Second-order Science: Logic, Strategies, Methods

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> Context • Philosophy of science is the branch of philosophy that deals with methods, foundations, and implications of science. It is a theory of how to create scientific knowledge. Presently, there is widespread agreement on how to do science, namely conjectures, ideally in the form of a mathematical model, and refutations, testing the model using empirical evidence. **> Problem** • Many social scientists are using a conception of science created for the physical sciences. Expanding philosophy of science so that it more successfully encompasses social systems would create new avenues of inquiry. Two dimensions could be added to philosophy of science: the amount of attention paid to the observer and the amount of impact of a theory on the system described. **> Method** • My approach is to illuminate underlying assumptions. I claim that there are at least three epistemologies and that they can be combined to form a more robust conception of knowledge and of how to do research. There are at least four models and four basic elements (i.e., ideas, groups, events, variables) being used by (social) scientists. **> Results** • The article identifies the logical propositions underlying second-order science. It suggests strategies for developing second-order science. And it describes several methods that can be used to practice second-order science, including how past theories have not only described but also changed the phenomenon being studied. **> Implications** • The task for members of the scientific community, particularly social scientists, is to practice second-order science and to develop further its theories and methods. A practical implication is to accept methods for acting as well as theories as a contribution to science, since methods explicitly define the role of an observer/ participant. **> Constructivist content** • The paper is an extension of the work of Heinz von Foerster and other second-order cyberneticians. **> Key words** • **Philosophy of science, epistemology, models, descriptions, cybernetics.**

Introduction

« 1 » We have come a long way since the 1600s in England, when Robert Boyle organized a luncheon group called the "Invisible College." The group eventually became the Royal Society for the Advancement of Natural Knowledge, now called the Royal Society (de Beer 1950). The founding of the Royal Society is one sign of the transition from theological knowledge to natural or scientific knowledge. Since then, natural knowledge (i.e., science) has contributed enormously to our physical quality of life.

« 2 » We are now in a transition to a new kind of knowledge. It could be called reflexive knowledge or a greater self-awareness as a result of cognitive science and an awareness of our impact on our social and biological environment. In this paper, I start with a review of the conceptual foundations of second-order science and relate it to three epistemologies that sometimes vie for influence. Next, I point to the ways in which science is changing. In particular, I emphasize that over time science has used four different models as explanatory vehicles to describe social processes. And I note four basic elements used by different disciplines. Subsequently, I present the main motivation for introducing second-order science, based on the argument that social systems, which are composed of thinking participants (including scientists), are different from physical systems, which consist of inanimate objects. In order for philosophy of science to serve as a guide for creating knowledge of social systems, two dimensions should be added, i.e., the amount of attention paid to the observer and the effect of a theory, once adopted, on the system observed. These dimensions can be added in accordance with the correspondence principle, a rule for describing one way that science grows. I conclude with a description of the logic, strategies, and methods of second-order science.

Conceptual foundations of second-order science

« 3 » The idea of second-order science grew out of the idea of second-order cybernetics. The basic idea of second-order cybernetics is that science should be expanded by adding the observer to what is observed (Foerster 1974). This intention may seem to contradict a key assumption about science, namely that the purpose of science is to create objective descriptions. The observer can be excluded because, if an experiment is conducted properly, any observer will see the same things. However, if we include the observer in what is observed, we can shift our thinking from viewing science as creating descriptions of systems to viewing science as an active part of social systems. We would then think about the co-evolution of theories and societies.

« 4 » Figure 1 illustrates several subjects of research in the history of cybernetics in the past 50 years. Karl Popper (1972) spoke about Worlds 1, 2, and 3. World 1 refers to the "mind independent world," World 2 to mental events, and World 3 to the descriptions that are found in books and libraries. Assume for a moment that the triangle depicts three epistemologies. According to the triangle, there are three ways of thinking about knowledge. The mostly widely used one is on the left side. That is, scientists are supposed to create descriptions of the world and then test them with experiments and observations. Ideally, the descriptions are accurate and statistically valid. A theory should be a "picture" of the mind-independent world. In this realist epistemology, when we are talking about descriptions of the world, we explicitly exclude the observer. The observer is not part of what we are studying. We are only studying the mind-independent world and creating a description of it.

« 5 » But if one becomes interested in cognition and how the brain works, then attention shifts to the observer and how an observer creates descriptions. When the focus shifts to the observer and descriptions, there is a tendency to de-emphasize the world. After all, the world is present in the conceptions in our minds. Realists concede that although we perceive the world through our senses, our senses can be unreliable. People sometimes see mirages. And other animals live in different sensory worlds. Dogs smell and hear better than humans, and insects see infrared light. In this second epistemology, depicted by the base of the triangle, the emphasis is on how an observer creates descriptions. In this constructivist epistemology, no attention is given to a mind-independent reality.

« 6 » The third epistemology emphasizes the observer and the world. The key question is how a person should act in the world in order to achieve his or her purposes. In this pragmatist epistemology, knowledge is evaluated by its practical utility. Theories are of interest only if they contribute to effective action. Knowledge tends to be embodied in methods – do A, then B, then C. Practically oriented people have little interest in theories or philosophies. They simply want to know how to act effectively in the world. Once again, one corner of the triangle is deemphasized, in this case descriptions or theories.

« 7 » Second-order science is the idea that we should use all three epistemologies, since second-order science values multiple perspectives. Rather than defining science as the left side of the triangle, let us expand science to include the observer, as Heinz von Foerster (1974) suggested. We could then make greater use of what we have learned from cognitive science and from practical affairs.

« 8 » In addition to including the observer in science, we could also acknowledge that theories (at least in the social sciences) affect what is studied. We are aware that theories affect society. Indeed, that is why we create social science theories. We hope that they will be accepted and acted upon, and the social system will perhaps operate better. But when we are acting as scientists, we tend not to think that way. We assume that our descriptions have no effect upon the phenomenon. When we seek to influence social systems, we try to formulate persuasive arguments. But when we do social science research, we assume that theories have no effect on society. We think and act in this divided way because we are trying to create objective descriptions rather than describing our perceptions.

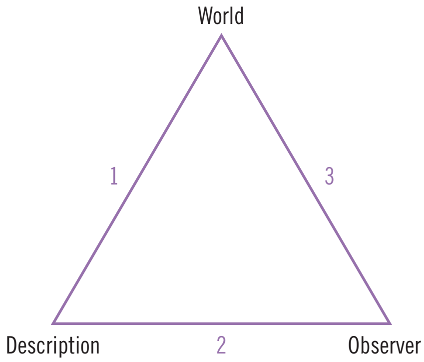


Figure 1 • Popper's three worlds and three epistemologies.

Three conceptions of how science is changing

« 9 » Recently, several people have described how science is changing. In an article in *Science* called "Science 2," Ben Shneiderman (2008) points out that, with the internet, scientists can share their data and their preliminary ideas. They can access other people's data and engage in conversations with colleagues far away. They can conduct experiments that can be replicated in many locations quickly. This is certainly an important trend in science. The internet creates opportunities.

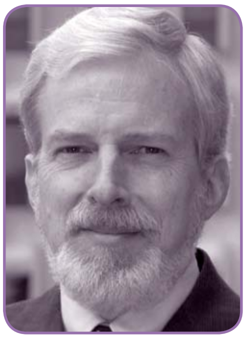
« 10 » Karl Müller (2011) has proposed the idea of "meta-science," or research on research. He created this point of view as a result of operating a social science data archive. He stored and made available the social science data that people sent to him. He not only collected it, he tried to make sense of it. Müller has been developing methods for combining the results of studies that used different research methods. The goal is to formulate more general knowledge that is supported by a large number of studies. And he has designed a doctoral program to teach people how to do this kind of second-order science.

« 11 » What I am suggesting is a third conception, where the intent is to take account of the observer and examine the co-evolution of theories and phenomena, particularly in the social sciences.

Four models used in science

« 12 » To understand how science is changing, it is helpful to reflect on different types of models that are used in science. The first type of model describes *linear causal* relationships. How does variable A affect variable B, perhaps with an intervening variable C? There are many statistical methods that are available to help us establish relationships among variables, ideally cause and effect relationships. Finding these relationships is what many scientists spend their lives doing. It is certainly what many doctoral students do.

« 13 » The second type of model describes *circular causal* relationships. Circular causality is essential in a regulatory process. For example, if you are driving a car, managing a firm, or managing a household, you are engaged in a circular causal process where you observe, make a decision, act, observe, make a decision, and so on. Circular causal



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processes in social systems can be modeled with causal influence diagrams and system dynamics models.

« 14 » The third type of model is now described as *self-organization,* i.e., "any isolated, determinate, dynamic system obeying unchanging laws will develop organisms adapted to their environments" (Ashby 1962). The concept of self-organization has been important in the history of science because it explains emergence, e.g., new species or new institutions. It is the model that was used by Adam Smith when he described a society as composed of firms competing with each other and nations that compete with each other. This was also the model used by Charles Darwin when he said that organisms and species compete within an environment. A self-organizing system is a system with elements that interact within that system (ibid). Depending on the interaction rules, the elements of the system go toward a particular equilibrium. In the case of social systems, the interaction rules can be changed by changing laws, regulations, or incentive systems. For example, if society does not want businesses polluting the environment, the legislature can pass a law against it, with the result that there is less pollution. As a second example, an incentive system for sales personnel is intended to increase sales efforts. By changing the interaction rules, the system goes toward a different equilibrial state.

« 15 » The fourth type of model is *reflexivity*. There are various conceptions of reflexivity (Lefebvre 1977, 1982; Soros 1987, 2013; Beinhocker 2013) but all of them have three characteristics. The first characteristic is that there is a circular process. The second is that an observer is included. The third is that a reflexive system operates on two levels. Each person or organization in a social system both observes and participates. John Boyd (1976) calls this an "Observe, Orient, Decide, Act" (OODA) loop. Second-order science uses the model of reflexivity but it goes beyond saying that the elements of social systems both observe and act. Second-order science claims that scientists also observe and act. They do not stand outside the system observed.

Examples from three fields

« 16 » How would social science change if the perspective of second-order science were adopted? Let us consider three fields – management, sociology, and economics.

Management

« 17 » In the field of management, including the observer is not new. The phenomenon of management is a recursive process of observing, deciding, and acting. However, for most US management scholars, research involves finding linear relationships among variables, ideally at a high level of statistical significance, thus a long way from the reflexivity of second-order science. Nevertheless, within the field of management, there are many methods: for example, how to improve a manufacturing process, how to create a business plan, and how to conduct a strategic planning exercise. There is a large literature on how to act using management methods (Ackoff 1981; Beer 1985; Checkland 1999; Deming 1986). Some of the most influential management literature has been created by consultants. Often their contributions take the form of methods. Consultants do not limit themselves to the point of view of a particular academic discipline. Practicing managers may find the academic management literature to be of little help, since genuine management problems are multi-disciplinary and do not fit within a single discipline.

« 18 » For several years, I taught philosophy of science to doctoral students in the School of Business at The George Washington University. Those familiar with the literature in philosophy of science know that most of the examples are from physics. In class, there were many discussions about how physical systems are different from social systems. Does it matter that social systems are composed of thinking participants who sometimes change their behavior? Can the same methods be used for the physical and the social sciences? The class was usually divided, with students in finance saying that the same methods could be used and students in organizational behavior saying that changes were needed. In his doctrine of the unity of method, Popper (1957) claims that the method of conjectures and refutations works in the social sciences as well as in the physical sciences. That is, formulate a hypothesis and then attempt to refute it. However, the elements physicists deal with are inanimate objects. The elements social scientists deal with are thinking participants (see Figure 2). If one feels it is important to take that difference into account, a second question arises: Should we disregard philosophy of science? Faculty members in organizational behavior and public administration often maintain that philosophy of science does not work for social systems (Umpleby 2002). Some people consider science to be a particular style of rhetoric (McCloskey 1985; Myers 1990). They argue that science is a way of persuading other scientists. Some philosophers emphasized that science is a search for reliable knowledge about the world (Comte 1856; Schlick 1925; Popper 1989). I claim that philosophy of science can and should be expanded so that it can encompass behavior in social systems. If we do that, then we can ask: Should knowledge be organized as theories or as methods (Umpleby 2002)? The practice of management requires a large amount of procedural knowledge: If you want a particular result, do this. Baking a cake or writing a business plan or conducting a planning activity are similar in that one follows a well-defined procedure. Management and other professions, such as law and medicine, emphasize procedural knowledge because practitioners both observe and participate. So if second-order science is accepted, management scholars may spend less time trying to find reliable linear causal relationships and more time developing and improving methods to guide actions in organizations.

