theory is an attempt to explain how and why the world seems to work as it does. To that effort, second-order science adds explicit attention to human purposes and actions. The attempt to eliminate human bias also eliminates human purpose, which provides vital information for understanding a theory. Whereas philosophy of science uses primarily the method of rational criticism, second-order science can use the theories and methods of any scientific field – psychology, sociology, anthropology, political science, or neurobiology. That is, second-order science uses the results of investigations in many fields to illuminate the processes of learning and knowing.

« 26 » Contrary to **Notturmo's** (§12) claim that I reject the method of conjectures and refutations, I find this method extremely useful in stable environments. Rather, I question the assumption that we are searching for systematic general knowledge. I think we are trying to function effectively in achieving our purposes. In less stable environments, such as social systems, perceptions and actions sometimes change rapidly. In such environments, finding an appropri-

2| See <http://www.gwu.edu/~umpleby/ptp.html> for a list of publications on the technology of participation.

3| <http://www.gmu.edu/depts/t-iasis/wandwaver/wandw.htm>

ate model, such as reflexivity theory rather than equilibrium theory in economics, may be what we are looking for.

Second-order mathematics

« 27 » Jean Paul Van Bendegem (§1) claims that second-order science requires a second-order mathematics. Science and mathematics often advance together, and that has been the case with second-order science. For many years, self-reference, and the attendant paradox and inconsistency, was seen as an obstacle to creating a science of cognitive and social systems. As von Foerster (1971) shows, the problem was noticed and resolved by those working on cognition and computers.

« 28 » Also important has been the work of Vladimir Lefebvre (1977, 1982) on reflexive control. His work has been very influential in education and psychotherapy in Russia. His version of reflexivity theory was used at the highest political levels in the US and the USSR at the time of the break-up of the Soviet Union to improve mutual understanding and prevent the outbreak of war.

« 29 » In order to refer to itself and its perceived context, an observer or regulator must have a minimum variety (*sensu* Ashby). So assuming a reflexive view of a social system, in order to be successful in modeling the goals and strategies of other actors, when the other actors are also modeling the goals and strategies of other actors, a talent for useful abstraction (variety reduction) is required, assuming that all actors have approximately the same regulatory capability.

« 30 » Modeling the perceptions, beliefs, and strategies in a population of agents is something that is now being done within the field of complex adaptive systems (e.g.,

Riegler & Douven 2009). It can be expected that this will have implications for second-order science.

« 31 » In §5, Van Bendegem refers to the effort to focus on all aspects of mathematics practice. He lists some questions that are central to the approach. Since in my view human beings are purposeful systems, I would add the question: What is the purpose of creating mathematical theories – to be more confident of one's logic, to persuade others with rational arguments, to deduce interesting theorems, or all of these? The purpose of this question is to focus attention on the agency or purpose of the mathematician. This is a reflexive move that is quite compatible with second-order science and second-order mathematics.

Conclusion

« 32 » Today, many doctoral students and young faculty members spend their lives attempting to establish linear causal relationships at a high level of statistical significance. If we could change the way that social science research is done, we would have many more people working to improve society by developing improved methods for thinking, communicating, and acting.

« 33 » A first step in the right direction is to ask why scientists exclude the observer and the effects of theories on society (Hu §19). Probably they do this because they think that is the way to do science. Management scholars normally use a pragmatist epistemology, but they try to be scientific by using a realist epistemology. If they took seriously the management methods that they develop, they would be using a constructivist epistemology. Changing the perception that social scientists need to imitate the

physical sciences is part of the purpose of second-order science.

« 34 » The next step could be to ask how we can measure inclusion of the observer and consideration of the effects of theories on society (Hu §18). I would be satisfied with simply asking scientists to deal with these two factors and then discussing the success of their efforts. I am confident that useful methods would be devised.

« 35 » Furthermore, should we chose a bottom-up approach? Michael Lissack (§15) maintains that my approach is top-down and that a bottom-up approach would be helpful as well. He says that second-order science needs a foundation in the way people live their lives. He maintains that second-order science is enacted all the time. With this I agree. The purpose of discussing second-order science is to call attention to the context of scientific work and the purposes of scientists.

