

**ADVANCES IN CYBERNETICS
PROVIDE A FOUNDATION FOR THE FUTURE**

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Abstract

Interest in cybernetics declined in North America from the mid 1970s to 2010, as measured by the number of journal articles by North American authors, but increased in Europe and Asia. Since 2010 the number of books on cybernetics in English has increased significantly. Whereas the social science disciplines create descriptions based on either ideas, groups, events or variables, cybernetics provides a multi-disciplinary theory of social change that uses all four types of descriptions. Cyberneticians use models with three structures – regulation, self-organization and reflexivity. These models can be used to describe any systemic problem. Furthermore, cybernetics adds a third approach to philosophy of science. In addition to a normative or a sociological approach to knowledge, cybernetics adds a biological approach. One implication of the biological approach is additional emphasis on ethics.

Keywords: regulation, self-organization, reflexivity, ethics

Background

The field of cybernetics attracted great attention in the 1950s and 1960s with its prediction of a Second Industrial Revolution due to computer technology (Wiener, 1948). In recent years few people in the US have heard of cybernetics and the number of articles in cybernetics journals by authors in North America has declined dramatically (Umpleby, 2015a, see Figures 1 and 2). But a wave of recent books suggests that interest in cybernetics is returning (Umpleby and Hughes, 2016, see Figure 3). After describing the decline and rise of work in cybernetics in the U.S. this paper explains how cybernetics is different from traditional disciplines. Some people may claim that whatever was useful in systems and cybernetics has been incorporated in current work falling under the complexity label, but that is not the case. The three fields of systems science, complex systems and cybernetics have asked different questions and developed different theories

and methods. Although there is some overlap, these are three largely independent fields with their own associations, journals and conferences (Umpleby, 2017).

Other papers in this special issue deal with systems theory and complex systems. This paper reviews some basic ideas in cybernetics. I recommend these and other ideas as a resource for better understanding and modeling of social systems.

Trends in activity regarding cybernetics

What is the trend of research in cybernetics in the U.S.? Stuart Umpleby has observed that since the 1980s there has been more interest in cybernetics in Europe than in the U.S. To test this observation articles from thirty years in three journals *Cybernetics and Systems*, *Kybernetes* and *Systems Research and Behavioral Science* were studied. Articles in all three journals were sampled in three year intervals from 1974 through 2010. If an article had authors from more than one country, the country of the first author was used. Figure 1 shows how the number of articles from various regions has changed in recent years. In all three journals the number of articles written by North American authors has declined while the number of articles written by authors in Europe and particularly in Asia has increased. To make more clear the rise and decline, the number of articles produced in specific countries in 1974 and 2010 is shown in Figure 2. Although in 1974 the U.S. produced more articles than all other countries combined, in 2010 the U.S. had declined to third place after the U.K. and China.