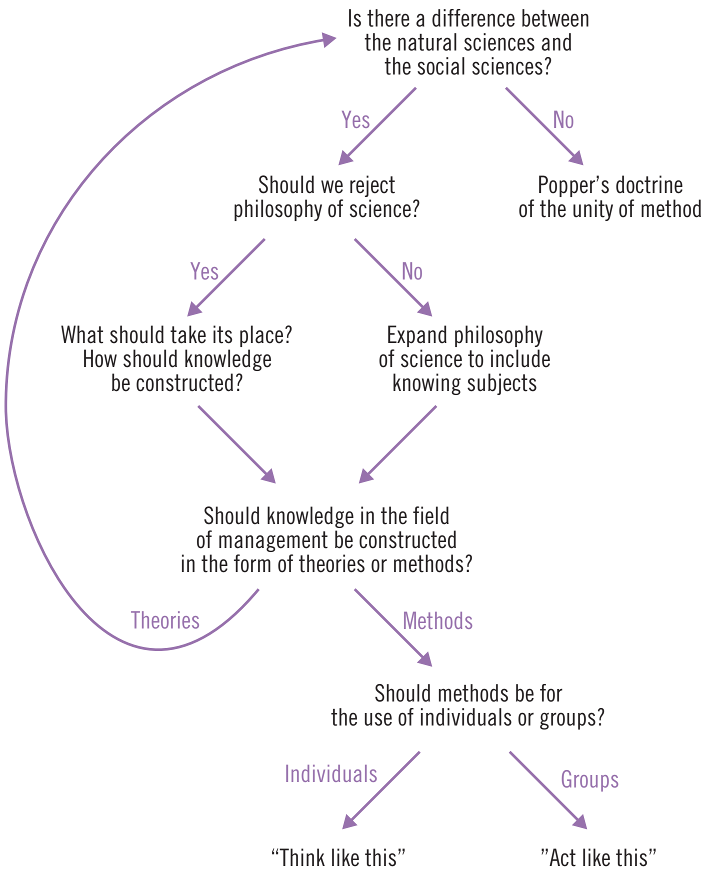

Figure 2 • Questions to guide the construction of knowledge of management.

Sociology

« 19 » The sociology of knowledge is an idea that goes back to the 1800s. People usually adopt the views of their reference group, whether defined by profession, religion or nationality. Hence, there is an interaction between one's circumstances and one's opinions. What one thinks about society is influenced by one's position in society (Mannheim 1960). When I encountered the idea of the sociology of knowledge as an undergraduate, I thought it should be not just part of sociology but part of the foundation of science. Thomas Kuhn's 1962 book, *The Structure of Scientific Revolutions*, helped to introduce the sociology of knowledge to the scientific community as a whole. Second-order science is another way of calling attention to both the context and the purpose of scientific activity. Science, like other forms of knowledge, is not separate from society. It plays a role in creating society.

« 20 » In the field of sociology, knowledge is not just the product of an investigation but also part of what is investigated. The roles that people hold shape their opinions. Sociology is probably the field whose perspective is closest to second-order science. Sociology, along with literary criticism, is a form of critical theory that regards ideologies as the principal obstacle to human liberation. A particular conception of science, like a particular conception of religion, shapes both world view and behavior. An overly limited conception of science (i.e., one that excludes the observer and the effects of theories on society) limits investigation and constrains how science can contribute to the improvement of society.

Economics

« 21 » Economics is the social science that has been the most successful at imitating physical science. Quantification is easier in economics due to prices and other measurable variables. Contemporary economics is defined primarily by its method, mathematical modeling, rather than its subject matter, economic activity. The predominant model in economics is equilibrium theory (Walras 1954; Debreu 1959), which is an example of self-organization. In the early days of physics, people dealt with planets, billiard balls, and pendula – systems with a small number of elements. Later, physicists developed an interest in gases and thermodynamics. In a gas, there are a very large number of particles. Using the earlier method of describing a few particles was unworkable. So physicists chose to look at gross parameters, such as pressure, volume, and temperature. For an economy, the gas model seemed to be a good choice as well: the particles would be people and institutions, and the gross parameters would be imports, exports, GDP per capita, savings, etc. The model is a self-organizing system, as described earlier. If an economic system is disturbed, for example by legislation or a new technology, the actors within the system act according to their rational self-interest and come to a new equilibrium. In order for the model to work, people need to behave in a similar manner or the differences in behavior need to cancel out. This conception of society is based on a number of assumptions. Economists

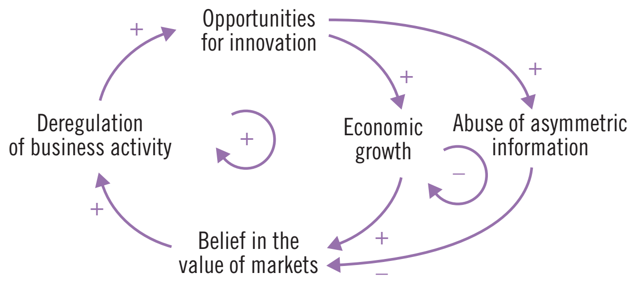

Figure 3 • The influence cycle causes swings between pro-market and pro-government positions.

have assumed that people seek to maximize their personal profit, that they are rational, that everyone has the same information, and that they all have complete information. In recent years, behavioral economics has been challenging these assumptions. Several Nobel Prize winners, such as Herbert Simon (1957), Daniel Kahneman (1973), and Joseph Stiglitz (Greenwald & Stiglitz 1990), have successfully argued against one or more of these assumptions.

« 22 » One way that economics is different from physics lies in how knowledge progresses. In physics, new ideas build on older ideas and some ideas, like the ether, are discarded. In economics, there tend to be swings between left and right political positions. In his book *Capitalism 4.0* Anatole Kaletsky (2011) notes that there was a laissez faire approach to macroeconomics following the stock market crash in 1929. Then, in 1936, John Maynard Keynes published his general theory, which justified government deficit spending during an economic downturn in order to provide demand and stimulate economic growth. Later, there was a return to free market economics, led by Friedrick Hayek and Milton Friedman theoretically and Margaret Thatcher and Ronald Reagan politically. *Capitalism 4.0* marks a return to the belief that some regulation is necessary. There is no theory in economics that resolves these two points of view. Rather, the two points of view guide the actions of political groups and the resolution occurs in the political process. There are swings between left and right. Society never returns exactly to earlier theories or to earlier legal regimes, because the economy and institutions are always changing. There is no linear progression of steady improvement in explanations. Just as there are left and right swings in politics, there are swings between pro-government and pro-market points of view in economics. Economic theories become part of governmental processes, which act to regulate growth and distribution within society.

« 23 » Surprisingly, the history of economic thought is no longer taught in many US universities.[1] There is a belief among economists that earlier theories were inferior (i.e., qualitative rather than quantitative) and that there are so many new results there is no room in the curriculum for earlier ideas. But if earlier ideas are eliminated, students do not develop a sense of how the field has evolved. One solution would be to have a second-order theory, a theory that explains the swings between pro-market and pro-government positions. Such a theory would describe a control system or a regulatory process. First-order economic theories (i.e., our current economic theories) would be used in the regulatory process.

Expanding philosophy of science

« 24 » In addition to the assumptions challenged by behavioral economics, there are deeper assumptions about science and how we construct scientific theories (Umpleby 2011). These assumptions include the belief that the observer should not be included in what is observed and the belief that theories do not affect what is observed. These assumptions would change if second-order science is accepted.

« 25 » If we were to decide that it is time for second-order science, for example second-order economics, how would we make the transition? Scientists need methods. They need tools to work with. A carpenter has a saw and a hammer and nails. Scientists have laboratory experiments, statistical methods, computer simulations, microscopes, and telescopes. How would scientists practice second-order science? As Kaletsky suggested, in economics there is an influence cycle. One can model cycles in economics, such as credit cycles, with positive and negative feedback loops. In the influence cycle (see Figure 3), if the party in power wants to emphasize markets, then the government could deregulate business activity or the party in power may choose not to enforce the rules that are on the books. In a democracy, the people have a chance to influence the amount of government regulation.

« 26 » Figure 4 shows what George Soros (1987) calls a "shoelace model." It depicts the interaction between ideas and society (Umpleby 1990). On the left side are listed Adam Smith, Karl Marx, John Maynard Keynes, and Milton Friedman. In each case, when the ideas are accepted and acted upon, society changes – the growth of industry, the rise of labor unions, and larger government. New ideas lead to new social structures, and new social problems lead to new ideas. There is a co-evolution of theories and social systems.

Four basic elements for describing systems

« 27 » Another way of thinking about second-order science is to look at the basic elements of systems. If one studies systems in several fields, eventually one realizes that the various disciplines describe systems differently. That is, the basic elements are different. The most popular elements, the most admired basic elements of a system, are *variables*, as in economics or in physics – entities that can be measured and quantified. But not all fields can easily find

1| "Economics students need to be taught more than neoclassical theory," by Zach Ward-Perkins and Joe Earle in The Guardian, 28 October 2013. Available at: http://www.theguardian.com/commentisfree/2013/oct/28/economics-students-neoclassical-theory measurable variables. In psychology or anthropology, the *ideas* in people's minds are important. In sociology and political science, *groups* and coalitions are important. Historians and legal scholars emphasize *events* such as inventions or new legislation or court decisions. We can arrange these basic elements in a circle – ideas, groups, events, variables (see Figure 5) (Umpleby 1997; Medvedeva & Umpleby 2004). We then have a theory of social change. This depiction is a special case of Müller's (1998) epigenetic research program (Figure 6). An epigenetic view of life and society places science within the system observed, not outside. The genotype can be a pattern, a theory, a blueprint or a gene. The phenotype is an organism, an organization or a species. Müller proposed a general theory of evolution that encompasses both biological and social systems. An organism with new features either survives or it does not. If it does, then there is a new pattern, usually a small change from the old pattern. In the case of social systems, one can identify ideas, groups, events, and variables. When social scientists study social systems, they analyze what is happening (variables) and propose a new course of action (ideas). If the idea is adopted (groups), a new product may be invented or a bill may be passed in the legislature (event). Then the consequences are studied and a new idea is proposed. This is a multidisciplinary approach to understanding change in social systems. It provides a richer, more comprehensive description of a social system than any single discipline because it uses the modes of thinking in several disciplines.

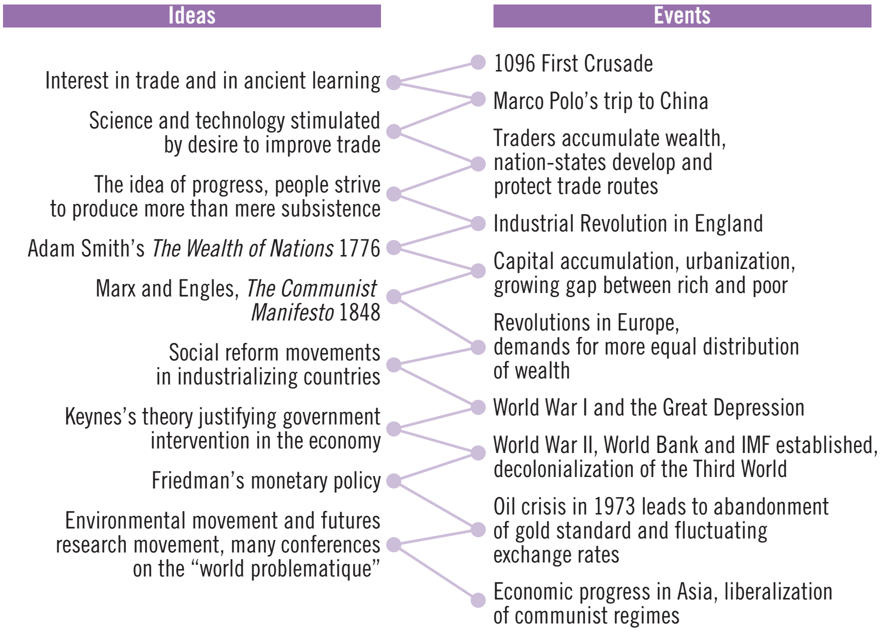

Figure 4 • Interaction between ideas and society.

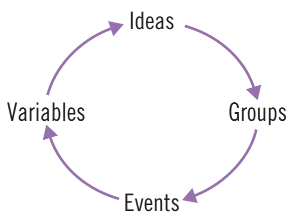

Figure 5 • Social change can be described using ideas, groups, events, and variables.

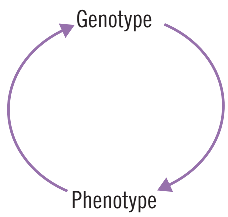

Figure 6 • Müller's epigenetic theory provides a general theory of evolution.

Why adopt second-order science?

« 28 » Second-order science requires thinking outside one's primary discipline. By adopting second-order science, we would cease thinking that we can study social systems in the same way that we study physical systems. If we thought about things differently, we would no doubt invent new theories and methods. We would have a larger conception of science, and would be able to explain and influence processes we would not be able to explain otherwise.

