

SYSTEMIC SOLUTIONS FOR SYSTEMIC PROBLEMS

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“The logic of the world is the logic of descriptions of the world.”

-- Heinz von Foerster

Abstract

The systems sciences and cybernetics emerged in the years after World War II. These fields created many new approaches to engineering and management and contributed new ideas to existing academic fields. The new fields also identified similar concepts across a range of fields and began to create a general theory of systems. In addition the systems sciences created a variety of methods for managing complex systems, for example logistics, operations research and computer simulations. In the 1970s there was concern about population and environment balance. Currently there is increasing concern with governance, since the rate of presentation of problems seems to be greater than the ability of our institutions to manage them. This paper will discuss the history of systems science and cybernetics, the questions formulated and the solutions proposed, the difficulties encountered in finding a home within contemporary universities and some exciting lines of research now underway.

Keywords: General systems theory, cybernetics, systems engineering, complexity, epistemology

1. Introduction

In order to explain the various points of view in systems science and cybernetics, I shall present descriptions on three levels: The first level, on the bottom, is the world we want to describe: technology, population, pollution, climate change, diseases, inequality. The second level, above the first, is science, which we use to organize our knowledge of the world: physics, chemistry, biology, economics, psychology and systems science. The third level, above the second, is philosophy: ontology (what exists),

epistemology (how we know what exists) and philosophy of science (our conceptions about how to create scientific theories).

People create scientific theories because they want to understand the world and because they want to be more effective in achieving their purposes. Theories are helpful because they are parsimonious, meaning they explain a large number of phenomena with a small number of statements. Heinz von Foerster once said that science is the observer's digest. If people are having difficulty solving problems (at level 1), it

may be because they have insufficient knowledge (level 2) or it may be because their rules for creating knowledge need to be modified (level 3).

We usually assume that systemic problems exist in the world and that systemic solutions come from science. But some systemic problems may lie in our conception of science. Perhaps we have trouble finding systemic solutions because our conception of science is too narrow or too limited. In this paper about finding systemic solutions to systemic problems, sometimes I shall be describing problems in the world (level 1). Sometimes I shall be describing changes in science (level 2). And sometimes I shall be describing a change in our thinking about what science is and how to practice it (level 3).

Lately scientists in the U.S. and Europe have been rethinking the conception of science. Thinking about philosophy of science may seem to be far removed from systemic problems like reducing pollution or increasing per capita income or preventing climate change. Why should we pay attention to philosophy? Although the current conception of science has worked well in solving problems in the natural world, as attention has shifted to social systems and purposeful systems in general – individuals, groups, organizations, nations, and some machines – the earlier conception of science has proved to be too limited.

Early methods in systems science often used mathematics and computers. The emphasis was on lowering costs and optimizing processes. Later work often focused on understanding stability and instability in complex systems (Umpleby 2010) or on group facilitation methods for achieving agreement on appropriate actions (Umpleby 2015). Partly because of a steady

stream of new information technology, increasingly managers are confronted with the need to change work processes. They need methods for communication and decision-making that help people work together smoothly.

The effort to create theories of purposeful systems has revealed differences in the conception of science in the U.S. and Europe. American and European scientists usually assume that their conceptions of science are the same. However, in Europe the sciences are thought to have grown out of philosophy. For example, Adam Smith (1776), who founded the field of economics with his book *The Wealth of Nations*, was a professor of moral philosophy. In Europe there are several philosophical traditions, for example French rationalism, German idealism, and British empiricism. In the U.S. philosophy is seen as one of the humanities and is not usually regarded as essential to an understanding of science. Among most scientists and engineers in the U.S. a philosophy of realism is assumed to be the only correct point of view. Realism is the belief that objects are independent of the human mind or language or our observing them and the faith that this view is correct. Idealism is the belief that ideas are primary, not the world, because we have immediate access to the ideas in our minds. The world, on the other hand, we know through our senses, which can be mistaken. For example, we sometimes see a “lake” on a road in the summer time. Constructivism, the belief that the mind constructs an image of the world on the basis of experiences and interpretations, is closer to idealism than realism. Because they have more education in philosophy, Europeans often approach a scientific problem

with a larger set of conceptual possibilities than do Americans.