« 36 » Finally, second-order science will certainly have to, as David Rousseau states, “preserve the practical powers of current science” (§15) and “preserve the capabilities of the social and human sciences” (§16). I like his suggestion that second-order science is a step toward the unification of science. For me the purpose of second-order science is to expand our conception of science to enable scientists to deal more effectively with social systems and to remind physical and biological scientists of the social context within which they operate and that shapes them.

RECEIVED: 7 NOVEMBER 2014

ACCEPTED: 13 NOVEMBER 2014

Combined References

- Acemoglu D. & Robinson J. A. (2012)** Why nations fail: The origins of power, prosperity and poverty. Crown Publishers, New York.
- Ackoff R. L. (1981)** Creating the corporate future: Plan or be planned for. Wiley, New York.
- Ashby W. R. (1952)** Design for a brain: The origin of adaptive behavior. Chapman & Hall, New York.
- Ashby W. R. (1962)** Principles of the self-organizing system. In: Foerster H. von & Zopf G. W. Jr. (eds.) Principles of self-organization. Pergamon, New York.
- Barnosky A. D., Hadly E. A., Bascompte J., Berlow E. L., Brown J. H., Fortelius M., Getz W. M., Harte J., Hastings A., Marquet P. A., Martinez N. D., Mooers A., Roopnarine P., Vermeij G., Williams J. W., Gillespie R., Kitzes J., Marshall C., Matzke N., Mindell D. P., Revilla E. & Smith A. B. (2012)** Approaching a state shift in Earth's biosphere. *Nature* 486: 52–58.
- Bateson G. (1970)** Form, substance, and difference. *General Semantics Bulletin* 37: 221–245. Reprinted in: Bateson G., Steps to an ecology of mind. Ballantine, New York: 448–466.
- Bateson M. C. (2004)** Learning in layers. In: Bateson M. C., Willing to learn: Passages of personal discovery. Steerforth Press, Hanover NH: 250–262.
- Beer S. (1985)** Diagnosing the system for organizations. Wiley, New York.
- Beinhocker E. D. (2013)** Reflexivity, complexity, and the nature of social science. *Journal of Economic Methodology* 20(4): 330–342.
- Berger P. L. & Luckmann T. (1966)** The social construction of reality: A treatise in the sociology of knowledge. Doubleday, Garden City NY.
- Bertalanffy L. von (1976)** General system theory: Foundations, development, applications. Revised Edition. Braziller, New York.
- Bohr N. (1920)** Über die Serienspektren der Elemente. *Zeitschrift für Physik* 2(5): 423–478. English translation in: Bohr N. (1976) Collected works. Volume 3: The Correspondence Principle (1918–1923). Edited by L. Rosenfeld and J. Rud Nielsen. North-Holland, Amsterdam: 241–282.
- Boyd J. R. (1976)** Destruction and creation. US Army Command and General Staff College. Available at http://www.goalsys.com/books/documents/DESTRUCTION_AND_CREATION.pdf
- Brand S., Bateson G. & Mead M. (1976)** For God's sake, Margaret: Conversation with Gregory Bateson and Margaret Mead. *Co-Evolutionary Quarterly* 10: 32–44. Available at <http://www.oikos.org/forgod.htm>
- Chalmers D. J. (2010)** The character of consciousness. Oxford University Press, New York.
- Checkland P. (1999)** Systems thinking, systems practice. Wiley, New York.
- Clarke D. M. (2006)** Descartes: A biography. Cambridge University Press, Cambridge.
- Comte A. (1856)** A general view of positivism. London.
- Cooperrider D. L. & Whitney D. (2005)** Appreciative inquiry: A positive revolution in change. Berrett-Koehler, San Francisco, CA.
- de Beer E. S. (1950)** The earliest fellows of the Royal Society. *Notes and Records of the Royal Society of London* 7(2): 172–192.