« 29 » Are there any reasons for not adopting the idea of second-order science? Most obviously, scientists would have to alter the claim of objectivity if they say that the observer is important. And that might reduce the authority of science in the minds of some people. But second-order science would increase self-awareness and require responsibility. There are also some logical difficulties, such as self-reference. Self-reference can lead to paradox and logical inconsistency. This issue was addressed by von Foerster:

> “[…]'self-reference' in scientific discourse was always thought to be illegitimate, for it was generally believed that The Scientific Method rests on 'objective' statements that are supposedly observer-independent, as if it were impossible to cope scientifically with self-reference, self-description, and self-explanation – that is, closed logical systems that include the referee in the reference, the observer in the description, and the axioms in the explanation.
>
> This belief is unfounded, as has been shown by John von Neumann [1951, 1966], Gotthard Gunther [1967], Lars Löfgren [1962, 1968], and many others who addressed themselves to the question as to the degree of complexity a descriptive system must have in order to function like the objects described, and who answered this question successfully.” (Foerster 1971: 239)

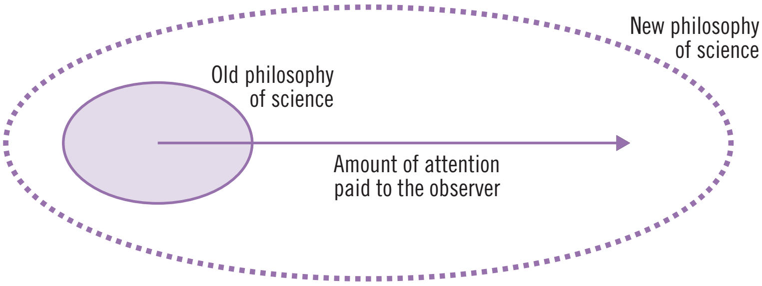

Figure 7 • An example of the correspondence principle.

« 30 » In fact, we cope with self-reference quite regularly. We deal with self-reference each time we buy something from someone who we know is trying to sell it to us. A sales person does not provide an objective description but rather a description intended to persuade you to buy. Also, we try to eliminate conflicts of interest. We know there are problems, so we try to minimize them. In the US, the Fifth Amendment to the Constitution prohibits self-incrimination. If self-incrimination is legally prohibited, torture is ineffective, because the state cannot use that testimony as evidence against the accused person. And we let juries decide who to believe. In practical affairs, we have learned to cope with self-reference. We think of ourselves as actors in a multi-person game where everybody else is thinking about what is happening and is pursuing their own goals.

« 31 » Also, we lose nothing by adding a new dimension to science. The science we practiced before can still be practiced. Niels Bohr (1920) formulated the correspondence principle when he was developing the quantum theory. The idea is that science progresses when we add a new dimension to an existing theory, something that was not considered before or was thought to have no effect, see Figure 7 (Krajewski 1977). In second-order science there are two dimensions – the amount of attention paid to the observer and the effect of a theory, once adopted, on the system observed. These dimensions are added to philosophy of science, not just to a theory within a particular field. The correspondence principle says that any new theory should reduce to the old theory to which it corresponds for those cases for which the old theory is known to hold. That means that all the data that supported the old theory also support the new theory, but we can now explain things we could not explain before. We do not lose anything by expanding science in accord with the correspondence principle.

Logic strategies and methods

« 32 » Second-order science has some basic logical propositions, some strategies to promote its growth and acceptance, and methods that can be used in its practice. Second-order science makes several assumptions that serve as starting points for logical arguments. The starting points are:

1 | Include the observer in what is observed.

2 | Accept that theories in social systems can sometimes change the phenomenon observed.

3 | Organize knowledge as methods, in addition to theories, since methods describe the actions of observers/participants.

4 | Add the dimension of time to resolve problems involving self-reference.

Strategies for doing second-order science

1 | Study the biology of cognition and incorporate what is learned in our understanding of knowledge and epistemology. In cybernetics, when people studied cognition, they brought together scientists from several fields and tried to develop a new understanding of knowledge (Pias 2003). People in more specialized disciplines have tended to focus on advancing their discipline rather than reconsidering theories of knowledge. A change in epistemology can affect science as a whole.

2 | Study high-performing research teams and commit to using the results of that research. Universities sometimes do not act on the research that they produce. We know how to create high-performing research teams. A key requirement is that a team be composed of people from more than one discipline (Umpleby, Anbari & Müller 2007).

3 | Include in literature reviews not only a description of the earlier work on the subject, but also a description of the consequences of acting on the results of earlier studies. Doing this would help to correct for the absence of instruction in the history of economic thought. An early indication of the impact of a theory can be obtained by counting citations. A second stage of impact is the use of research by professional people (e.g., engineers, therapists, legislators, and managers). Long-term impact can be assessed by historians of ideas. Examining the consequences of previous ideas, and how their evaluations have changed over time, would likely be helpful to researchers in all fields.

4 | Focus more attention on participatory methods. Paying attention to the observer for a single observation suggests paying attention to multiple observers in the case of social systems. Numerous methods of increasing participation have been developed in recent decades, including process improvement methods in management (Deming 1986), service learning in education (Umpleby & Rakicevik 2008), and group facilitation methods in planning and community development (Cooperrider 2005).

Methods for doing second-order science

1 | Model cycles or swings in preferred theories. Use causal influence diagrams to study positive and negative feedback processes (see Figure 3).

2 | View first-order theories as elements of social control processes (Umpleby 2011).

3 | Chart the interaction between ideas and society (see Figure 4).
4 | Create multi-disciplinary descriptions using ideas, groups, events, and variables (see Figure 5).
5 | Create more general theories based on cross-cultural studies (Acemoglu & Robinson 2012).
6 | Develop and use group facilitation methods, which have proven to be very effective both at improving the performance of organizations and in education (Umpleby & Oyler 2007).

Conclusion

« 33 » Human beings change social systems by passing laws and creating theories. As technology improves, human beings are even changing the natural environment, e.g., species extinction and climate change. We are learning to think about ourselves as participants in the systems we study. But to do that we need to change our conception of science. Robert Boyle's Invisible College in the 1600s, which later became the Royal Society, was one sign of a transition from theological knowledge to scientific knowledge. Currently, the development of cybernetics, including the various theories of reflexivity, combined with climate change, may be signs of a transition from an earlier descriptive conception of science to a more participatory conception of science.

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Open Peer Commentaries

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Do We Need a Second-Order Science?

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> Upshot • This article argues that we do not need a new scientific method or a "second-order science" to deal with the facts that the individual characteristics of observers may affect the nature and quality of their observations and that the application of scientific theories may affect the systems they describe. It also argues that Umpleby has not given us good reason to think that we do.

« 1 » Stuart Umpleby would like us to rethink and expand the philosophy of science. In his structured abstract, he writes that "many social scientists are using a conception of science created for the physical sciences," that "expanding philosophy of science so that it more successfully encompasses social systems would create new avenues of inquiry," and that philosophy of science should be expanded to pay more attention to "the observer" and the impact of a theory upon the system it describes. I am not exactly clear who "the observer" he is talking about actually is, let alone whether "the observer" is someone or something about which we can usefully or accurately generalize. But I certainly agree that different observers may have different characteristics, including different sensory capacities, beliefs, and biases; that their different characteristics may affect the nature and quality of their observations; and that theories may have impacts upon the systems they describe when we apply them to alter those systems. I think most other philosophers of science do too. But whether or not this means that we should rethink or expand the philosophy of science in the way Umpleby suggests is an entirely different question. It is a question that I do not think we can even begin to thoughtfully consider unless and until we know what it might actually involve. I do not think that Umpleby has explained what it might actually involve. And in what follows, I will try to explain some of the reasons why I remain skeptical about his idea of "second-order science."

« 2 » Umpleby says that "second-order science makes several assumptions that serve as starting points for logical arguments" (§32). He says that one starting point is to "include the observer in what is observed" and that another is to "[a]ccept that theories in social systems can sometimes change the phenomenon observed" (§32). These, of course, are not so much assumptions about what is or is not true as they are injunctions about what scientists should or should not do. I am not sure whether or to what extent that is important. But it is obviously one thing to say "include the observer in what is observed," and quite another to say how that can or should be done. And Umpleby, so far as I can see, never quite addresses the problem of how to include "the observer" in what is observed beyond saying that we should do it. He writes as if there is or should be little or no problem in doing it. But he never quite tells us how to do it, let alone how to do it in a way that would yield the kind of systematic general knowledge for which we have traditionally valued science.

« 3 » Umpleby also writes as if very few philosophers of science have recognized the fact that the characteristics of observers may have an effect upon their observations. But I would have thought that most, if not all, philosophers of science have long recognized that fact – and that everyone accepts the fact that theories about social systems, if actually applied, can change those systems. That, I think, is what applied science – both social and natural – is all about. And it is, regardless of whether you like it or not, what social engineering is all about. My own sense is that the philosophy of science has long known that the theories and beliefs and biases of observers (and theorists for that matter) may – along with their sensory systems – have an affect upon what they think they observe, and that we cannot entirely rely upon the truth of their observation reports as a result.

« 4 » This, contrary to what Umpleby suggests, was one of the starting points for Karl Popper's philosophy of science. It was also a starting point for Thomas Kuhn's. And it was, unless I am seriously mistaken, a starting point for Descartes, Bacon, Hume, and Kant as well. Be this as it may, calling attention to the role of "the observer" and the fact that theories may be applied to impact the systems that they describe says very little in and of itself about what we can or should infer, let alone do, about it. And Umpleby, so far as I can see, never quite tells us what we should do to include "the observer" in what we observe, and never quite comes to grip with any of the philosophical problems that might accrue from it. Here, I want to be clear. I have no doubt whatsoever that different observers perceive the world differently. But the fact that different observers perceive the world differently does not mean that the world is really different, or that they *construct* the world – or even what they perceive to be the world – let alone that they construct it differently. We simply cannot infer anything about whether the world is mind-dependent or mind-independent from the fact that different observers perceive it differently.

« 5 » We know that observers who are color-blind may not be able to observe colors, and that observers who are deaf may not be able to observe sounds. We also know that observers who are committed to a theory may overvalue observations and evidence that corroborate it, and completely ignore observations and evidence that might refute it. We know that observers who are skeptical of a theory may overvalue evidence that might refute it and ignore evidence that might corroborate it. And we know that some observers may not be affected all that much by their theories and biases when evaluating the evidence at all. But what else can a second-order science, or a philosophy of science that is expanded to include it, say about the role of "the observer" beyond that? And how can an observer observe him- or herself observing? Other observers, one might think, can. But would *their* theories, biases, and sensory apparatuses not also affect what they observe? And who, in any event, would be observing them? And what about the effects that their theories, biases, and sensory apparatuses might have upon their observations? And why, in any event, should we need a new second-order science to say that the characteristics of observers may affect what they observe and that the application of theories may affect the phenomena that they describe when most contemporary philosophers of science already take it for granted?

« 6 » Umpleby, however, says that we need a second-order science – a science of science so to speak – and that the philosophy of science should be expanded to include it. But the same reasoning that argues for a second-order science would also seem to argue for a third-order science, and a fourth-order science, and so on *ad infinitum*. For if we need a science that takes into account "the observer," then we should also need sciences that take into account the observers who observe "the observer," and the observers who observe the observers observing "the observer." This, no doubt, might create new avenues of inquiry. But unless we can construct general explanatory theories about "the observer," as opposed to specific conjectures about this or that observer, I do not see that it would add much useful general knowledge beyond the well-known fact that we cannot entirely rely upon the observation reports of observers. And I fear that going down this route may all too easily trap us in a hall of mirrors where observers are preoccupied with observing each other, themselves, and each other, and themselves observing each other and themselves without yielding any systematic general knowledge about how "the observer" affects what he or she observes, and without usefully addressing any real scientific problems at all.

« 7 » This is my primary reason for remaining skeptical about the need to pursue a second-order science. But there are other reasons that pertain more to Umpleby's understanding of the philosophy of science that he wants to expand.

« 8 » Umpleby says that "philosophy of science is the branch of philosophy that deals with methods, foundations, and implications of science." So far so good. But he then says that "it is a theory of how to create scientific knowledge," which is not so obviously true and seems to beg one of the major questions about which philosophers of science have differed over the years and still differ – namely, whether and to what extent scientific knowledge is something that we create or something that we discover. This is no small point. Umpleby, as I have already suggested, seems to uncritically accept a theory of social constructivism – the idea that we actually create the world that we observe – that in no way follows from the facts that the characteristics of an observer may affect his or her observations and that the application of a theory may affect the phenomenon that it seeks to explain. Be this as it may, it is one thing to accept a theory of social constructivism uncritically and quite another to build it uncritically into your very concept of the philosophy of science. And this, I submit, is what Umpleby does when he says that philosophy of science is a theory of how to create scientific knowledge.