Figure 1. Total articles per year by region over time in the three journals

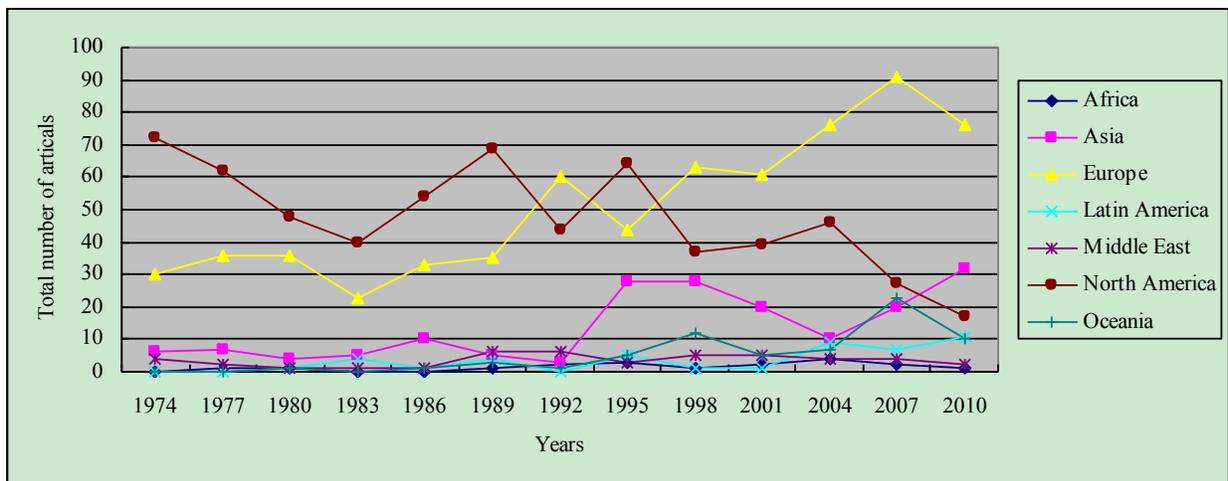
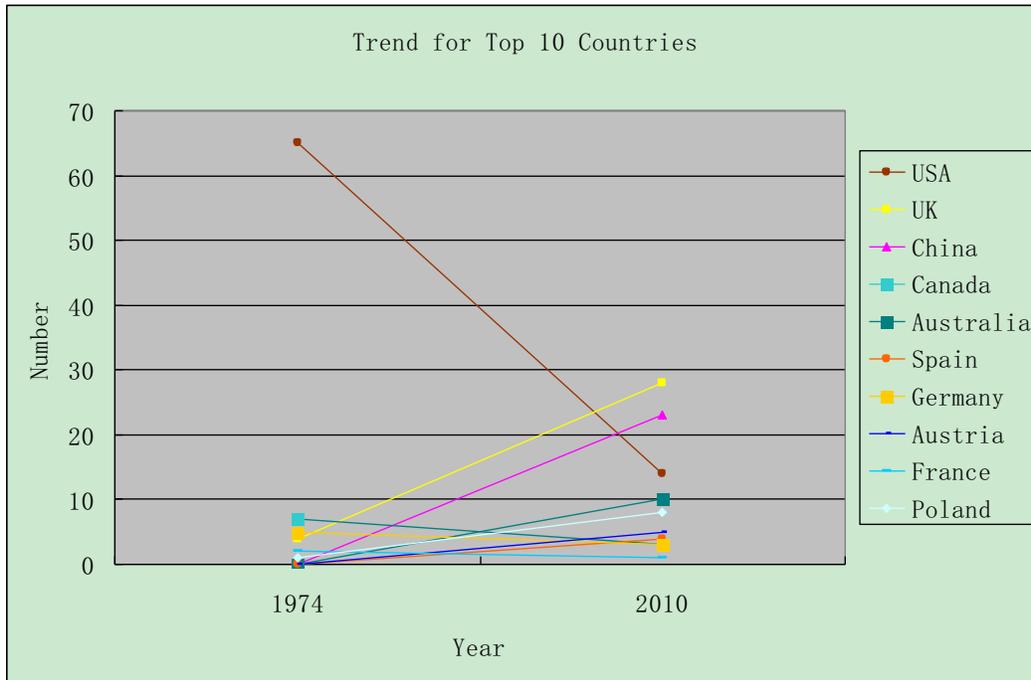


Figure 2. The number of articles in 1974 and 2010 for the top ten countries (Ranked by the total number of articles from year 1974 to 2010)



Recently Stuart Umpleby observed an increase in books being published about cybernetics. Elise Hughes used Google Books and Amazon.com to search using the keywords “cybernetic,” “cybernetics,” and “cybernetician.” She used each of the keywords as a general search as well as restricting the search to the title and subject fields. For example, the keyword “cybernetic” was used as a search term three times in Google Books, once in the standard search bar, once in the advanced search function on “title” and once in the “subject” field. This process was repeated for each of the keywords and on Amazon. At the end of this process each keyword had been used six times, and overall a total of 18 searches were completed. She restricted the publishing date to 2000 and later. The list of books in Umpleby & Hughes, 2016, includes books that have been rereleased within this period of time.