2. Some Current Systemic Problems

In the 1960s and 1970s there was increased interest among academics from many countries in the “world problematique” – population, resource depletion, food production, industrial development, and pollution (Boulding 1964, Meadows et al. 1972). These are problems at level 1. In October 2015 these topics were discussed at a Conference on Energy, Environment and Commercial Civilization held in Chengdu, China. The primary concern continues to be that the current use of resources is greater than what is sustainable in the long term. Ocean acidification, loss of top soil and species extinctions are just some of the signs that human actions are reducing the carrying capacity of the Earth. And since burning fossil fuels contributes to climate change, the sea level is expected to rise by a meter or more by the end of this century. Protection of coastal cities will be required (sealevel.climatecentral.org).

The challenges of economic development within the context of environmental uncertainties, is putting new stress on government structures and processes. The number of failed states is growing (Brown 2003, 2011). Failed states are countries where the government is not operating well enough to insure the safety of citizens. There are, increasingly, religious wars. Migration to avoid violence and governmental instability has affected several countries. There is increasing inequality in incomes and wealth in some countries (Pikety 2014). Weak governments are present in many countries, regions and the world

as a whole. The global financial system is largely unregulated. And, as illustrated by the recent financial crisis, there are inadequate theories and monitoring of economic and social systems.

Solutions have been proposed to many of these problems. There are efforts to capture or store carbon to slow or prevent climate change. Educating women has been shown to improve the health and education of families, to reduce the number of children and to increase family incomes. Process improvement methods increase the productivity of organizations. There are efforts to increase recycling and to treat wastes as resources. Individuals, businesses and governments are adopting these solutions and new businesses are being created to spread the use of new solutions.

The financial system is also being redesigned. Some recommendations are a tax on financial transactions to fund bank regulation and/or international development projects. Banks that are so big that the government could not allow them to fail, else the economy would collapse, could be broken up. Rather than taxing labor, the use of resources could be taxed, thus encouraging jobs and recycling. Economic theory could be modified from a presumption of stability to a presumption of instability due to positive feedback loops, sometimes called “animal spirits.” There are a few websites that list solutions: The Alliance for Sustainability and Prosperity, www.asap4all.com; the Club of Rome, www.clubofrome.org.

Of course, implementing solutions is much more difficult than inventing them. Any change in the existing pattern of social relationships will encounter some opposition. And powerful

interest groups usually act to enhance, not simply preserve, their privileged positions. Perhaps the most challenging systemic problem is maintaining an innovative society with a fair distribution of wealth in the presence of powerful groups that seek additional advantages for themselves.

A variety of obstacles prevent the implementation of helpful actions. Sometimes the problem is not having a solution, for example a vaccine against an infectious disease. Sometimes the problem is insufficient resources such as not having enough doctors and health clinics to meet the need. Really large problems, such as climate change, require a shift to more sustainable sources of energy and major changes by many organizations.

Fortunately, there is now a widespread recognition of the need to improve the sustainability of human civilization. We no longer assume that the human population can continue to grow indefinitely on a finite planet. We no longer assume that air and water are so abundant they are “free goods.” An increasing number of people no longer think that economic systems are self-regulating and require no government oversight. There is now a more scientific approach to societal improvement. Rather than seeking to implement a political ideology, governments increasingly adopt strategies of “piecemeal social engineering,” treating reforms as experiments, and continuing successful programs while ending unsuccessful ones (Campbell 1988). Inventing and testing reform proposals is increasingly done by corporations, governments, and international organizations. Results of experiments are discussed at policy meetings, and reports are

shared on-line.

The number of universities is growing and their quality is improving. Our ability to manage our societies and the planet is improving. The question is whether we are learning fast enough in order to solve problems before they cause substantial disruption, for example through the forced migration of large numbers of people due to sea level rise. Are our institutions keeping pace with new problems by devising and implementing new solutions?