- Debreu G. (1959)** Theory of value. Wiley, New York.
- Deming E. (1986)** Out of the crisis. MIT Press, Cambridge MA.
- Descartes R., Cottingham J., Stoothoff R. & Murdoch D. (1985)** The philosophical writings of Descartes. Volume 2. Cambridge: Cambridge University Press.
- Edge H. (2002)** Dualism and the self: A cross-cultural perspective. In: Steinkamp F. (ed.) Parapsychology, philosophy and the mind. McFarland, Jefferson NC: 33–56.
- Farias I. & Ossandon J. (eds.) (2006)** Observando sistemas. Nuevas apropiaciones y usos de la teoría de Niklas Luhmann. RiL editores, Fundación Soles, Santiago de Chile.
- Faye J. (2014)** Explanation revisited. In: Lissack M. & Graber A. (2014) Modes of explanation: Affordances for action and prediction. Palgrave Macmillan, New York: 233–240.
- Ferreiros J. & Gray J. (eds.) (2006)** Architecture of modern mathematics. Essays in history and philosophy. Oxford University Press, Oxford.
- Fischer M. & Marcus G. (1999)** Anthropology as cultural critique: An experimental moment in the human sciences. Second edition. University of Chicago Press, Chicago IL.
- Foerster H. von (1971)** Computing in the semantic domain. *Annals of the New York Academy of Sciences* 184: 239–241.
- Foerster H. von (1974)** Notes on an epistemology for living things. In: Morin E. & Piattelli-Palmerini M. (eds.) L'unité de l'homme: Invariants biologiques et universaux culturels. Editions du Seuil, Paris. Reprinted in: Foerster H. von (1981) Observing Systems. Inter-systems Publications, Seaside CA: 258–265.
- Foerster H. von (1991)** Ethics and second-order cybernetics. In: Ray Y. & Prieur B. (eds.) Système, éthique, perspectives en thérapie familiale. ESF éditeur, Paris: 41–55. Republished in: Foerster H. von (2003) Understanding Understanding: Essays on Cybernetics and Cognition. Springer, New York: 287–304.
- Foerster H. von (2003)** Understanding understanding: Essays on cybernetics and cognition. Springer, New York.
- Freeman R. E., Harrison J. S., Wicks A. C., Parmar B. L. & de Colle S. (2010)** Stakeholder theory: The state of the art. Cambridge University Press, Cambridge.
- Gillett C. & Loewer B. (eds.) (2001)** Physicalism and its discontents. Cambridge University Press, New York.
- Glaser B. G. & Strauss A. L. (1967)** The discovery of grounded theory: Strategies for qualitative research. Transaction Publishers, New Brunswick.
- Glaserfeld E. von (1995)** Radical Constructivism: A way of knowing and learning. Falmer Press, London.
- Goetz S. & Taliaferro C. (2008)** Naturalism. Eerdmans, Cambridge UK.
- Greenblatt S. (2011)** The swerve: How the world became modern. Norton, New York.
- Greenwald B. C. & Stiglitz J. (1990)** Asymmetric information and the new theory of the firm: Financial constraints and risk behavior. National Bureau of Economic Research, Cambridge MA.
- Guenther G. (1967)** Time, timeless logic and self-referential systems. *Annals of the New York Academy of Sciences* 138: 396–406.
- Hornung B. R. (1988)** Grundlagen einer problemfunktionalistischen Systemtheorie gesellschaftlicher Entwicklung, Sozialwissenschaftliche Theoriekonstruktion mit qualitativen, computergestützten Verfahren. Peter Lang, Bern.
- Hornung B. R. (2006a)** El paradigma sociocibernético, Conceptos para la investigación de sistemas sociales complejos. In: Marcuello Servós C. (ed.) Sociocibernética, Lineamientos de un paradigma. Institución "Fernando el Católico" (CSIC), Zaragoza: 41–79.
- Hornung B. R. (2006b)** From cultural relativism to the unity of science by means of epistemological constructivism. In: Marcuello C.