« 9 » But regardless of whether or not social constructivism is true, a scientific theory, contrary to Umpleby, is not so much a picture of the mind-independent world as an attempt to explain how and why it seems to work as it does. It is, in a nutshell, an attempt to solve a problem by explaining something that we do not already understand. It may be a theoretical problem, where the question it answers is "Why?", or a practical problem, where the question it answers is "How?" But in either case, one of the primary tasks of the scientist is to test the answer an explanatory theory gives by seeing whether and to what extent the consequences we derive from it seem to be true.

« 10 » This is also no small point. Umpleby cites Karl Popper's theory of the three worlds. He says that "World 1 refers to the 'mind independent world,' World 2 to mental events, and World 3 to the descriptions that are found in books and libraries" (§4). But he seems, for some reason, to think that Popper's theory gives rise to three different *epistemologies*, which he represents by the triangle in his Figure 1.

« 11 » In §§4–6, Umpleby says that the left side of the triangle represents the first and most widely used epistemology, in which "scientists are supposed to create descriptions of the world and then test them with experiments and observations;" that the bottom of the triangle represents the second epistemology, which shifts the scientist's focus "to the observer and how an observer creates descriptions;" and that the right side of the triangle represents a third epistemology, which "emphasizes the observer and the world," where "the key question is how a person should act in the world to achieve his or her purposes." But an epistemology is a theory of knowledge that we proffer to answer such questions as what knowledge is, how we might acquire it, and, most important, how good or reliable it is. And my own sense is that Umpleby's triangle does not suggest three different epistemologies, but three different possible foci of study. We can study the world of material objects. We can study the world of observers. And we can study the world of human artefacts. Indeed, we already do. But everything is what it is and nothing else. And a focus of study, or a subject matter, or an object of inquiry is not itself a theory of knowledge. It is a focus of study, or a subject matter, or an object of scientific inquiry. And while we may take epistemology itself as an object of scientific inquiry, descriptions of the world or a focus upon the observer or an emphasis upon the observer and the world are not themselves theories of knowledge and should not be confused with them.

« 12 » Umpleby also cites Popper's doctrine of the unity of scientific method, namely, "that the method of conjectures and refutations works in the social sciences as well as in the physical sciences. That is, formulate a hypothesis and then attempt to refute it" (§18) – which he seems to reject. This is because he thinks that social science needs a different method from natural science because it deals with thinking participants. I do not understand why or how a difference in what we study should mean that we need to do something different from trying to explain things that we do not understand by formulating tentative theories to explain them, and testing those tentative theories by deriving their consequences and deciding whether or not they seem to be true in light of what we observe about them. And I do not, once again, see that or how Umpleby actually supplies a different method for studying them. He does, no doubt, talk about four different models that can be used in science and about four different basic elements for describing systems. He says that there are models that describe linear causal relationships, circular causal relationships, self-organized adaptations, and reflexive feedback loops (§§12–15) – and that different disciplines may take variables or ideas or groups or events as their basic elements (§27). But everything, once again, is what it is – and not everything is a method. A method tells you how to proceed. It may describe a process or procedure, in this case a process or procedure for doing science. But models are not methods; nor are basic elements. I do not deny that one might present a model of a method. Popper does this with his tetradic schema. But Umpleby, so far as I can see, does not. He writes:

> "When social scientists study social systems, they analyze what is happening (variables) and propose a new course of action (ideas). If the idea is adopted (groups), a new product may be invented or a bill may be passed in the legislature (event)." (§27).

But why should social scientists study what is happening? How should they analyse it? What might lead them to propose a new course of action? Why should we think that studying a social system should require a new and different method of inquiry? And what exactly is it?

« 13 » Popper (1972), in any event, used his so-called "tetradic schema"

$$P_1 \rightarrow TT \rightarrow EE \rightarrow P_2$$

to describe what he regarded as the general method of all scientific enquiry, and indeed the general method of all rational discussion. Here P_1 is a problem that we want to solve. TT is a theory that we tentatively offer in an attempt to solve it. EE is an attempt to eliminate errors in TT through rational criticism. And P_2 is a new problem that results from rational criticism and, more precisely, our discovery of errors in the tentative theory that we proposed to solve P_1. The schema, of course, is an oversimplification. Scientists typically work with several different problems and theories at once – and their problems, theories, and attempts at error elimination are often related in ways that are far too complex to be captured by an arrow. But Popper intended it to emphasize the facts that science begins with the recognition of problems – be they theoretical problems about how to understand nature and society, or practical problems about what to do and how to act in the world – and that the growth of knowledge depends upon our success in finding and eliminating the errors in our theories. The general method of science that he describes is first to find a problem that you want to solve; to then formulate a tentative theory or conjecture to solve it; to then subject that theory to critical analysis in an attempt to find errors, or, more precisely, contradictions between what the theory predicts we should observe and what we actually do observe; and to then try to eliminate any errors that you might find. Following this method will typically lead us to new problems, if only the problem of how to solve our original problem now that we see that the theory that we proffered to solve it does not really work. And it is easy to see how science, thus construed, may be a never-ending affair. Umpleby, however, does not cite Popper's tetradic schema, even though it seems to employ the causal relationships, circular causal relationships, self-organized adaptations, and reflexive feedback loop processes that he seems to prize. Nor does he mention Popper's idea that the primary task of the social sciences is to trace the unintended consequences of the theories we propose to solve our problems.

« 14 » This last idea – that the primary task of the social sciences is to trace the unintended consequences of the theories we propose to solve our problems – is also no small point. Umpleby says that "human beings change social systems by passing laws and creating theories." He says that "if society does not want businesses polluting the environment, the legislature can pass a law against it, with the result that there is less pollution" (§14). Just like that! But we can also change social systems by dropping bombs and killing people. And Umpleby seems to ignore the fact that our theories and laws often, if not indeed always, have unintended consequences – and that laws against pollution may have not only the unintended consequence that the businesses and individuals they affect may look for and find ways to get around them, but also the unintended consequence that the laws themselves might actually lead to greater pollution.

« 15 » Umpleby says that we are now "in a transition to a new kind of knowledge. It could be called reflexive knowledge or a greater self-awareness as a result of cognitive science and an awareness of our impact on our social and biological environment" (§2). In the structured abstract he says that "expanding philosophy of science so that it more successfully encompasses social systems would create new avenues of inquiry." But I think that this is something that science, and the philosophy of science, and human beings already do. Is a good deal of scientific psychology not devoted to studying observers while they are studying something? And is a good deal of our practical knowledge not the product of seeing what works in life and what does not? I also think that it is important to recognize that a lot of our knowledge about the world is not, and should not be regarded as, *scientific* knowledge. Here, I want to be very clear that the fact that it is not scientific knowledge does not mean that it is not true or that it is not important – let alone that it is literally nonsensical or devoid of cognitive significance, as Ludwig Wittgenstein and the logical positivists unfortunately thought. But it does mean that it may not be systematic knowledge, or methodical knowledge, or empirically testable knowledge, or knowledge that we can usefully generalize – which, in turn, means that we cannot, or at least should not, draw widespread inferences from it. Knowing that a given observer is biased in one way or another, or color-blind or deaf for that matter, does not mean that all observers – or even "the observer" – are biased or sensory deprived in the same way, let alone that their biases or sensory deprivations will actually, let alone necessarily, affect their scientific judgment. And knowing that the theories we hold may have an impact upon some system that we are studying if and when we try to apply them to that system does not mean that all applications will have the same or even similar consequences.

« 16 » This, I would think, should be wisdom for the ages. But it is a kind of wisdom that many if not most philosophers of science already have.

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New Challenges to New Science

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> Upshot • The humanities are gaining a new self-awareness of the role of observers who develop theories, and of the interplays between the theories and the system being studied. This article follows up the target paper with extended challenging questions, inviting more discussion.

« 1 » Humans want to understand the world and control it. Science started from dealing with nature. Therefore, natural science had set the tone of the enterprise when scientists expanded their inquiries to human psychology, sociology, economy, politics, and cultures. In doing so, they directly borrow the effective methods of natural science – i.e., observer-independent observation, repeatable experimentation, confirmation, or falsification. All these approaches can be said to have one ultimate purpose – to make sure that the theory being constructed is able to capture the unchanging nature of the system being studied in so-called "natural laws" and, consequently, to gain the ability to predict its behavior in order to understand it and to control it. It feels all right when we try to control our cars or airplanes or even our weather – but how about other human beings?

« 2 » This might be why, when Norbert Wiener thoughtfully worded the subtitle of his ground breaking 1948 book *Cybernetics*, he used "control and communication" instead of just "control." By doing so, Wiener expanded the purpose of science – even though he was just talking about cybernetics – from "control" to "communication" whenever human beings are involved. That, I think, was the seed of second-order science. For all systems that involve human beings, the purpose of science should be shifted from control to communication.

« 3 » Therefore, it is high time that scientists address this key issue – from control to communication, from objectivity to shared subjectivity, and from theory-as-natural-law to theory-as-communication-tool. These tools are for peace and co-existence instead of control and domination, the latter having been the major theme of earlier civilizations full of wars, conquests and colonialism. We need a clear description of why and how to make such a transition. Umpleby's target paper is a first step towards this goal. So the key point of second-order science is that by putting the observer into the spotlight and noting the consequences that a theory about society brings to society, it calls for abandoning the attempt to control human beings, and for improving communication instead. This makes Umpleby's article – and second-order science – so important: it calls for all scientists to reconsider their assumptions.

« 4 » In what follows, I suggest two potential amendments to Umpleby's target paper. I conclude my commentary with several questions that need to be addressed by second-order science.

More types of models

« 5 » In §§12–15, Umpleby discusses four types of models used in science. My argument is that there might be more than four types if we increase the resolution of our cognitive lenses or the complexity of our vision. I agree that at the basic level should be linear causal relationships, even a number of sub-levels can be identified here, i.e., single causal links "A causes B"; multiple parallel causes (multiple variable functions or laundry lists); and tree-structured variable sets (excel spreadsheets, corporate financial models, fish-bone diagrams used in Total Quality Management, etc.). The chief assumption underlining the first type is that there exist stable natural laws, waiting for scientists to discover them.

« 6 » I also agree that the next level of modeling should be circular causality, although again sub-levels can be distinguished here, such as single-loop models (i.e., a positive or negative feedback loop that causes stabilization or growth, or a positive or negative feed-forward loop that causes self-fulfilling or self-defeating predictions); and multiple-loop models or networks that describe or simulate large scale complex systems (system dynamics models, macro economy, ecological systems). The assumptions underlining this second type are that linkages of linear causality form a system containing circular causal loops, i.e., parts of the system have linear causalities – the circularity is in the structure of the system, or how the parts are connected.

« 7 » However, between Umpleby's third and fourth types (§§14f) – self-organization and reflexivity – we may need to add at least one more important level. This is Heinz von Foerster's "non-trivial machine" model, i.e., a machine that has developed an internal status, a memory, and is, therefore, influenced by its own history. A non-trivial machine may have not yet reached the status of being able to "reflect," but its changing internal state becomes part of the transfer function between its input and output. A broken car, or a virus-infected computer, or a developing country choosing its value system might be examples here.

« 8 » There might still be another level – systems that not only have a memory but also a purpose, or an internal, self-developed goal. Externally imposed goals can be found in the second type of models, such as automatic control machines.[1] A well-programed robot and a brainwashed communist official might be examples here. The phenomenon of "learning" starts at this level, although not yet the phenomenon of creativity and innovation.[2]

« 9 » Regarding Umpleby's fourth type of the reflexivity model, where phenomena of learning dominate, leading towards creativity and innovation if lucky, we can distinguish the following, based on Umpleby's earlier work of classifying four levels of regulation (Umpleby 1990):

a | first loop reflection (questioning on error measurement);
b | second loop reflection (questioning the path in reference to the goal);
c | third loop reflection (questioning the legitimacy or value of the goal);
d | fourth loop reflection (questioning value, in reference to natural conscience and universal humanity, if any.)

« 10 » The significance of the above distinctions is that the second-order scientists will be clearer about which sub-type of reflection is being focused on, and be aware of the increasing difficulty of the phenomenon of reflexivity being seen by the public. For example, George Soros's reflexivity model of the financial market was already published in the 1980s (Soros 1988), but a large number of Wall Street analysts have not understood or paid attention to it so far.

« 11 » In Umpleby's third type of model, the timing or the process needed for self-organization to happen plays a key role. The cause-effect dynamic does not happen immediately, as in the cases of most type 1 and type 2 models, but happen with time lags, reaction time, or emergence time – the "self-organization time."[3] In Umpleby's fourth type, the focus is on the interaction between the observer and the system being observed, or the interactions between the two players of a game; each is both observer and actor. Therefore, if we add the two types I suggested above, i.e., non-trivial machines and purposeful systems, the shifting of focus (of science) across the full spectrum will be:

- simple natural laws;
- circular causalities;
- self-organization;
- self-memorization;
- self-orientation;
- self-reflection.