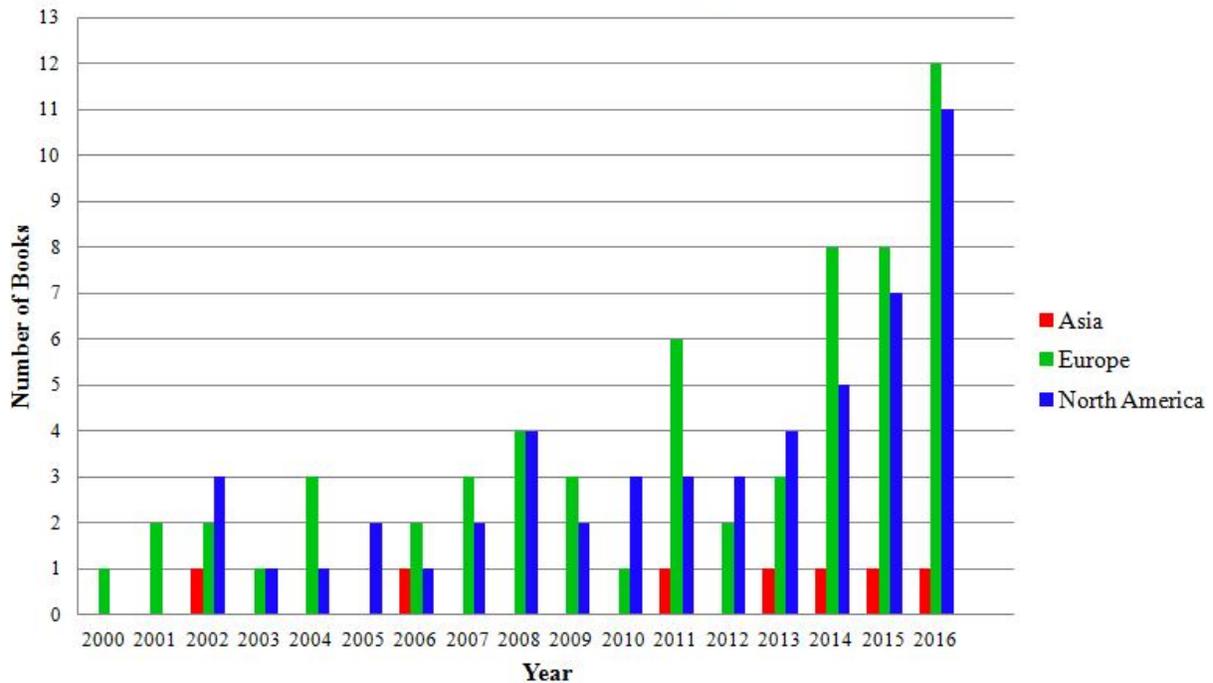
In order to find the first author’s country of origin Ms Hughes used the “About the Author” section of Amazon, book jacket biographies, and Google. Many of the authors of the rereleased books had Wikipedia pages. Figure 3 shows the results of this research, with the number of books released each year broken down by region – Asia, Europe, and North America. This

research included only books in English. Even so, the number of books is greater in Europe than in the U.S. If other languages were included, e.g., French, German, Spanish, Italian, and Russian, the number of books published in Europe would be even greater.

Four types of descriptions used in social science

How are cybernetics and systems science different from earlier disciplines? Physics and chemistry serve as the foundation of the engineering disciplines. One first studies physics, chemistry and mathematics and then chooses an engineering field to specialize in, such as mechanical, electrical, aeronautical or civil engineering. The social sciences are different in that they do not have a common foundation. Perhaps in the future systems and cybernetics will be seen as the foundation for the social sciences. If so, students would begin with systems and cybernetics and then specialize in psychology, sociology, economics, anthropology or political science. If this were to happen, then the social sciences would have a common set of principles to refer to as do the fields that use physics and chemistry as a foundation.

Figure 3. Recent books about cybernetics



Currently in the social sciences, different academic disciplines use different basic elements (Umpleby, 2015a). 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 *groups*, organizations, coalitions and alliances. 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. For examples, 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

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 possible improvements. 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 used by the traditional disciplines are based on 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 of a car, a manager of a

business firm and a teacher with students in a classroom. The Law of Requisite Variety (Ashby, 1952) provides 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 global 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 state 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 entity, expose it to an environment such that the interaction between the elements and their environments move the elements in the direction you want them to go. This idea is the foundation for agent based models and 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).

Because social systems are composed of purposeful systems, 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. Table 1 arranges the four basic elements and the three models in a matrix. The basic elements are associated with 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

<i>Model > Elements ∨ Variables</i> (economics)	Regulation	Self-Organization	Reflexivity
	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	Describe the purposes of actors and institutions?
Groups (sociology and political science)	How to assemble a winning coalition?	Interaction rules, cultural and religious beliefs and norms	Redefine and realign 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 second order cybernetics. Each of the three models are associated with modeling languages. For systems engineering and first order cybernetics there are the modeling methods from operations research and system dynamics. For complex systems there is agent-based modeling. For second order cybernetics and reflexivity theory reflexive systems are represented in a variety of ways, including causal influence diagrams (Umpleby, 2010) 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 has 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

Table 2: Three philosophical positions

	Popper	Kuhn	Von Foerster
The view of epistemology	A normative view of epistemology: how scientists should operate	A sociological view of epistemology: how groups of scientists operate	A biological view of epistemology: how the brain functions
A key distinction	Non-science vs. science	Steady progress vs. revolutions	Realism vs. Constructivism
The puzzle to be solved	Solve the problem of induction: conjectures and refutations	Explain the turmoil in original records vs. smooth progress in textbooks	Include the observer within the domain of science
What must be explained	How science as a picture of reality is tested and grows	How paradigms are developed and then replaced	How an individual constructs a “reality”
A key assumption	Scientific knowledge exists independent of human beings	Even data and experiments are interpreted	Ideas about knowledge should be rooted in neurophysiology
An important consequence	We can know what we know and do not know	Science is a community activity	If people accept this view, they will be more tolerant

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; Maturana, 1975; 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 2 (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 required.

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