- & Fandos J. L. (eds.) Sociological essays for a global society. Prensas Universitarias de Zaragoza, Zaragoza: 81–120.
- Hutto D. & Myin E. (2012) Radicalizing enactivism: Basic minds without content. MIT Press, Cambridge MA.
- Jahoda M., Lazarsfeld P. F. & Zeisl H. (2002) Marienthal: The sociography of an unemployed community. Transaction Publishers, New Brunswick. German original published in 1933.
- Kahneman D. (1973) Attention and effort. Prentice-Hall, Englewood Cliffs NJ.
- Kaletsky A. (2011) Capitalism 4.0: The birth of a new economy in the aftermath of crisis. Public Affairs, New York.
- Keynes J. M. (1936) The general theory of employment, interest, and money. Harcourt, Brace & World, New York.
- Kjellman A. (2002) The subject-oriented approach to knowledge and the role of human consciousness. *International Review of Sociology – Revue Internationale de Sociologie* 12(2): 223–247.
- Kjellman A. (2006) The crisis of contemporary science. *Kybernetes* 35(3/4): 497–521.
- Koons R. C. & Bealer G. (eds.) (2010) The waning of materialism. Oxford University Press, Oxford.
- Krajewski W. (1977) Correspondence principle and growth of science. Reidel, Boston.
- Kuhn T. S. (1962) The structure of scientific revolutions. University of Chicago Press, Chicago.
- Lakatos I. (1976) Proofs and refutations. The logic of mathematical discovery. Cambridge University Press, Cambridge.
- Landsberger H. A. (1958) Hawthorne revisited. Cornell University Press, Ithaca NY.
- Lefebvre V. A. (1977) The structure of awareness: Toward a symbolic language of human reflexion. Sage Publications, Beverly Hills CA.
- Lefebvre V. A. (1982) Algebra of conscience: A comparative analysis of Western and Soviet ethical systems. Reidel, Boston MA.
- Lissack M. & Graber A. (2014) Modes of explanation: Affordances for action and prediction. Palgrave Macmillan, New York.
- Loefgren L. (1962) Kinematic and tessellation models of self-repair. In: Bernard E. E. & Kare M. R. (eds.) Biological prototypes and synthetic systems. Plenum Press, New York: 342–369.
- Loefgren L. (1968) An axiomatic explanation of complete self-reproduction. *Bulletin of Mathematical Biophysics* 30: 415–425.
- Luhmann N. (1987) Soziale Systeme. Grundriß einer allgemeinen Theorie. Suhrkamp Verlag, Frankfurt am Main. English translation: Luhmann N. (1995) Social systems. Stanford University Press, Stanford CA.
- Luhmann N. (1989) Ecological communication. University of Chicago Press, Chicago. German original published in 1986.
- Luhmann N. (1990). The autopoiesis of social systems. In: Luhmann N., Essays on self-reference. Columbia University Press, New York: 1–20.
- Luhmann N. (1993) Deconstruction as second-order observing. *New Literary History* 24: 763–782.
- Mancosu P. (ed.) (2008) The philosophy of mathematical practice. Oxford University Press, Oxford.
- Mannheim K. (1960) Ideology and utopia: An introduction to the sociology of knowledge. Routledge and Kegan Paul, London.
- Marx K. (2002) Theses on Feuerbach. Translated by Cyril Smith. Originally written in 1845. Available at <http://www.marxists.org/archive/marx/works/1845/theses/theses.htm>