« 12 » The higher the scientists go in level/types, the higher the cognitive capacity is needed to understand and work with it and the more difficult it will be to communicate their key findings to the public. Take, for example, Darwin's theory of evolution, a self-organization model: it is still not understood by a large portion of the general population.

1 | This corresponds to Maturana's distinction between autopoietic and allopoietic machines.

2 | By stressing the "phenomenon of learning," I stress my role as an observer who observes the situation in which I see "learning" happening in the system being observed. "Learning," "creativity," and "innovation" in themselves are complex systems that are subject to various interpretations or theories. Instead of invoking any such theory I simply refer to the phenomenon, thereby avoiding an unchecked "objectivity" mode.

3 | Electronic engineers are familiar with the concept of "response time" – the time needed to charge up a capacitor or a conductor. System dynamic model builders are familiar with time-delay variables. For all second-order scientists, it is important to be aware of this timing factor whenever self-organization is involved.

« 13 » The above spectrum might also expands Aristotle's "Four causes" paradigm. Instead of using "material, formal, efficient, and final" causes to explain the world, we now have natural law (direct), structure (circularity), past (history and memory), future (goal), self-image (identity), and value system (guidance of reflection) as causes to explain, and hopefully to cope with, the world and ourselves as humans. This spectrum links a deterministic world on one side, with human free will and humanity on the other.

More basic elements

« 14 » My second suggestion is a possible hidden structure underlying Umpleby's list of the four basic elements for describing systems, i.e., variables, ideas, groups, and events (§27). There is an internal logic/relationship among these four basic elements. The measurable variables, (also non-measurable but perceivable variables) are at the bottom. Ideas may consists of variables (such as $f = ma$) or not (such as Freud's id, ego, and superego). Ideas may "infect" more than one individual, so that they become one "P-individual" or a group. Groups make things happen, and those happen-ings are events (individuals make things happen too, but most historical events are done by groups, whether large or small.) Therefore, the four elements of study are actually four different levels of analysis.

« 15 » What is then the next level above groups and events? I would suggest value systems such as cultures and civilizations.

« 16 » In addition, if we increase our cognitive resolution, then each level of these four elements can be classified into a number of sub-levels, i.e., variable types, idea types, group types, and event types. I shall leave the details of this suggestion to our readers as exercises.

More questions

« 17 » The following questions deal with measurement, objectivity, and ethics. They need to be answered before the proposed second-order science can be effectively launched.

« 18 » In science, measurements can be conducted using four different scales: nominal, ordinal, interval, and ratio. However, are these four scales of measurement still useful when dealing with the key dimensions of second-order science:

a | measurements of the amount of attention paid to the observer – by the observer herself i.e., the author of the theory in discussion, or by the second observer i.e., the commentator reviewing the theory, and

b | measurements of the effect of the adopted theory on the system observed? Do we need to construct a new type of scale to make distinctions of "the observer-dependence" and "the effects of theory"?

« 19 » Why do first-order scientists exclude the observer and the effects of theories on society? There are good reasons, which we need to review. The first is the search for reliable knowledge that is independent from the knowledge creator, so that if you can use it, I can use it too. This conveys "universality" and therefore authority, trustworthiness, and an ability to provide effective guidance for actions. In second-order science, are we giving up all those benefits when giving up "objectivity?" In other words, once we accept the belief that the "observer is included in the observation and theory," will we compromise the criteria of "usefulness" or "universality" of the theory? An important example is the question about the usefulness of "democracy" in China. Those promoting it believe that it is observer-independent, or actor-independent. Those against it believe that it is observer-dependent, or actor-dependent. Chinese people, due to their cultural traditions, the latter argue, do not know how to behave in a democracy. What would the second-order science perspective be on this?

« 20 » In first-order science, the effect of a theory about society on that society was either not an issue, or was ignored, because once applied, the effectiveness of a good theory is expected. What Umpleby is trying to highlight for second-order science might be "the side-effect of the theory," i.e., the unintended, unanticipated, but built-in effects that create new problems from a supposed solution provided by the theory. If this is correct, more needs to be discussed on how exactly the suggested co-evolution between theory and society can be conducted. Would that be in the format of therapeutic intervention, or manipulation? If so, should all second-order scientists also have to take a sort of Hippocratic Oath, i.e., to do no harm to our social system with our knowledge and skills about social systems? In human history, we have seen the evidence that when such an ethical code is missing, huge damage is done by those such as Hitler, Stalin, Mao, etc., who gained the capacity to manipulate social systems through their theories and actions. In other words, when we adopt the belief in co-evolution of theories and social systems, we must be aware of the fact that there will be individuals who understand the dynamic between theory and society to alter the social system – ideally for the benefit of all people, but more likely for their own interests – and there will be people who are manipulated. How should second-order science be developed to cope with such a situation?

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Science Is not Value-free

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> Upshot • The author claims that second-order science leads to "an awareness of our impact on our social and biological environment." If this is true, it is sheer irresponsibility not to address the possibility that human activity is leading the biosphere to a point of catastrophic collapse. More generally, I hold that science should openly address explicitly value-laden issues.

« 1 » Stuart Umpleby writes that we are now "in a transition to a new kind of knowledge. It could be called reflexive knowledge or a greater self-awareness as a result of cognitive science and an awareness of our impact on our social and biological environment" (§2). If this is to be more than an empty generality, it requires fleshing out with some convincing examples. A major case is that of the possibility, only too real, that human activity is leading the biosphere to a point of catastrophic collapse (Barnosky et al. 2012). This case is exemplary indeed because of the high stakes involved (neither more nor less than the survival of the human race), to which may be added the fact that due to a combination of vested interests, a mechanism for making major social and political decisions (the market economy) that is manifestly grossly inadequate, and an ostrich-like unwillingness to face unpleasant realities, this issue is not receiving anything like the serious attention it requires. Added to this is the urgency of the case: current best estimates are that we have something like 10 years, maybe 20, to change current trends; after that, the damage to the eco-system will likely be irreversible. In this pretty desperate and frightening situation, scientists have a major social responsibility; all the more so, since science-based technology has been largely instrumental in getting us into this situation in the first place. Umpleby writes: "natural knowledge (i.e., science) has contributed enormously to our physical quality of life" (§1). Well, yes; but our current predicament shows that there is a flip-side to this. This brings me to a more general point: the question as to whether science is, and/or should be, value-neutral.

« 2 » There is a widespread idea that science is, and should be, "value-neutral." I hold that this idea is pure ideology (the hallmark of a successful ideology being that it does not appear as such). I further hold that this idea is doubly mistaken: firstly, *de facto*, science is not and never has been value-neutral; and secondly, even if science could somehow be "value-neutral," it *should not* be so. I will examine these points in order.

« 3 » Firstly, science is not value-neutral. Books have been written on this subject but here I will be brief. Right at the start of modern science, Descartes openly proclaimed that the aim of science is "the mastery and domination of nature." The synergy between science and technology, as it has developed over the centuries, has very largely led to the fulfillment of this aim. Now there is much to be said both for and against Descartes' avowed aim, but however one weighs up the advantages and disadvantages (and there is room for legitimate political disagreement on this point), this means that science is anything but value-neutral.

« 4 » Secondly, there is no good reason why science *should* be value-neutral. Putting it briefly again, if science really were "value-neutral," this would quite simply mean that there would be no point in doing science; the whole exercise would be avowedly pointless. Putting it the other way round to introduce a more positive note, the advantage of openly admitting that science is value-laden is that the values in question can become the object of discussion; and while there can be no guarantees, this could only increase our chances of getting the values right.

« 5 » To what extent do the subsequent sections in Umpleby's article address these issues? In §8, he writes:

> "we could also acknowledge that theories (at least in the social sciences) affect what is studied. We are aware that theories affect society. Indeed, that is why we create social science theories. We hope that they will be accepted and acted upon, and the social system will perhaps operate better."

Later on, in §26, he fleshes this out by thematising the "shoelace" effect and noting that social theories (notably those of Marx and Friedman among others) clearly have an effect on social reality, and designedly so. This is indeed a step in the direction I am calling for. However, to my mind it is insufficient, as I will now attempt to explain. The point I wish to make here is that the real-world effects of science are not restricted to the social sciences: they apply to *all* science. To introduce this dimension, a key text is that of Robert Young (1977), which may seem to be somewhat dated but, as Young himself has remarked, is now more relevant than ever. "Science *is* social relations": this applies to physics (for example, but of course also to all natural science) for at least two reasons. Firstly, physicists are themselves socialized human beings, and their research is funded by social resources. Secondly, and even more importantly, research in physics has major effects in the real world. In §33, Umpleby even acknowledges this explicitly: "Human beings change social systems by passing laws and creating theories. As technology improves, human beings are even changing the natural environment, e.g., species extinction and climate change." This is indeed closer to what I am trying to get at; my only regret is that it is reduced to a rather off-the-cuff remark, relegated towards the end of the article and not taken up in the major "Implications" mentioned at the start of the paper.

« 6 » Umpleby advocates "second-order science," which involves reflexivity and which would increase self-awareness. This is fine as far as it goes, but to my mind it is not enough. Maybe what we need is something like "third-order science," in which we are not just "aware" of the effects of science, but we actually get round to *doing* something about it. Umpleby, again in §29, raises the theme of "responsibility." Human responsibility, as I understand it, consists of facing up to the consequences of one's actions – irrespective of whether these consequences were deliberately intended. I am not saying that natural scientists have deliberately set out to damage the eco-system, but this lack of intent does not absolve them from all responsibility. Descartes' doctrine of "mastery and domination of Nature," which has permeated the whole of modern science, is *not* an attitude of due respect to Nature, and so the worm has been in the fruit for some time. To conclude, I will reiterate my conviction that "third-order science" will require full acceptance of the fact that the practice of science inevitably involves *values*.

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Second-Order Science, Unity of Science and Methods of Research

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> Upshot • Umpleby's target article is important for bridging the gap between the natural and social sciences. While I agree with his claims, his proposals may not reach far enough. Concrete methods of empirical research, which are of crucial importance for a breakthrough, deserve further elaboration.

« 1 » While the title of Stuart Umpleby's target article, "Second-order Science: Logic, Strategies, Methods" is very promising as it points at bridging fundamental reflections on science with the practical application of methods, some readers may remain disappointed. Umpleby certainly makes a strong case for the unity of science and logic but in §32 he only briefly goes into the issue of strategies and even more briefly mentions methods. The key to further developing and especially expanding the acceptance and use of second-order cybernetics, and hence the importance of this article, lies, in my opinion, precisely in the issue of developing second-order cybernetic methods.[1]

« 2 » There are numerous publications on second-order cybernetic theory but serious empirical applications using methods to deal with specifically second-order issues seem rare. Such empirical applications require methods that, as Umpleby justly remarks, are suitable for meeting the requirements of the specific theory (§25, also §17, 18).

« 3 » The sociological theories of Niklas Luhmann are an example of the empirical application of a special kind of second-order cybernetics. They have been discussed seriously, going beyond the superficial issues, in both the framework of some of the Dubrovnik conferences organized by Gorm Harste and his colleagues[2] and the books published by a group of followers and students of Luhmann (e.g., Farias & Ossandon 2006). In both cases, however, the focus was on theory and empirical content rather than on methods of empirical research. At any rate, it may be doubted that Luhmann himself, being a lawyer by training, used "methods" in the usual sense of the natural and social sciences.

« 4 » In my own publications, I always stated that (socio-)cyberneticians and systems scientists can make use of any method of empirical (social) research and data collection that is useful for their research question (Hornung 2006a: 53; Hornung 1988: 38f). So I fully agree with Umpleby and support his statement that a newer theory, such as second-order cybernetics, does not make an older theory, such as first-order cybernetics, obsolete (§31) – very much like quantum theory did not render Newtonian physics invalid, wrong and useless. Within the new framework of the former, the latter is just a particular theory applicable to particular cases only and its limitations and drawbacks are known. Methods adapted to the older theory, however, may not be very useful for tackling the specific issues of the newer theory. Of course, the development of new methods and the identification of existing ones that are suitable for investigating empirically specific issues of second-order cybernetics beyond the reach of first-order theories and methods is a challenging task for the cybernetic and constructivist community.

« 5 » A scientific revolution and change of paradigm often means putting established knowledge in a new (here second-order cybernetic) framework and – which is not made very explicit by Umpleby – in a constructivist framework. Only a philosophical constructivist foundation permits resolving the problems the unity of science encounters from a realist's point of view (cf. Hornung 2006b). For the realist, Cartesian dualism, and in its wake the split between natural and social sciences, is an ontological given. For the philosophical constructivist, it is a human construction and hence could be replaced by a different – better – construction. The same could also be said for an idealistic, purely subjectivist position: if the world was only our subjective idea, we would have no problems changing it. Evidently this is not the case. In philosophical constructivism, however, we have both the flexibility of changing our constructions and a criterion for "truth" and for which constructions are better or worse. This is the pragmatic criterion of viability rather than the realist's criterion of truth in terms of correspondence with an external "reality."

