UMPLEBY STUART RECONSIDERING CYBERNETICS

The field of cybernetics attracted great attention in the 1950s and 1960s with its prediction of a Second Industrial Revolution due to computer technology. In recent years few people in the US have heard of cybernetics (Umpleby, 2015a, see Figures 1 and 2 at the end of Paper). But a wave of recent books suggests that interest in cybernetics is returning (Umpleby and Hughes, 2016, see Figure at the end of Paper). This white paper reviews some basic ideas in cybernetics. I recommend these and other ideas as a resource for better understanding and modeling of social systems, including threat and response dynamics. Some may claim that whatever was useful has already been incorporated in current work generally falling under the complexity label, but that is not the case. Work in cybernetics has continued with notable contributions in recent years. Systems science, complex systems, and cybernetics are three largely independent fields with their own associations, journals and conferences (Umpleby, 2017).

Four types of descriptions used in social science

After working in social science and systems science for many years I realized that different academic disciplines use different basic elements. Economists use measurable *variables* such as price, savings, GDP, imports and exports. Psychologists focus on *ideas*, concepts and attitudes. Sociologists and political scientists focus on *group*s, organizations, and coalitions. Historians and legal scholars emphasize *events* and procedures. People trained in different disciplines construct different narratives using these basic elements. One way to reveal more of the variety in a social system is to create at least four descriptions – one each using variables, ideas, groups, and events (See the figures and tables in Medvedeva & Umpleby, 2015). Creating four quite different descriptions of a system reduces the chance that something important will be overlooked.

Combining the four types of descriptions

Furthermore, acting to change a social system implies using all four types of descriptions. Usually one begins by observing the system to assess its performance and operation. After studying the system using *variables*, one develops one or more *ideas* about how it might be improved. Then it is necessary to assemble a supportive *group* to discuss aspects of the idea, obtain needed resources and conduct experiments to test improvement ideas. Assuming the experiments are successful, one then seeks a noticeable change in the form of an *event*, for example, obtaining approval for a change in procedure, creating a new organization or passing a piece of legislation. Following implementation of the change, the organization is assessed again using *variables* and the cycle repeats. Note that the various social science fields focus on just part of the process of social change.

Three models used in cybernetics

Whereas the descriptions created by the traditional disciplines are based on the kinds of elements. The models created by cyberneticians are distinguished by their structures. Three ideas are used by cyberneticians when modeling social systems. The first model assumes there are two elements – a regulator and the system being regulated. Examples are a driver and a car, a manager and a business firm and an architect and the plans for a building. The Law of Requisite Variety (Ashby, 1952) suggests a quantitative relationship between the regulator and the system being regulated: If successful regulation is to be achieved, the variety in the regulator must be at least as great as the variety in the system being regulated. This law provides the foundation for strategies to amplify management capability. The key to amplification of capability is that the regulator can define those aspects of the system that are to be regulated. Then a hierarchy of conceptualization is constructed. For an explanation of how it is possible to regulate a large social system, such as the world economy, see Umpleby (1990).

The second model uses the principle of self-organization and assumes there are a large number of elements in the system (Foerster, 1960; Ashby, 1962). The elements interact according to rules. By changing the interaction rules the equilibrial states that the system goes to can be changed. Examples are a chemical process, an educational system for children, an incentive system for sales people or laws that are enforced by police and courts. The principle of self-organization leads to a general design rule: In order to influence any system, expose it to an environment such that the interaction rules between the elements and their environments move the elements in the direction you want them to go. This idea is the foundation for simulations of complex systems.

The third model is a reflexive model. It uses the idea of reflexivity. Reflexivity assumes that the observer or actor is not outside the system but rather is an element of the system. The essential feature of this model is that the actor operates on two levels – both as an observer/ designer of the system and as a participant in the operation of the system. This model is particularly helpful in understanding the role of ideas in society (Soros, 1987).