3. Branches of Systems Science

In the years after World War II several centers or institutes in systems science were established on university campuses in the U.S. and in other countries. Each center was guided by one or a few faculty members who had a particular interest and devised unique solutions in the form of theories or methods. Eric Dent has pointed out that a set of eight assumptions distinguish the work of these centers from earlier disciplines (Dent and Umpleby 1998). There was a move a) from reductionism to holism; b) from entities to relationships, c) from environment free descriptions to including the environment; d) from order that is designed to order that occurs automatically through self-organization; e) from deterministic to probabilistic systems; f) from systems composed of inanimate objects to systems composed of knowing subjects; g) from linear causality to circular causality; and h) from not paying attention to the observer to including attention to the observer (the scientist).

These eight assumptions are important for two reasons. First, they show how the systems sciences are different from earlier schools of

thought. Second, they help us to understand why the systems sciences did not come together as a unified field: different research centers had different concerns. In addition to working with different assumptions, the groups had different goals (Umpleby and Dent 1999). They were asking different questions, so they created different theories. I shall describe several of these groups to indicate the key authors and their primary interests.

The General Systems Theory movement, initiated by Ludwig von Bertalanffy (1968), was based, in the U.S., primarily at the Mental Health Research Institute (MHRI) at the University of Michigan. It was a very interdisciplinary group. The director of MHRI, James G. Miller, looked for similarities among living systems and organizations in their matter-energy and information processes. He identified several levels of living systems – cell, organ, organism, group, organization, nation and supranational system, and he suggested that in every living system similar structures and processes could be found (Miller 1978). For matter–energy the processors are: ingestor, distributor, converter, producer, storage, extruder, motor, and supporter. The processors of information are: input transducer, internal transducer, channel and net, decoder, associator, memory, decider, encoder, and output transducer. There were several other well-known scholars at MHRI. Kenneth Boulding (1978) described the similarity between biological evolution and the evolution of social and economic systems. John Platt (1966, 1970) wrote a series of essays on the contributions of science and technology to human development. Richard L. Meier (1962, 1974) examined the role of cities in economic

development. Anatol Rapoport was a leading contributor to game theory (1960). *General Systems*, the annual yearbook of the Society for General Systems Research, was edited by Rapoport at MHRI for several years.

The Systems Approach was developed originally at the University of Pennsylvania. Key scholars were E.A. Singer, Jr. (1923, 1924), C. West Churchman (1968) and Russell Ackoff (1972, 1978). The early work founded the field of operations research. Later they developed conversational methods, such as Ackoff's Interactive Planning (1981). A key idea in the systems approach is that optimizing each part of a system independently will not lead to a system optimum, and attempting to optimize each part will probably worsen the performance of the whole (Churchman 1968). This work was widely known in the field of management in the 1970s, 1980s, and 1990s. A very important but less well-known part of their work is that both Singer (1923, 1924) and Churchman (1971) described various philosophical perspectives. This work greatly expands the conceptual approaches one can use in analyzing systems.

Organizational Learning was a field developed primarily at Harvard University and MIT. It was influenced by the work of Ross Ashby (1952) and Gregory Bateson (1972). Chris Argyris (1985, 1993, 1999), Donald Schon (1973, 1985, 1987, 1994) and later Peter Senge (1990) were leaders. This work was guided by an analogy between individual learning and organizational learning. Their ideas were based primarily in psychology. The work on organizational learning has been influential in management and education.

Quality Improvement Methods were

developed in the U.S. in the 1930s. They were taken to Japan in 1950 and then were influential again in the U.S. after 1980 (Walton 1986). Walter Shewhart (1931, 1939), Edwards Deming (1986, 2000), and Joseph Juran (1951, 1964) were leaders in developing these methods which became the most influential management methods of the last half of the 20th century. The idea was to use statistics in monitoring processes so managers would know when to intervene and when not to. The procedure for making improvements is to define a process, brainstorm improvements, select one idea and test it, either adopt and further test it or discard it and then test another improvement idea. This method is widely taught in corporate training programs, but less often in universities. It is puzzling why these methods are not the foundation for all of management education in universities. Probably the reason is that no field in management, except perhaps project management, takes ownership of these methods and many fields feel threatened by them.