« 6 » As in the case of a change of paradigm, some of the strategies listed at the end of the target article are not new but need to be seen – and applied – within a new, i.e., constructivist second-order cybernetic framework. For Strategy 1, the biology of cognition, incorporating its consequences into our (empirical) research would certainly be progress and innovation, and as such it deserves and needs further elaboration. On the theoretical side, however, it also needs to be connected more closely to philosophical constructivism and epistemology. This is a level quite different from empirical epistemology in the way it has been developed in Maturana & Varela's (1980) biology of cognition (to which, I assume, the cybernetician Umpleby refers), or by Jean Piaget or by sociological constructivists such as Peter Berger and Thomas Luckmann (1966). At least as a first step, such an empirical epistemology can be developed as first-order research: investigating how another human being perceives, how a child develops its cognitions or how human beings construct their social systems. It is clear, that, e.g., Maturana and Varela made the second step to the philosophical-epistemological level, including reflexively their own activity as scientific observers, while I cannot find this in Berger and Luckmann. Without the second step, these are empirical investigations and theories that nevertheless have philosophical

1 | I shall continue to use the term "cybernetics." Umpleby, as a past president of the American Society for Cybernetics, presumably does not refer just to any kind of second-order science but to a cybernetic or systemic one. On the other hand, there was, for example, a period when sociology of sociology was quite fashionable. This is indubitably a second order – i.e., reflexive – discipline, but neither systemic nor cybernetic.

2 | "Luhmann in Action, Empirical Studies of Structural Couplings," Conference at the Inter-University Centre (IUC), Dubrovnik, Croatia, 11–15 April 2011. See http://www.iuc.hr/conference-details.php?id=155

implications and consequences that may or may not become visible to the respective investigator. However, this kind of empirical epistemology and constructivism should not be confused with genuine philosophical constructivist approaches as proposed, e.g., by Ernst von Glasersfeld (1995), Edmund Husserl (who is not labeled a "constructivist," but whose phenomenology is often quoted by Luhmann (e.g., Luhmann 1987: 93, 122, 153, 201, 357, 367, 368), or as proposed more recently by Arne Kjellman (2002, 2006). Philosophical constructivism and epistemology come into play only once the researcher becomes aware and takes into account that his own research activity on such cognitive issues is subject to the same mechanisms he is investigating in others.

« 7 » While Strategies 2 and 4, interdisciplinarity and participative research, are not new either, Strategy 3 can be considered genuinely second-order because in literature surveys it includes the historical dimension as well as the feedback on the effect that the studies and theories reviewed have had on the scientific community and on society at large. The systematic inclusion of the historical dimension, which turns circular (causality) processes into evolving spirals of iterations, is a bridge between nomothetical (natural) sciences and historical or ideographic (social) sciences. So far, this has been considered another split in the unity of science.

« 8 » There is one disagreement I have with Umpleby. This concerns the role he assigns to variables in §27 as one of the four basic elements for describing systems. Umpleby's Figure 5 depicts these elements as belonging to the same category. However, this mixes quite different levels of analysis that should be kept distinct. To combine these into a "theory of social change" (§27) is at least misleading. Ideas, representing culture, and groups are certainly sociological categories that could be considered variables at the sociological level. Events, however, are a much more general category that should go along with the categories of process and structure, three concepts that are of use in any science, although at a quite abstract level. In a sociological context, it should rather read "social action," "social process" or "social events." Umpleby probably wants to refer to these after all. Variables, finally, are part of a mathematical framework (although many sociologists like to forget that) and go along with constants and equations. At the level of a substantial science, e.g., sociology, these need to be interpreted, e.g., as ideas, social action, etc.

« 9 » The ambition of Umpleby to argue in favor of the unity of science, i.e., including the natural sciences and the social sciences, or what are also called the humanities, and to make a case for second-order cybernetics and its practical application in a second-order science is laudable and important. However, the question remains: How can scientists not familiar with second-order cybernetics be convinced of the usefulness of this approach in science at large? The point where a genuine breakthrough could be expected, i.e., the "methods for doing second-order science," remains sketchy at best, with only a few references to some ideas of the author and two references to literature. Substantial progress could be achieved at this point, both with regard to the existing deficit in empirical research and with regard to providing a full package of practically applicable methods.

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Observer Effects in Research

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> Upshot • The evaluation of what (we think) we know is an urgent and evolving issue. The issues discussed by Umpleby have been raised earlier, particularly in the social sciences. Arguably, in some quarters they are exaggerated. But an awareness of observer effects is of great importance and is greatly enhanced by second-order cybernetics applied more widely as second-order science.

« 1 » In order to understand Stuart Umpleby's discussion of "second-order science," it is necessary to go further back than the work of Heinz von Foerster, as referenced by Umpleby in §7. Thus, in many contemporary contexts it is necessary to defend the very possibility of knowledge from emphasis on the various effects of the observer on the system observed and the kinds of bias that an observer may introduce. Modern learning theory, going back to the work of Jean Piaget (e.g., 1930), suggests that all concepts are "constructed" as a result of experience by the learner or passed on as a products of social construction in a given social context. Arguably, an awareness of alternative ways of constructing reality first arose in contexts of profound cultural difference, leading investigators to an awareness of the arbitrariness of their own assumptions.

« 2 » The emphasis on knowledge as socially constructed within a given context is often discussed in *post-modernism*, where it is used to question the validity of cross cultural observations or interpretations made of another social context or era. It is important to note that, although the observer effect is most significant for the social sciences, it can be recognized in descriptions of the physical world as well, as in the example to which Umpleby refers of the concept of the "ether" (§22) or the contrasting constructions of the physical world of Aristotle and Lucretius, as described in Greenblatt (2011).

« 3 » It was a significant advance for sociology and psychology when the Western Electric Hawthorne Studies recognized the

Hawthorne effect[1] created by Elton Mayo's study in 1924–1933 of the responses of factory workers to changing conditions.

« 4 » Carl Jung made an important contribution to our understanding of mental phenomena with his distinction between *pleroma* and *creatura*, corresponding roughly to Popper's Worlds 1 and 2 (§4), which was further developed by Gregory Bateson (1970) in his exploration of mental phenomena in self-corrective systems.

« 5 » Anthropologists working in isolation within preliterate communities have for a long time been aware of the psychological effects on themselves of such isolation, (often described as "culture shock"), in which what has been learned as "common sense" is no longer valid, and also of the inevitable effect of their presence on the community studied. Recently, the analysis of the observer's experience has become the focus of much ethnographic writing under the term "reflexivity" (Fischer & Marcus 1999), dealing with the way in which observers seek disciplined subjectivity by becoming aware of their responses and effects as participants in the systems they study, an awareness crystallized in the description of ethnographic method as "participant observation."

« 6 » Umpleby's reference to climate change (§33) might well be supplemented by a discussion of how "denial" – the desire *not* to know – can distort observation and rational decision making, often for the economic or political advantage of the decision maker.

« 7 » Second-order cybernetics has an immensely important potential role to play for all the social sciences in reinforcing awareness that observation is itself a form of participation. This awareness is advanced through the emphasis on circular (as opposed to linear) causation and the importance of feedback. Umpleby offers a number of useful approaches in training researchers to this awareness, which has implications not only for philosophy of science but also for all fields dealing with causation in living systems, especially ethics, which one might hope would be relevant in management, economics, and political science. In living systems, including human societies and ecosystems, simple linear causation may be the exception rather than the rule, because such systems are responsive to differences, which leads to a need for a more complex theory of causality and systematic attention to circular loops and side effects such as environmental pollution and disruption (Bateson 2004).[2]

1| Also known as the "observer effect," it describes the fact that individuals change their behavior when they become aware of being observed (Landsberger 1958).

2| See also my dinner speech "Living in cybernetics – making it personal" at the 2014 Annual Meeting of the American Society for Cybernetics, http://asc-cybernetics.org/2014/?page_id=121

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Second-Order Observation in Social Science: Autopoietic Foundations

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> Upshot • Second-order science requires a specific methodology. It thereby reverses the classical observer-observed relation in favor of the observed – i.e., the first-order observers – if the principle of autopoiesis is acknowledged.

« 1 » Karl Popper wanted to "exorcise the ghost called […] 'the observer'" (Popper 1967: 7). This was not to deny the importance of the observer but to clarify its role. An observer tests theories since each observation is guided by a theory as a self-made instrument of thought (Popper 1989: 157). With this clarification, Popper justifies second-order thinking. That is, the inclusion of the observer in what is observed. Another observer could choose another theory and observe something different in the same situation (without being wrong). The observer is "inside the box," as Gregory Bateson and Margaret Mead formulate it (Brand, Bateson & Mead 1976: 38 or "a person who considers oneself to be a participant actor," in the words of Heinz von Foerster (2003: 289).

« 2 » Since the inclusion of the observer changes the scope of the object of investigation, Stuart Umpleby is quite right to emphasize the importance of particular second-order theories and methods. He sketches a program for second-order science by addressing specifically the social sciences. As a sociologist, I am very much in favor of such an undertaking because "participant observation" is a basic methodology in sociology, with early use in empirical investigations such as "Mariental" or "Street Corner Society," which became sociological classics.

« 3 » There exist a broad variety of methodological considerations addressing participant observation. Umpleby lists some of them, and others could be added such as grounded theory or stakeholder theory (Glaser & Strauss 1967; Freeman et al. 2010). Niklas Luhmann's theory of social systems could also be instrumental for the further elaboration of second-order science, since it already took up basic ideas of second-order observation (Luhmann 1989, 1993). Both the observed system and the observing system are here conceptualized as autopoietic entities constituting themselves and constructing the reality of their world through self-referential operations. Thereby, the observed system's mode of attribution – i.e., the observed actor is the first-order observer – is distinguished from the observer's mode of attribution – i.e., the second-order observer. In the following, the examples of "Mariental" and "Street Corner Society" are first used to illustrate aspects of second-order science and then to show how the notion of autopoietic systems can be applied.

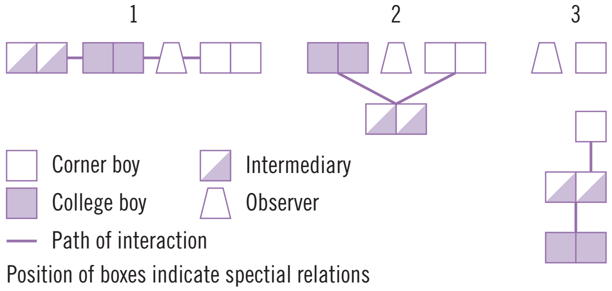

Figure 1 • Development of a street corner conversion in three steps (informal meeting in the evening on the street) (Adapted from Whyte 1993: 95).

Participant observation in the examples "Mariental" and "Street Corner Society"

« 4 » "Marienthal. The Sociography of an Unemployed Community" (Jahoda, Lazarsfeld & Zeisl 2002) studied the impact of long-lasting total unemployment in a community in Austria from 1931 to 1932. It became a classic because of its methodological approach. This approach linked non-reactive techniques such as statistical evaluation, analysis of documents, and methods of observation with reactive techniques such as participant observation, action research, surveys, and tests. Researchers did not see themselves as detached and uninvolved or as mere reporters or outside observers. Instead, they tried to adapt to the community's life by participating in activities useful to the community. They offered courses on how to make new clothing for the children out of the discarded clothes of the adults, conducted gymnastic courses to establish contact with the youth, organized free doctors' advice on all sorts of medical problems once a week and established contacts with political and semi-political organizations in the industrial village (1486 inhabitants). Especially welcomed was their organization of a collection in Vienna of clothes that were, after cleaning and repairing, distributed in the village, together with new shoes and socks that they bought for the children with their own funds. All these different activities allowed deep insights in the needs, struggles and survival strategies of those investigated.

« 5 » "Street Corner Society: The Social Structure of an Italian Slum" (Whyte 1993) is a community study that changed the way poverty was understood. The field work took place in Boston from 1937 to 1938, with the author living with an Italian-American family that operated a restaurant. Key to his access to the community was a young man called "Doc," who agreed to support the research and established access to the Norton Street gang and the Italian Community Club. Whyte describes how he started the field work as a nonparticipating observer. As he became accepted into the community, he found himself becoming almost a non-observing participant since he enjoyed the life in the community very much. It was the pressure of writing reports to receive his grants that reminded him to pursue his studies. He used diagrams to represent and analyze the communicative interactions between various types of participants, including the observer himself (Figure 1). Before finalizing the study, Whyte discussed the manuscript with Doc, which resulted in long conversations on his suggestions and criticism, and beyond that received further feedback from other group members.