I find that any problem or dissertation topic in a social science field can be described and analyzed using each of these three models. Each model has a supporting literature with examples. These models can be used in social science, engineering, or management.
Table 1 arranges the four basic elements and the three models in a matrix. The basic elements indicate the existing social science disciplines: *Variables* are used by economics and demography; *Ideas* are used by psychology and cultural anthropology; *Groups* are the province

Table 1. Traditional Disciplines vs. Systems Science

Model > ***Elements*** \/	**Regulation**	**Self-Organization**	**Reflexivity**
Variables (economics)	Use of system dynamics models and statistics	Many variables with well-defined relations	Who chooses the variables is a primary concern
Ideas (psychology)	Promoting or selling an idea in an effort to persuade buyers or voters	Rules of interaction among ideas or products	Who is the client? Who is the modeler? Self-awareness
Groups (sociology and political science)	How to assemble a winning coalition?	Interaction rules, cultural and religious beliefs and norms	Redefining and realigning a coalition
Events (history and law)	Steps needed to start a company or pass a law	Self-organizing systems, complex systems, agent based models	A retreat, a sabbatical, time for reflection
Newer academic fields	Systems engineering, first order cybernetics	Self-organizing systems, complex systems	Second order cybernetics, reflexivity theory

of sociology and political science; *Events* are treated by history and law. The three models across the top indicate the three branches of current systems science – systems engineering, complex systems, and cybernetics. Each of the three models has a modeling language. For systems engineering and first order cybernetics it is system dynamics. For complex systems it is agent-based modeling. For second order cybernetics and reflexivity theory there is no specific mathematical approach. Currently reflexive systems are represented in a variety of ways, including the algebra of Vladimir Lefebvre (1982) and the work of Louis Kauffman (2016). Reflexive systems are purposeful systems. Hence, participation is emphasized (Umpleby, 2015b).

Two conceptions of cybernetics

It is important to understand that there are two conceptions of cybernetics. Most people, if they have heard of cybernetics, associate it with computers, information technology and robotics. But the field began in the late 1940s and early 1950s, when scientists were working to understand communication and regulation in biological and social systems (Wiener, 1948, 1954; Pias, 2003). Some scientists sought to embody those principles in computers and information technology. That engineering effort has been very successful, and many people have forgotten that the other, earlier part of the field is the development and testing of theories of cognition, learning, and adaptation whether these occur in organisms, societies or machines.

Cybernetics is a transdisciplinary field that has influenced and been influenced by many fields including neurophysiology (Maturana, 1975), psychology (Watzlawick, 1983), engineering (Sage, 1992), management (Beer, 1972; Ackoff, 1981; Schwaninger, 2008), mathematics (Wiener, 1948; Kauffman, 2016), political science (Deutsch, 1966), sociology (Buckley, 1968), economics (Soros, 1987), anthropology (Bateson, 1972; Mead, 1964), philosophy (Abraham, 2016) and design (Glanville, 2015). Cybernetics conferences attract people from all of these fields and the conference participants communicate easily with each other due to shared assumptions, principles, and models.

In his recent book, *The Cybernetics Moment: Why we Call our Age the Information Age*, Ronald Kline (2015) describes how during the 1950s and 1960s a wide variety of terms competed to describe the growth of computers, management information systems and networks. He concludes that by the mid 1970s the linear conceptions of input, process and output had become the accepted metaphor for understanding information systems and the more complicated ideas of cybernetics involving circularity and reflexivity had been largely forgotten.

Cybernetics today is still concerned with circular causal mechanisms in biological and social systems, but whereas the general public associates “cyber” with computers, the members of the American Society for Cybernetics have focused on cognition, social systems, philosophy and design. Whereas physics creates theories of matter and energy and deals with inanimate objects, cybernetics creates theories of communication and regulation and deals with purposeful systems (individuals, organizations, and some machines). Because purposeful systems are fundamentally different from inanimate objects, cyberneticians have expanded the philosophy of science so that it can more adequately encompass the social sciences (Umpleby, 2014). In addition to the normative approach to philosophy of science of Karl Popper (1962) and the sociological approach of Thomas Kuhn (1962), cyberneticians added a biological interpretation of the philosophy of science (McCulloch, 1965; Foerster, 2003). The biological view of the philosophy of science is different from the normative and sociological views in that it contains an explicit connection to ethics. Since our knowledge of the world is limited by our experiences, and others have different experiences, we need others to challenge or support our perceptions. For a summary of the three approaches to philosophy of science, see Table 1 in Umpleby, 2016.

One way to do research in the future in cybernetics would be to use both traditional and new disciplines to describe current challenges and then evaluate the contributions made by the new approaches. Some instruction and coaching would be necessary.

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