System Dynamics, a method of analysis and computer simulation, was developed at MIT by Jay Forrester. His books *Industrial Dynamics* (1961), *Urban Dynamics* (1969), and *World Dynamics* (1973) were all very influential. Currently there is an effort to teach system dynamics in grade schools and high schools. Positive and negative feedback diagrams are a widely used systems method for identifying stable and unstable systems.

The fields of systems science have not yet come together as a well-integrated whole, primarily because they have lacked a continuing presence on university campuses. Other than the fields of systems engineering, cognitive studies,

communications and complex systems, multi-disciplinary fields have had difficulty establishing themselves in universities in the US.

In the 1980s and 1990s almost all the university centers and institutes devoted to systems science closed when their founders retired and died. Many of the founders were scholars from Europe who had come to the U.S. before, during, or after World War II. They had a more theoretical and philosophical approach to research than did the practice-oriented Americans (Umpleby 2005). Some of the ideas from systems science and cybernetics continue to be present on university campuses in a wide range of fields – engineering, psychology, management, and literature to name a few. But systems science as a subject itself for university courses largely disappeared in the U.S. during this period. However, journals in the field prospered and even grew as a result of articles submitted by people who were teaching in a wide range of fields, but writing about systems science.

4. Complex Systems

A more recent research group is the Santa Fe Institute in New Mexico, founded in 1984 (Waldrop 1992). Their interest is primarily in developing mathematical and simulation methods with some interest in theory and philosophy as well (Arthur 2014, Holland 1995, Kauffman 1995). Agent-based modelling is a new simulation method developed by this group (Hamill and Gilbert 2016). A few people have had contact with more than one group – systems science, cybernetics, or complex systems -- but on the whole the three fields have developed

independently with their own journals and associations. There is more communication between systems science and cybernetics than between either of those groups and complex systems. Probably due to the absence of academic programs in the field, the research that uses the name “complex systems” has been slow to discover the earlier work. And the fields of systems science and cybernetics have been slow to adopt the methods developed in complex systems. Each group rarely cites the work of the other two groups. The methods developed in the field of complex systems have functioned as if they are contributions to statistics and computer simulation.

The original motive for developing the systems sciences and cybernetics was not just problem solving. There was also a search for general theories of living systems, of purposeful systems, and of cognition. In addition there was the desire to develop the social sciences. I shall now describe the history of cybernetics since World War II.

5. A History of Cybernetics

The field of cybernetics is one of the systems sciences, but its development in the U.S. has had an independent trajectory because it has developed an alternative epistemology. Following World War II there was excitement about the utility of applied science and numerous academics wanted to discuss their wartime experiences. One example was the Josiah Macy, Jr. Foundation conferences in New York City, 1946-1953. They were chaired by Warren McCulloch (Pias 2003). The title of the conferences was “Circular Causal and Feedback Mechanisms in Biological and Social Systems.”

The shorter name of “cybernetics” was adopted after Norbert Wiener’s book was published in 1948.

Gregory Bateson (1972, 2002) and Margaret Mead (1964, 1967), two influential members of the Macy conferences, thought that the new ideas of feedback and circular processes would help the social sciences to advance by using ideas and methods being developed by philosophers, biologists, physical scientists and engineers (Kline 2015).

McCulloch, Rosenblueth, Maturana, and von Foerster wanted to understand cognition. The intent was to test available theories of knowledge from philosophy by studying the operation of the nervous system, hence, test philosophies using science. McCulloch called this work “experimental epistemology.” They sought to test various theories of knowledge from philosophy using neurophysiological experiments (McCulloch 1965, Foerster 2003).