Participant observation in terms of autopoiesis

« 6 » In both studies – "Marienthal" and "Street Corner Society" – the researchers were quite creative at coping with the "problem" of autopoiesis, i.e., of including "itself in the fields of its objects" (Luhmann 1990: 15f). Initially, an autopoietic (that is, self-reproducing) system is unobservable because the observer's self-referential operations are different from the self-referential operations of the observed systems (i.e., the actors' self-referential operations). Consequently, the actors' behaviors are contingent for the observer. This problem can be solved by the second-order observing system (the observer) via focusing on those self-determined and self-determining distinctions that the first-order observing systems (the actors) use to frame their own observations. Thereby the observer develops (or tests) a theory as an instrument of thought (in the meaning of Popper) as second-order distinctions. The main challenge in the "Marienthal" and the "Street Corner" study was therefore to learn what the self-determined and self-determining distinctions of the first-order observing systems (the actors) could be and how this would relate to (new or altered) second-order distinctions. This was neither possible from a distance nor could it be done in one or two short interactions. Instead, the observers became located "inside the box" (Bateson & Mead) as persons who acted over a longer period of time as "participants" (Foerster), and were on this basis able to cope with the unavoidable contingency resulting from their own and the observed actors' autopoiesis (Luhmann). Umpleby's starting points for logical arguments of second-order science perfectly reflect this thinking (§32). In particular, I appreciate his notions that:

a | knowledge has to be organized as methods (in addition to theories) since methods describe the actions of observers/participants; and
b | the dimension of time has to be added to resolve problems involving self-reference.

« 7 » In summary, it can be said that the idea of second-order observation reverses the classical observer-observed relation. Whereas the definition power is with the observer in the classical observer-observed relation, it is with the observed in the framework of an autopoiesis-acknowledging second-order observation.

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Do We also Need Second-Order Mathematics?

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> Upshot • The author makes a strong plea for second-order science but somehow mathematics remains out of focus. The major claim of this commentary is that second-order science requires second-order mathematics.

« 1 » This commentary does not question the validity of developing a second-order science as a research project. Rather it raises a question about the limits of the project. More specifically, whenever mathematics is mentioned in the paper, it seems clear to me that, although new methods and results need to be developed in order to describe second-order science appropriately, mathematics itself seems to "escape" from this new view. In the next paragraphs I want to argue for two claims:

a | that second-order science requires a second-order mathematics, and
b | that we have a sufficient amount of materials at our disposal to execute this task.

« 2 » Let me take Figure 7 as a point of departure. Replace "science" with "mathematics." Does the resulting figure still make sense? I think the answer must be positive. The "Old philosophy of ~~science~~ mathematics" is indeed an approach where the human being doing mathematics, known as "the mathematician," has completely disappeared out of sight. Of course, this was not an accidental happening, he or she had to be eliminated as mathematical truths are supposed to be eternal, unchanging, immutable, and so forth (and human beings are not). The focus therefore was on what mathematicians produced: theorems and their proofs in first instance, and, by extension, mathematical theories that unified a set of theorems. This gave rise to the ultimate unification in the form of set theory, although this should rather be labeled a majority view as alternatives exist such as alternative set theories, category theory, or homotopy type theory (I will come back to this particular case further on as it has some special features that set it apart). Nevertheless, such foundational approaches share no (or cannot even share) features with second-order science as the "observer" is entirely lacking.

« 3 » If the above description is valid then a strange situation obtains that, I believe, is potentially harmful for the second-order science project. A critic might reason as follows: there is no problem in introducing the observer into the sciences, especially the human and social sciences, but that does not necessarily have to lead to a constructivist view since the underlying mathematics does not itself require an observer. Hence mathematics can serve as an external reference point, free of constructivist worries (and one might even indulge in a form of Platonism, old or new). As the author certainly does not reject the use of mathematics for all sciences, it follows that second-order science, with the inclusion of the observer, can be described in an observer-free language, namely that of mathematics, and thereby the second-order science project loses its original appeal, if not its philosophical motivation. This supports my first claim that second-order science requires second-order mathematics.

« 4 » Let me return to Figure 7 for my second claim. At the top right one now reads "New philosophy of ~~science~~ mathematics." What could that be? The good news is that this question has already been partially answered and those answers fit in nicely with the author's project. What follows is a (very) brief summary and I refer the reader to Van Bendegem (2014) for a more complete presentation. Imre Lakatos in his seminal book *Proofs and Refutations* was without any doubt the very first not so much to introduce the mathematician into the story (although the book is written as a dialogue between teacher and pupils) as to show that proofs have a "history," i.e., they can change over time, be revised, be rewritten, be rejected, be accepted, and finally (more or less) become stabilized. Turning proofs into objects with a historical record seems an inevitable step closer to the writer of such texts, who therefore also starts to play a role. And this is exactly what happened.

« 5 » One of the outcomes of the development set in motion by Thomas Kuhn (1962) – and mentioned by the author in §19 – has been and still is the focus on scientific practices so as to include all aspects of the scientific process. It has taken a while but the same evolution is now happening in the philosophy of mathematics. I just mention three books, Ferreiros & Gray (2006), Mancosu (2008) and Van Kerkhove & Van Bendegem (2007), as important stepping stones in this development. Examples of questions and problems that are central to this approach are:

a | What makes a proof convincing?
b | How does proof relate to argumentation and rhetoric?
c | How do diagrams function in (understanding) proofs?
d | Can there be experiments in mathematics?
e | What role does the computer play and what impact can it have?
f | Do modern social media have an impact on the development of mathematics?
g | What are the (social and other societal) sources of mathematical certainty?
and so forth.

« 6 » It seems obvious to me that these questions fit quite nicely into a constructivist framework. This supports my second claim that a happy marriage between second-order science and the philosophy of mathematical practices is perfectly possible and that no delay is necessary since the initial work has already been done.

« 7 » To end this short commentary, let me return as promised to the example of homotopy theory, merely as an illustration (without too much detail) of what §5 of this commentary is all about. At first one might think that this is just another foundational theory, but this is not the case for two reasons. The first reason is that the authors who wrote the basic text all collaborated via blogs and other media and everybody involved contributed almost simultaneously so that the author of this text can only be the entire group.[1] The second reason is that they were looking for a foundation that would make it easier to write mathematical proofs in such a way that computer verification would become a standard exercise. As mathematicians are presently dealing with proofs that

1 | For more details, see http://math.andrej.com/2013/06/20/the-hott-book/. The basic textbook is to be found at http://homotopytypetheory.org/book and can be downloaded there.

tend to become longer and longer, the control of the correctness becomes more difficult and hence computer assistance is needed – in short, human-machine interaction is required. Note that what seems to be a traditional, foundational theory at first sight turns into a nice, typical example of second-order mathematics once the mathematicians are brought into the picture. That is precisely what second-order science is all about.

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Second-Order Science is Enacted Constructivism

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> Upshot • Umpleby's approach to second-order science is top-down, and as such, fails to distinguish the cognitive mechanisms that provide the direct enacted link between such science and constructivism. When the idea of "ceteris paribus" holds little meaning to the examined situation, we are in the realm of second-order science, or Science 2. Only Science 2 can deal with emergence, volition, and reflexive anticipation. These three properties are how constructivism gets enacted and provide the foundation upon which Science 2 inquiries rest.

« 1 » Stuart Umpleby's new era of reflexive knowledge (§2) is surely upon us, but in describing the relationship between the fundierungs[1] of this new era and second-order science, he has somehow failed to make explicit the very cognitive mechanisms that underlie that relationship. The purpose of this commentary is to begin to provide the foundation on which Umpleby's claims can comfortably rest.

« 2 » Providing this foundation was the very purpose of a meeting held in May 2013 entitled "Modes of Explanation," which resulted in the book of the same title (Lissack & Graber 2014). Since the fifty plus academics devoted the better part of a week to debating these issues, it seems only appropriate to highlight some of their observations here.

« 3 » Steven Wallis (2014: 202) claims that "Science 1 empiricism and Science 2 logics are of different worlds. They are things and connections. Like yin and yang, they are 'differentiable, yet inseparable.'" Following from the "Modes" conference and book, I would argue that the two sciences are orthogonal – aspects of each are ever present and it is a mistake to attempt to eliminate the one from the other when apprising or cognizing any given situation.

« 4 » Beckett Sterner, commenting on the idea that Science 1 (what I would refer to as "hard science" and Umpleby as "first-order science") is based on physics as an exemplar, suggests that Science 1 "aims for universal, exceptionless laws and axiomatically rigorous theories." Taking Science 2 (Umpleby's "second-order science") as based on the human sciences, with history, sociology, and psychology as exemplars, "narrative takes the place of law, emphasizing contingency and context rather than necessity and universality" (Sterner 2014: 250).

« 5 » However, whenever we discuss the two sciences, we must take Lev Vygotsky's (1997) warning into account: we should not "mix up the epistemological problem with the ontological one." Umpleby suggests that epistemological differences between the two sciences are also accompanied by ontologic differences (§2). The Vygotsky warning applies to Umpleby's labelling (§7 and §11): what makes an activity "science" is how the scientist goes about their inquiry – not their understanding of what "is" in the world (ontology). But that "how" (epistemology) is not so different between the two sciences that we should seek to exclude one from the label "science." Or as Lee McIntyre (2014: 230) notes: "… science is not a subject matter. Neither is it a method. Instead, science is an attitude that can be applied to any field of study. You cannot break things off into different senses of science based on some alleged a priori distinction about what you are studying." Umpleby (§28) agrees with this, it seems.

« 6 » Foundationally, however, where Science 1 and Science 2 differ is in objective and purpose. The hard sciences (Science 1) are marked by "objectivity and a goal of reliable predictivity." In the hard sciences (and as Umpleby points out in §18 with respect to any non-sentient phenomenon), it makes sense to label and categorize via deduction, probabilistic inference, and induction. The world of Science 1 excludes context dependence. By contrast, context dependence is the hallmark of Science 2/second-order science. Here, the objective and purpose are discovery and attunement to context. Where "models of" are the currency of Science 1, "models how" are the currency of Science 2. Here, the scientist seeks to identify relationships, affordances, and potential actions and asks questions rather than seeks to label or categorize.

« 7 » Science 2 explicitly makes room for the context dependencies that Science 1 has excluded. These can be characterized as emergence, volition, reflexive anticipation, heterogeneity, and design, among others. Science 2 embraces the complexities that Science 1 attempts to make simple.

« 8 » Science 1 has a focus on regularities. As such, the bulk of philosophical activity in Science 1 is often based in scientific realism, and the relevant questions explored concern ontology: "Science 1 target[s] objectivity, truth, universal laws, invariance, and context-free descriptions by the use of models of representing" (Faye 2014: 235). By contrast, in Science 2, the focus of scientific inquiry is on the context and contingencies that have provided an environment wherein the "to be explained" occurs despite regularities. It…

> "works with meaning and contexts, with how context influences our thinking and bestows meaning to our actions. This position considers the world in which we live and acts as a result of useful constructions." (ibid)

The related philosophical activity is most often based on forms of pragmatic construc-

1 | I.e., the foundational assumptions that allow one to make use of the mechanisms perceived in the world (Lissack & Graber 2014: 95–104).

What Science 1 is good at	What Science 2 is good at
Dealing with "knowns"	Dealing with "unknowns" & emergence
Decomposition	Network interaction
Discovered, well formed, realistic modeling	Exploring, continually emergent, cybernetic modeling
Risk analysis	Opportunity analysis
Categorization, sensing & matching	Learning, probing & sense making
Operating as planned	Redoing, replanning
Distributing "knowledge" to individual actors	Highlighting co-ordination across systems
History	Reflexive anticipation
Actors differentiated by defined properties	Volition
Responding to planned contingencies	Revising in light of unplanned contingencies
Simplifying the complicated	Narrating the complex

Table 1 • What each of the two sciences is good at.

tivism and the debates concern epistemology rather than ontology. Faye (ibid) cautions: "Like all generalizations, these worldviews only hold at a certain level of abstraction."

« 9 » It is between two such levels of abstraction where Umpleby makes his argument and where I believe that a cognitive methodological foundation needs to be placed underneath. Jan Faye continues, "we often exhibit contrasting cognitive interests in Science 1 and Science 2 because we believe their research objects come into the world by different causes." (Faye 2014: 235). Indeed, if context matters and if the assertion of "ceteris paribus" results in the erosion of meaning associated with a causal claim, then clearly something different is at work than when context can be "bracketed away" and ceteris paribus asserted.

« 10 » Karl Marx (2002) noted: "All mysteries which lead theory to mysticism find their rational solution in human practice and in the comprehension of this practice." Practices and their comprehension across the two sciences are illustrated in Table 1.