- Maturana H. R. & Varela F. J. (1980) Autopoiesis and cognition. Reidel, Dordrecht.
- McCloskey D. N. (1985) The rhetoric of economics. University of Wisconsin Press, Madison WI.
- McIntyre L. (2014) The scientific attitude toward explanation. In: Lissack M. & Graber A. (2014) Modes of explanation: Affordances for action and prediction. Palgrave Macmillan, New York: 229–232.
- McSherry W., Cash K. & Ross L. (2004) Meaning of spirituality: Implications for nursing practice. *Journal of Clinical Nursing* 13(8): 934–941.
- Medvedeva T. A. & Umpleby S. A. (2004) Four methods for describing systems with examples of how management is changing in the U.S. and Russia. In: Trappl R. (ed.) Cybernetics and Systems '04. Austrian Society for Cybernetic Studies, Vienna: 375–379.
- Mitroff I. & Blankenship V. (1973) On the methodology of the holistic experiment: an approach to the conceptualization of large-scale social experiments. *Technological Forecasting and Social Change* 4: 339–353.
- Moore G. E. (1965) Cramming more components onto integrated circuits. *Electronics* 38(8): 114–117
- Morgan G. (ed.) (1983) Beyond method: Strategies for social research, Sage Publications, Beverly Hills CA.
- Myers G. (1990) Writing biology: Texts in the social construction of scientific knowledge. University of Wisconsin Press, Madison WI.
- Müller K. H. (1998) The epigenetic research program: A transdisciplinary approach to the dynamics of knowledge, society and beyond. Sociological Series No. 24. Institute for Advanced Studies, Vienna.
- Müller K. H. (2011) The new science of cybernetics: The evolution of living research designs. Volume II: Theory. Edition Echoraum, Vienna: 277–316.
- Müller K. H. & Riegler A. (2014) A new course of action. *Constructivist Foundations* 10(1): 1–6. Available at <http://www.univie.ac.at/constructivism/journal/10/1/001.editorial>
- Neumann J. von (1951) The general and logical theory of automata. In: Jeffress L. A. (ed.) Cerebral mechanisms in behavior: The Hixon Symposium. Wiley, New York: 1–31.
- Neumann J. von (1966) Theory of self-reproducing automata. Edited and completed by A. W. Burks. University of Illinois Press, Urbana IL.
- Nordenfelt L. & Edgar A. (2005) The four notions of dignity. *Quality in Ageing and Older Adults* 6(1): 17–21.
- Piaget J. (1930) The child's conception of physical causality. Kegan Paul, London. French original: Piaget J. (1927) La causalité physique chez l'enfant. F. Alcan, Paris.
- Pias C. (2003) Cybernetics: The Macy conferences 1946–1953. Diaphanes, Zurich.
- Popper K. R. (1957) The poverty of historicism. Beacon Press, Boston.
- Popper K. R. (1967) Quantum mechanics without “the observer.” In: Bunge M. (ed.) Quantum theory and reality. Springer, Berlin: 7–44.
- Popper K. R. (1972) Objective knowledge: An evolutionary approach. Clarendon Press, Boston.
- Popper K. R. (1989) Conjectures and refutations: The growth of scientific knowledge. Fifth edition. Routledge, New York. Originally published in 1963.
- Riegler A. (2001) Towards a radical constructivist understanding of science. *Foundations*