Cyberneticians have tried to create a common foundation for the social sciences by focusing on circular causal and feedback mechanisms initially and later by emphasizing perception, cognition, knowledge, autonomy and understanding. In recent years there has been increased attention to reflexivity. Vladimir Lefebvre has created a theory of human reflexion that includes two systems of ethical cognition (1977, 1982). George Soros’s theory of reflexivity connects cybernetics to economics and finance. He notes that people not only observe, they also act and participate (Soros 1987, 2014).

There were other schools of thought within the field of cybernetics. Gordon Pask (1975a, 1975b), who was based in the UK, created

conversation theory. He worked on developing prototypes for teaching machines. However, his teaching machine would not just pose problems and grade answers. The machine would also build a model of each student – what the student knew already and what the student’s learning style was. Pask’s student Ranulph Glanville, when he was president of the American Society for Cybernetics from 2008 to 2014, connected the fields of cybernetics and design (2014). Paul Pangaro (2016), another former student of Pask, spent some time at the MIT Media Lab and has designed interactive museum exhibits.

Humberto Maturana (1975, 1978, 1992) and Francisco Varela (1991, 1999) worked on the question, What is life? They answered by inventing the terms *allopoiesis* (other production) and *autopoiesis* (self-production). These terms can be illustrated using the analogy of a business firm, such as the Ford Motor Co. We could say that a customer views Ford as an *allopoietic* system. It produces something other than itself, namely automobiles. However, the managers of Ford are most concerned with maintaining the company as a *viable* system. They must hire, train, and supervise employees, purchase raw materials, schedule production, find customers and deliver cars to them. The Ford Motor Co. is an *autopoietic* system in that it produces and maintains itself through its structures and processes. Maturana and Varela created the term “*autopoiesis*” to describe the functioning of a biological organism (1975, 1978, 1992). An organism must maintain itself as a *viable* entity through a set of structures and processes which function to create and maintain those structures and processes. Similarly, cognitive processes, such as the development of self-confidence,

enable individuals to create and maintain themselves psychologically.

Stafford Beer, a management consultant and friend of McCulloch, Ashby, Pask and Maturana, created a model of an organization based on the structure of the human nervous system. He called it the *Viable System Model* (1972, 1979, 1985). Beer used this model in his consulting work with business and government organizations (Madina 2011). Raul Espejo (1989, 1996, 2011), Markus Schwaninger (2008) and others have extended Beer’s work.

The key difference between systems science and cybernetics lies in the treatment of information, the conception of knowledge and the choice of epistemology. People in systems science have sometimes used a transportation analogy for information. That is, they see a message as being like a train that enters a station. Cars or words or ideas are moved around, some are stored and then a new message or train leaves the station. Cyberneticians have taken a more philosophical approach to information. They have focused on meaning in addition to signaling and autonomy in addition to knowing. These additional reflections on information enable the solving of deeper problems and call attention to ethics.

6. Neurobiology and Epistemology

Studying the brain to understand processes involving information and regulation began at MIT in the work of McCulloch, Wiener, Rosenblueth, Maturana, and others from the 1940s to the 1960s. The theoretical and philosophical work on cybernetics at MIT largely ended when McCulloch and Wiener both died in the 1960s. Thereafter work on the biology of

cognition and philosophical cybernetics continued at the Biological Computer Laboratory (BCL) at the University of Illinois in Urbana-Champaign. The director of BCL was Heinz von Foerster. Other scholars were Ross Ashby (1956) and Gotthard Gunther (1978). Frequent visitors were Humberto Maturana (1975, 1978, 1992), Francisco Varela (1991, 1999) and Gordon Pask.

If one is interested in systemic solutions to systemic problems, why study the brain?

Abraham Lincoln once said (approximately), "If I have 3 hours to cut down a tree, I'll spend the first 2 hours sharpening the blade." The brain is the principal tool that we use to solve problems. If we do not know how it works, we shall not be very good at using it. And if our conception of how the brain works changes, our approach to research, education and ethics may change as well (Foerster 2003).

Here are some examples of how the nervous system works.

1. When you listen to a speech given by a person who speaks your language with an accent, you may find that you have to listen very carefully in the beginning to understand what is being said. After 10 or 15 minutes of listening closely, you may find that you are not working as hard to understand. Your brain has learned an algorithm which makes it easier for you to understand.