« 11 » Table 1 highlights the idea that the human practices that underlie Science 2 are to be found in reflective anticipation, volition, and emergence. These three properties are how constructivism gets enacted and provide the foundation upon which Science 2 inquiries rest. Because of these traits, the phenomena studied by Science 2 are less epistemically tractable than are the phenomena studied by Science 1. That relative intractability gives rise to epistemic uncertainty – uncertainty that those who practice Science 1 tend to reject. Indeed, Science 1 is successful at asserting ceteris paribus in its efforts to fend off such uncertainties. As pointed out in Lissack & Graber (2014: 216),

> "In Science 1, explanations are about regularities and the task is to bracket (to commandeer from Husserl) the contingencies that otherwise can obscure the explained regularity. In Science 2, explanations are about the contingencies that have arisen and thus afforded deviance from expectation – where the expectation is a series of regularities. Contingencies play the role of 'noise' in Science 1 explanations and, along with volitions, the role of protagonist in Science 2 explanations."

These contingencies are the foundational difference between Science 1 and Science 2, which I believe needs greater emphasis than Umpleby provides.

« 12 » The hows and whys that context and contingency get enacted are thus the foundation of Science 2, or second-order science. The assertion of regularities that can be overlooked (and thus the ability to assert ceteris paribus) is the foundation of Science 1. Each foundation holds with respect to some orthogonal portion of the world while failing miserably in other portions, and providing barely adequate explanations/narratives in still others.

« 13 » Methodology in Science 2 makes explicit use of the three epistemologies mentioned by Umpleby (§§4–8). This methodology allows for causal relationships that may be fleeting, temporal, and/or context dependent – relationships that underlie those placed in a typology by Umpleby (§§12–15) at a higher level of abstraction. It is because Science 2 affords the ontological status of "cause" to situations, volition, and context dependency that the practitioners of Science 1 have so much trouble with Science 2. But that "trouble" seems only to extend to their expository articulations. Practitioners of Science 1 live day to day lives that can be seen as examples of enacted sense-making, of attunement to context and to exploration of adjacent possibles. This is how they get to work, interact with peers, and enact their lives – lives that resemble the practice of Science 2 rather than the prediction focused, "true"-cause-seeking expositions of Science 1. To the extent that human life (at least in Western societies) can be viewed as a continued series of experiments, then sense-making, volition, and reflexive anticipation are all prominent features of those very experiments. Umpleby hints at such a perspective (§30 and §33) but fails to base his argument upon the very enacted lives that his intellectual antagonists lead.

« 14 » It is important to note that this is not a claim regarding "enactivism"[2] (Hutto & Myin 2012) or other such related theory. This is a claim that when the limitations of Science 1 regarding emergence, volition, and reflexive anticipation are highlighted and acknowledgement is made of the difference between a focus on reliable prediction (as in Science 1) and attunement to context and adjacent possibles (as in Science 2), then day to day life can be seen as an enactment of the constructivist principles that provide the fundierung for Science 2.

« 15 » Thus, the final point of this commentary: arguments from the "top-down" such as Umpleby's presents attempts to define a problem (§2) for which Science 2 is suggested as a logical "solution." Such arguments can only succeed if the reader/listener agrees with the characterization of the complexity/uncertainty/emergence "gap" as a "problem" and that this said problem demands something other than an incremental solution. Indeed, Umpleby's intellectual opponents might point to such things

2| See, e.g., the conference paper "Constructivism + embodied cognition = enactivism: Theoretical and practical implications for conceptual change" by Douglas Holton at AERA. Retrieved from http://www.academia.edu/232847 as "Moore's law" (Moore 1965) as suggesting that over time Science 1 plus technological improvements can together deal with these issues. I would instead suggest that a "bottom-up" argument can aide in this discussion. Science 2 is enacted by Westerners all the time – including the fiercest advocates for an "only Science 1" approach. By highlighting how we make use of Science 2, we can perhaps bring some enlightenment to the "realist opposition." Science 2 is enacted constructivism. In that everyday all the time enactment lies the intellectual foundation for expanding the concepts we call "science."

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The Promise and Prospects of Second-Order Science

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> Upshot • I support Umpleby's advocacy for second-order science. I argue that the prospects are more optimistic than a superficial reading of Umpleby would suggest. I also argue that Umpleby's proposals imply that radical constructivism and critical realism will evolve towards consilience.

Introduction

« 1 » Stuart Umpleby proposes that the philosophy of science should be extended so that a second-order science can be realized (§§2, 18), and suggests ways to develop and practice it (§§11, 32).

« 2 » The vision for second-order science is to establish a science that is self-critical about its domain and that includes the observer as an element of the system under study. Second-order science is still nascent, but it claims substantive roots in the observer inclusivity of second-order cybernetics (e.g., Foerster 2003) and the critical epistemology of radical constructivism (e.g., Glasersfeld 1995). However, second-order science would go much further than either of these.

« 3 » Both second-order cybernetics and radical constructivism support important concerns of the social sciences, concerns that are poorly served by the methods created for the physical sciences (see Umpleby's abstract). I agree with Umpleby that second-order science would bring new, more appropriate methods to the social sciences and open up important new lines of enquiry (§2). But more than this, I also think, as I discuss further on, that the implications are even more extensive than Umpleby outlines, and will contribute to the resolution of the "science wars," itself a widening of C. P. Snow's problem of "The Two Cultures."

« 4 » Umpleby sees science's aim to be "objective" as a major obstacle for the development of second-order science (§§2, 3), and he is rightly very critical of it (§§5, 20, 29). However, in my view this is less of a *technical* problem than Umpleby implies, and more a matter of *outmoded politics and semantics*, as I explain further on.

« 5 » I agree with Umpleby that such success will hinge critically on developing second-order science in a manner that conforms to the "correspondence principle" (§31), by which any new theory should reduce to the old theory to which it corresponds for those cases in which the old theory is known to hold. However, in my view this pragmatic strategy has metaphysical implications for radical constructivism beyond what Umpleby discusses. I will argue further on that success in developing second-order science will entail moderating radical constructivism so that it engages more optimistically with ontological questions, leading it to evolve towards a kind of critical realist position, even as it further moderates the forms of critical realism in place today.

The political roots of scientific objectivity

« 6 » As Umpleby points out (e.g., §§3, 4, 29), current science's focus on being "objective" and on studying only "the mind-independent world" makes it largely oblivious to the role of the observer in how systems change, and the ways in which the nature and scope of accepted theories impact the evolution of the system of which researchers are part. However, this is not, as might be inferred from Umpleby's treatment, a *fundamental* problem for the emergence of second-order science.

« 7 » Science's focus on "the mind-independent world" originated not in a *technical* commitment of scientific epistemology to a distinction between an objective world accessible to science and a subjective one beyond science, but rather in a *political* move by Descartes aimed at establishing boundaries that would allow scientists to make investigations and publish findings without fear of persecution for religious heresy (Edge 2002).

« 8 » This was a serious issue facing the emergence of science in the socio-politically perilous 17th century. Descartes published his dualistic ideas in 1641, at which point Galileo had been under house arrest for heresy for eight years. It was only forty years after Bruno had been burned at the stake, and 15 years before Spinoza was excommunicated by his synagogue. Galen Strawson argues that Descartes was secretly what we would presently call a "dual aspect monist" – a property dualist but a substance materialist (Strawson 2006: 202–212).

« 9 » Descartes was indubitably a subtle thinker in such matters. In a letter to Hobbes, he says:

> "[…] it is perfectly reasonable […] for us to use different names for substances which we recognize as being the subjects of quite different acts or accidents [contingencies]. And it is reasonable for us to leave until later the examination of whether these different names signify different things [i.e., indicate substance dualism] or one and the same thing [i.e., reduce to a substance monism]" (Descartes et al. 1985: 124, *my insertions*);

…and he conceded to Frans Burman that

> "We cannot claim to have adequate knowledge of anything, including even bodies, and that we are obliged to work within the limitations of our concepts even if we recognize those limits." (quoted in Clarke 2006: 385)

« 10 » From this, it is evident that the historical restriction of science to the study of the physical aspects of the world was politically motivated, and by no means a matter of scientific or philosophical principle. Obviously, the reason for this restriction is now obsolete.

Semantic confusions regarding scientific objectivity

« 11 » Umpleby rightly points out that extending science's interest to include the observer would challenge the objectivity claimed in current scientific practice (see, e.g., §29). However, this practical notion represents an unwarranted narrowing of a more adequate notion of "objectivity" that has been in place in the philosophy of science since the early days of the scientific revolution. This involves perhaps the most significant factor setting science apart from doctrinal religion, namely the principle of independent verification of its truth-claims. "Objectivity" *in this sense* does not entail the absence of cognitive aspects in what is being asserted or modelled, but rather that whatever is proposed should be measurable or operationalizable or demonstrable in some way, so that it can be the subject of scientific theorizing, analysis and practice. The dominant view in contemporary consciousness studies, that mental phenomena involve conceptually coherent phenomena that are physically irreducible (Chalmers 2010), shows that science can in this sense be objective about subjective factors, and that science's allegiance to objectivity does not in principle exclude it from engaging productively with subjective phenomena (see also Searle 1995: 140–197).

« 12 » This philosophically sophisticated perspective on "objectivity" is consistent with classical science, but clearly not in tension with second-order science's commitment to the importance of observers.

« 13 » In the light of these reflections on the obsolescence of historical political and semantic constrictions on the limits of science, the prospects for developing second-order science seem much brighter than they have been historically.

The "science wars" and the correspondence principle

« 14 » Umpleby argues that the transition to second-order science should be unproblematic for science so long as it progresses under the guidance of the "correspondence principle" (§31). I agree, but there are interesting implications to such a progression that Umpleby does not discuss.

« 15 » First, *the point of second-order science* is to provide means of serving the social sciences and humanities as powerfully and coherently as is presently the case in the physical and biological sciences. However, in keeping with Umpleby's advocated adherence to the correspondence principle, such developments will preserve the practical powers of current science, which obviously includes the physical and biological sciences. This has interesting implications, because *these* sciences are grounded in critical realism, and their interest in ontological questions and their resultant metaphysical models contribute in important ways to the ability of these sciences to develop better methods of research and intervention in their domains. Consequently, second-order science's preservation of the powers of these models and methods would require a moderation of radical constructivism's disregard for ontological questions and its allied skepticism about narratives embedding claims about mind-independent realities (see, e.g., Riegler 2001).

« 16 » Second, consistency demands that under the correspondence principle, second-order science also preserves the current capabilities of the social and human sciences. This is interesting because by implication, the move towards a more realistic metaphysics predicated on second-order science's conservation of the powers of the physical and biological sciences must then not undermine the social/human sciences' capacities for critical reflection, tolerance for pluralism in life views, and concern for upholding certain kinds of human rights and values (e.g., Nordenfelt & Edgar 2005; McSherry, Cash, & Ross 2004). The implication is that the critical realism of current science would have to be moderated, extending its premises and methods beyond the physicalism that dominates current science. Encouragingly, pressure towards such a move is already well under way in the philosophy of science (e.g., Gillett & Loewer 2001; Goetz & Taliaferro 2008; Koons & Bealer 2010).

« 17 » The upshot of these two moderating moves predicated on the correspondence principle would be the evolution of a new ontological framework that is consilient between the academic disciplines, preserving what is of value in each magisterium without reducing any one to any of the others. This would achieve a mutually appreciative reconciliation between the natural and social/human sciences of their long-standing divide, resolving the tensions exemplified by the "science wars" and the "Two Cultures" model. Such an outcome is a dramatic prospect raised by the possibility of developing second-order science.

Emerging prospects

« 18 » Achieving this reconciliation is a long-standing ambition of the systems movement (e.g., Bertalanffy 1976: xxiii). However, until recently the way in which such an effort might proceed has been radically unclear, and the philosophical context for such a program has been unfavourable. However, credible arguments and practical proposals about viable philosophical frameworks and practical development programs are now strongly emerging in the systems community, suggesting that the vision of a genuine second-order science is no pipedream (Rousseau 2014a, 2014b; Rousseau & Wilby, 2014; Wilby et al. 2015).

« 19 » Umpleby's focus on expanding the scope of philosophy of science as a way to achieve second-order science is very apt, for it is clear that metaphysical differences between the natural and social sciences present a major hurdle to the emergence of second-order science. However, it is becoming increasingly evident that there are good prospects for the evolution of a consilient philosophical framework that will not only empower the social sciences but enrich the sciences overall, with immense benefits to the traditional concerns of the social sciences and the humanities.

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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 Notturno (§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. Notturno 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 » Notturno (**§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 oriented 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, Notturno 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 brain-storm 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 » Notturno (§§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 Notturno (§§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 management 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 Notturno (§§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 » Notturno (§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 Notturno'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.

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