- of Science 6(1–3): 1–30. Available at <http://www.univie.ac.at/constructivism/riegler/20>
- Riegler A. & Douven I. (2009)** Extending the Hegselmann–Krause model III: From single beliefs to complex belief states. *Episteme* 6(2): 145–163. Available at <http://www.univie.ac.at/constructivism/riegler/56>
- Rousseau D. (2014a)** Foundations and a framework for future waves of systemic inquiry. In: *Proceedings of the 22nd European Meeting on Cybernetics and Systems Research (EMCSR 2014)*. BCSSS, Vienna: 428–434.
- Rousseau D. (2014b)** Reconciling spirituality with the naturalistic sciences: A systems-philosophical perspective. *Journal for the Study of Spirituality* 4(2): 174–189.
- Rousseau D. & Wilby J. M. (2014)** Moving from disciplinarity to transdisciplinarity in the service of thrivable systems. *Systems Research and Behavioral Science* 31(5): 666–677.
- Schlick M. (1925)** *Allgemeine Erkenntnislehre*. Second edition. Springer, Berlin. Originally published in 1918.
- Schon D. (1995)** *The reflective practitioner: How professionals think in action*. Arena, Aldershot UK.
- Searle J. R. (1995)** *The construction of social reality*. Allen Lane, London.
- Shneiderman B. (2008)** Science 2.0. *Science* 319(5868): 1349–1350.
- Simon H. A. (1957)** *Administrative behavior: A study of decision-making processes in administrative organization*. Macmillan, New York.
- Soros G. (1987)** *The alchemy of finance: Reading the mind of the market*. Simon and Schuster, New York.
- Soros G. (1988)** *The alchemy of finance*. Simon & Schuster, New York.
- Soros G. (2013)** Fallibility, reflexivity, and the human uncertainty principle. *Journal of Economic Methodology* 20(4): 309–329.
- Sterner B. (2014)** Explanation and pluralism. In: Lissack M. & Graber A. (2014) *Modes of explanation: Affordances for action and prediction*. Palgrave Macmillan, New York: 249–256
- Strawson G. (2006)** Panpsychism? Reply to commentators with a celebration of Descartes. Special issue on realistic monism. *Journal of Consciousness Studies* 13(10–11): 184–280.
- Umpleby S. A. (1990)** Strategies for regulating the global economy. *Cybernetics and Systems* 21: 99–108. Originally published in 1989.
- Umpleby S. A. (1997)** Cybernetics of conceptual systems. *Cybernetics and Systems* 28(8): 635–652.
- Umpleby S. A. (2002)** Should knowledge of management be organized as theories or as methods? *Janus Head. Journal of Interdisciplinary Studies in Literature, Continental Philosophy, Phenomenological Psychology, and the Arts* 5(1): 181–195.
- Umpleby S. A. (2011)** Second-order economics as an example of second-order cybernetics. *Cybernetics and Human Knowing*. 18(3–4): 173–176.
- Umpleby S. A., Anbari F. T. & Müller K. H. (2007)** Highly innovative research teams: The case of BCL. In: Müller A. & Müller K. H. (eds.) *An unfinished revolution? Heinz von Foerster and the Biological Computer Laboratory*. Echoraum, Vienna: 181–202.
- Umpleby S. A. & Oyler A. (2007)** A global strategy for human development: The work of the Institute of Cultural Affairs. *Systems Research and Behavioral Science* 24: 645–653.
- Umpleby S. A. & Rakicevik G. (2008)** Adopting service learning in universities around the world. *Journal of the World Universities Forum* 1(2): 39–48.
- Van Bendegem J. P. (2014)** The impact of the philosophy of mathematical practice on the philosophy of mathematics. In: Léna S., Zwart S., Lynch M. & Vincent Israel-Jost V. (eds.) *Science after the practice turn in the philosophy, History, and social studies of science*. Routledge, London: 215–226.
- Van Kerkhove B. & Van Bendegem J. P. (eds.) (2007)** *Perspectives on mathematical practices: Bringing together philosophy of mathematics, sociology of mathematics, and mathematics education*. Springer, Dordrecht.
- Vygotsky L. (1997)** *Educational psychology*. St. Lucie Press, Delray Beach FL. Originally published in 1926.
- Wallis S. (2014)** Evaluating explanations through their conceptual structures. In: Lissack M. & Graber A. (2014) *Modes of explanation: Affordances for action and prediction*. Palgrave Macmillan, New York: 197–202.
- Walras L. (1954)** *Elements of pure economics*. Allen and Unwin, London. Originally published in 1877.
- Whyte W. F. (1993)** *Street corner society: The social structure of an Italian slum*. University of Chicago Press, Chicago. Originally published in 1943.
- Wiener N. (1948)** *Cybernetics, or control and communication in the animal and the machine*. John Wiley, New York.
- Wilby J. M., Rousseau D., Midgley G., Drack M., Rousseau J. & Zimmermann R. (2015)** Philosophical foundations for the modern systems movement. In: *Proceedings of the 17th Conversation of the International Federation for Systems Research*, St. Magdalena, Linz, Austria, 27 April–2 May 2014, in press.
- Young R. M. (1977)** Science is social relations. *Radical Science Journal* 5: 65–129. Available at <http://human-nature.com/rmyoung/papers/sisr1.html>