2. When you enter a cocktail party, there are many conversations you could join. You could join the conversation in front of you, to the left of you or to the right of you. Probably you have had the experience that you can listen to each conversation for a few minutes and then decide which conversation to join. Although the sound

waves from all three conversations, and others, were impinging on your ears, you could focus on each conversation, probably without turning your head. Hence, you were able to control the attention of the brain even if you did not know how you did it.

3. When you look at a person standing in front of you, simply due to optics, that person's head is at the bottom of your retina and the feet are at the top of your retina. But you perceive the person as being "right side up." Your brain has experience moving in the world and creates an appropriate image.

4. A common experiment in introductory psychology classes is the blind spot experiment. Make two spots on a sheet of paper. Close your left eye and focus your right eye on the spot on the left. Now move the piece of paper slowly close to your eye and farther away. There will come a time when the image on the right disappears. This happens because there are no receptor cells in the retina at the point where the optic nerve leaves the retina. There is a lack of sensation at that point. Since the surrounding area is white, the brain fills in the space with the color that surrounds it.

5. Put your fingers below your eyeballs and gently move your eyeballs within your head. If you do this correctly, you will see the room jump around in front of you. Using signals from your eyes and from your muscles, your brain normally "computes a stable reality." Moving the eyes relative to the head disrupts the normally stable reference frame.

These and similar experiments illustrate that the brain helps us in many ways that we are not aware of. The brain "constructs a reality" based on many sensory inputs. Since people have

different experiences – language, home life, culture, religion, academic training, and job experiences – each person’s “reality” is in some respects unique, though our knowledge of the physical and social world has many common features.

These and many more neurophysiological experiments provide the biological foundation for second order cybernetics (Foerster 1973). The experiments are important for philosophy of science because they show that “observations independent of the characteristics of the observer” are not physically possible. The idea that descriptions can be independent of an observer can be regarded as a hypothesis that has been tested by experiment and disproven. This is quite a different view from what is assumed in a realist philosophy of science. As Maturana and von Foerster have pointed out, “Every statement made is made by an observer to an observer.” Our experiences are interpreted using conclusions we have drawn from earlier experiences.

In 1974 Heinz von Foerster proposed the term “second order cybernetics” as a new development in cybernetics that would focus on including the observer in scientific research (Foerster 1979). Several definitions of first and second order cybernetics were proposed in the 1970s and 1980s. See Table 1.

By the 1990s the field of cybernetics had generated three areas of interest - engineering, the biology of cognition and management of social systems. The early work in cybernetics guided work in engineering, including computer science and systems engineering. The early interpretation of second order cybernetics

focused on the biology of cognition and could be called biological cybernetics.

Table 1 Definitions of first and second order cybernetics

Author	First Order Cybernetics	Second Order Cybernetics
Von Foerster	The cybernetics of observed systems	The cybernetics of observing systems
Pask	The purpose of a model	The purpose of a modeler
Varela	Controlled systems	Autonomous systems
Umpleby	Interaction among the variables in a system	Interaction between observer and observed
Umpleby	Theories of social systems	Theories of the interaction between ideas and society

In 1956 there had been a split between those interested in cybernetics, learning and cognition and those interested in artificial intelligence, who wanted to build machines and write computer programs. Those who were interested in management and sociology constituted a third group who worked on social cybernetics. When the observer is included in the work on social cybernetics, that field can also be considered part of second order cybernetics. See Table 2.

These three points of view (engineering cybernetics, biological cybernetics and social cybernetics) taken together constitute an expansion of science, because the observer, both biologically and socially, was taken into consideration.

Table 2 Three versions of Cybernetics

	Engineering Cybernetics	Biological Cybernetics	Social Cybernetics
The view of epistemology	A realist view of epistemology: knowledge is a “picture” of reality	A biological view of epistemology: how the brain functions	A pragmatic view of epistemology: knowledge is constructed to achieve human purposes
A key distinction	Reality vs. scientific theories	Realism vs. constructivism	The biology of cognition vs. the observer as a social participant
The puzzle to be solved	Construct theories which explain observed phenomena	Include the observer within the domain of science	Explain the relationship between the natural and the social sciences
What must be explained	How the world works	How an individual constructs a “reality”	How people create, maintain, and change social systems through language and ideas
A key assumption	Natural processes can be explained by scientific theories	Ideas about knowledge should be rooted in neurophysiology	Ideas are accepted if they serve the observer’s purposes as a social participant
An important consequence	Scientific knowledge can be used to modify natural processes to benefit people	If people accept constructivism, they will be more tolerant	By transforming conceptual systems (through persuasion, not coercion), we can change society

One way to understand these three varieties of cybernetics is to view them in relation to the epistemologies they use. Karl Popper (1978) suggested that there are three “worlds.” World 1 is the *world* that we observe. See Figure 1. World 2 is the ideas in the mind of an *observer*. World 3 is the *descriptions* of the world that are presented in scientific articles and are stored in libraries. In Figure 1 the three sides of the triangle correspond to three epistemologies and also three emphases in the history of cybernetics – engineering cybernetics, biological cybernetics, and social cybernetics. The left side of the triangle connecting “world” and “description”

represents a realist view of science and also first order cybernetics. In this epistemology the “observer” is excluded from discussion. The goal is to create unbiased or objective descriptions by eliminating any influence of the observer on descriptions. The bottom of the triangle connecting an observer and a description represents biological cybernetics or an early version of second order cybernetics. In this epistemology the “world” is deemphasized, since an image of the world is present in the mind of an observer, based on his or her experiences and interpretations. Referring not to the world but rather to perceptions of the world is thought to be

more accurate.

Social cybernetics, which emphasizes the relationship between an observer and the world, is a third conception of knowledge. Observers of social systems, such as managers of firms, are aware of their role as actors in social systems but often do not think in terms of theories or philosophies. They usually prefer procedural rules or methods (Umpleby 2002). Hence, the third epistemology deemphasizes descriptions. The emphasis is on methods to guide actions in the world.

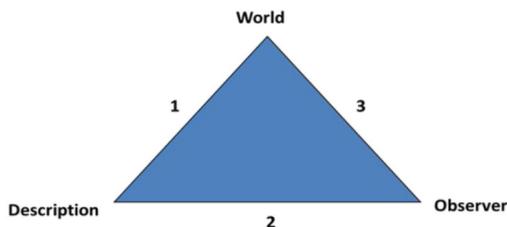


Figure 1 Popper's three worlds

The classical approach to science would be the left side of the triangle. Originally second order cybernetics was associated with biological cybernetics, the bottom of the triangle. More recently second order cybernetics has meant the whole triangle, that is, it includes both the biological and the social aspects of observation. Second order cybernetics thus constitutes a theory of epistemologies. The three epistemologies are different in that they focus on different aspects of knowledge. Second order cybernetics can be seen not as a competitor to realism but as an alternative view of knowledge that unites three epistemologies – realism, constructivism and pragmatism (Umpleby 2007). By considering the purposes of all three aspects of knowledge, more holistic descriptions are

possible.

One way to understand how cybernetics has contributed to the expansion of science is to consider the Correspondence Principle. The Correspondence Principle was proposed by Niels Bohr during the development of the quantum theory (Bohr 1913, Krajewski 1977). It states: 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. In other words a new dimension is added that previously was not considered or was thought to be insignificant. All the data that was consistent with the old theory is also consistent with the new theory.

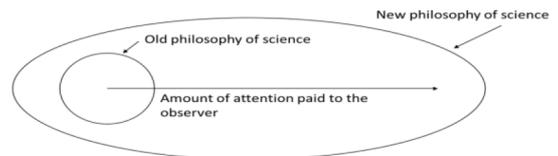


Figure 2 An example of the correspondence principle

If a new dimension is added to a scientific field, it expands the field. The problems the field can address increase and knowledge can then increase. Second order cybernetics, which suggested that the observer be added to what is observed, expanded the field of cybernetics in the mid-1970s. Work to develop the implications of this idea continues (Foerster 2014, Riegler and Mueller 2016).

For several decades social scientists have tried to imitate the physical sciences. Physics was regarded as the leading example of how to do science. In cybernetics the intent is to expand science so the physical sciences become a special case of a larger conception of science that includes purposeful systems. Studies of

inanimate objects become a special case (Umpleby 2014).

7. Current Work on Reconceptualizing Science

Two trajectories for advancing second order cybernetics have been the work on cybernetics and design (Glanville 2014) and the work on second order science (Riegler and Mueller 2014). Recently there have been several efforts to reconceptualize science. Ben Shneiderman (2008) defined science 2.0 as the result of how science is changing in response to the internet. An Office on Science of Science and Innovation Policy was created in the U.S. National Science Foundation a few years ago to improve our understanding of how science contributes to society. A meeting on the Science of Science was held at the Library of Congress in Washington, DC, in April 2016. It focused primarily on citation analysis as a method for understanding the scientific process. There was also concern about the lack of reproducibility of results in fields like medicine (Ioannidis 2005).

Karl Mueller's approach to second order science is to note that there are now three levels of scientific activity (Mueller 2016). Zero order science is concerned with science infrastructures, such as libraries, databases, telescopes, particle accelerators and satellites. The amount and cost of this equipment has grown dramatically in recent decades, stimulated in part by the need to monitor climate change. First order science for Mueller is the way most science is done now. Second order science would operate not on data directly but rather on scientific reports. It is similar to meta-analysis (Mueller 2014).

A second approach to reconceptualizing

science is to reflect on basic assumptions and occasionally add a new dimension to our conception of science (Umpleby 2014). A third approach to reconceptualizing science is to study how scientific ideas change social processes as they are translated into action by purposeful systems (Umpleby 2015).

Philosophers of science usually neglect this last approach. They place the scientist outside the system observed. But adding the observer to what is observed places the observer within the observed system. This point of view is particularly relevant for social systems. People in social systems both observe and participate (Soros 1987, 2014). The decisions people make change the way that social systems operate.

These various points of view of science 2.0, science of science, and second order science are bringing about a wide-ranging reconsideration of our conception of science. In recent years the people working on cybernetics no longer seek to use the physical sciences to guide the social sciences, rather they are working to expand the conception of science so that it more adequately encompasses the social sciences. There are two assumptions that scientists currently make that need to be altered if the social sciences are to be successful (Umpleby 2014).

First, in classical science (not including quantum mechanics and relativity theory) the observer can be excluded. This choice is made because scientists are trying to be objective, and they assume that if an experiment is done correctly, all observers will see the same things. But in social systems the observer matters. A message is interpreted differently depending on who says it and who hears it. Furthermore, complexity is observer dependent. What is

complex for one person may be simple for another person and vice versa.

Second, in classical science theories do not alter the system observed. The behavior of atoms and molecules is not influenced by what scientists say about them. But in social systems theories do change the system described. When Adam Smith described an economy and some people acted on his ideas, economic systems changed. When Karl Marx described social systems and some people acted on his ideas, social systems changed. In social systems there is a dialogue between ideas and societies.

If science expands by including these two considerations, there will be greater success in developing a science of social systems. The old conception of science, a science of inanimate objects, would be a subset of the new conception of science, which includes purposeful systems – individuals, groups, organizations, nations, and some machines. Just as physics provides a general theory of matter and energy, cybernetics provides a general theory of information and regulation. Today individuals, organizations and societies rely heavily on science for systemic solutions to systemic problems. New possibilities for research in the social sciences will mean advances in the social sciences at a time when they are greatly needed.

To return to my opening statements, as we work to develop systemic solutions to systemic problems, it is helpful to reflect on what we know on at least three levels – knowledge of the problem at hand, scientific knowledge about similar problems, and our conception of science and how we may need to modify it in order to increase our capabilities.

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