TOWARD A NEW SCIENCE OF INFORMATION

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ABSTRACT

The concept of information has become a crucial topic in several emerging scientific disciplines, as well as in organizations, in companies and in everyday life. Hence it is legitimate to speak of the so-called information society; but a scientific understanding of the Information Age has not had time to develop. Following this evolution we face the need of a new transdisciplinary understanding of information, encompassing many academic disciplines and new fields of interest. Therefore a Science of Information is required. The goal of this paper is to discuss the aims, the scope, and the tools of a Science of Information. Furthermore we describe the new Science of Information Institute (SOII), which will be established as an international and transdisciplinary organization that takes into consideration a larger perspective of information.

Keywords: Information, Science of Information, Information Society, Transdisciplinarity, *Science* of Information Institute (SOII), Foundations of Information Science (FIS)

1 INTRODUCTION

Information is emerging as a new and large prospective area of study. The notion of information has become a crucial topic in several emerging scientific disciplines such as Philosophy of Information, Quantum Information, Bioinformatics and Biosemiotics, Theory of Mind, Systems Theory, Internet Research, and many more. Furthermore, *information* has passed through an evolutionary development because of the theoretical efforts of scientists, from Claude Shannon, Warren Weaver, and Norbert Wiener through Gregory Bateson to Klaus Haefner and Tom Stonier, just to mention a few. Scientists such as John Archibald Wheeler, Anton Zeilinger, Stephen Hawking and Daniel Gottesman are currently internationally renowned for their endeavors which shape our concept of *information*.

Over the last fifteen years, an international online discussion group called *Foundations of Information Science* has made efforts to bring information theorists together around the concept of information as a theoretical subject. The work of scientists such as Hans Christian von Baeyer and Wolfgang Hofkirchner forms the basis for a new unifying perspective of *information*, which builds a necessary foundation for a new transdisciplinary *science of information*.

Information is developing its own theoretical basis as well as societal, personal, and commercial applications. We live in a so-called *Information Society*, and information commodities have become a principal driving force in national economies. Following these developments we face the need for establishing a new international and transdisciplinary development and coordination organization, the new *Science of Information Institute* (SOII) that takes into consideration a larger perspective encompassing many academic disciplines and new fields of interest.

In this paper we give an overview of historical milestones of the information concepts and scientific approaches of information. We draw attention to the need for a transdisciplinary approach of the new emerging science of information that builds the basis for the contemporary information society.

2 THE RATIONALE FOR A SCIENCE OF INFORMATION

Industrialized countries and less developed countries are all subject to transformation processes in the sphere of the technological organization of society because of the development and diffusion of modern information and communication technologies. These technologies are supported and furthered by national and regional policies, which in turn set up a tremendous number of technology-advancement programs. These policies largely reflect an assumption that technology is an independent factor in societal development.

However, there has been growing awareness that technological determinism is too myopic because the belief in technological progress, which *per se* entails social progress, has diminished. Development in technology is not accompanied by an equally rapid growth of scientific insight, let alone foresight, regarding the impact of technology on levels of society, other than that of technological organization. Attempts to observe and understand the basic nature of this change are still in their infancy.

In the words of Manuel Castells, author of the trilogy of the Information Age: "The dream of the Enlightenment, that reason and science would solve the problems of humankind, is within reach. Yet there is an extraordinary gap between our technological overdevelopment and our social underdevelopment" (1998, Castells). This gap stems from the fact that a scientific understanding of the development of society in the Information Age has not had time to develop. There is not yet a "science of the information society" which is a science for, about, and by means of the information society.

A research focus on information is the key to understanding the information society. Hence the importance of the establishment of a science of information, which will reveal the role information processes play in mankind's intervention into all spheres of reality**.**

3 SCIENTIFIC APPROACHES TO THE CONCEPT OF INFORMATION

As mentioned in the introduction above, the concept of information has developed over the last decades. Whilst at the end of the last World War the concept of information was still seen largely from a limited and one-sided military or commercial product viewpoint, scientific debate on the topic has since then been dominated by attempts to move away from these limitations and

see the subject in a different way. Claude Shannon's syntactic definition of 1948 was thus followed by attempts to formulate a semantically-based term, most notably by Yehoshua Bar-Hillel and Rudolf Carnap (1953). After that, came a pragmatically-based term, of which Carl Friedrich von Weizsäcker is seen as the most prominent proponent (1973, 1974, 1985).

Since then, there has been a search for a concept that can integrate the various aspects of information processes, that includes the useful findings of the old term as a special case and that extends the old information theory into a new, more universal theory. Conceptualizations dating from the second half of the 1980s mark a new period. These are:

- the hypothesis of the *control revolution* by which James R. Beniger (1986) draws parallels between the breakthrough to the information society and former revolutions in the course of life and culture; and

- the hypothesis of the evolution of *information-processing systems* put forward by Klaus Haefner in 1988 (and edited in 1992b, see also 1992a), which makes the information society the ultimate result of the evolution of systems within the universe that are capable of generating and processing ever higher information.

These two outstanding contributions are the initial steps towards a single and comprehensive science of information.

Writings of scholars who have a cross-disciplinary background build upon the same train of thought: the three-volume work of the Dutch expert in International Relations Johan K. De Vree (1990), who develops a system-theoretical approach, starting with thermo-dynamical considerations, and by doing so avoids the fundamental shortcoming of cutting society free from the material-energetic world (a mistake which Niklas Luhmann makes), has to be mentioned here as well as the science-of-information trilogy written by Tom Stonier (1990, 1992, 1995), an educated biologist and, finally, before he passed away, Professor Emeritus for science and society at the University of Bradford. Stonier offered an evolutionary perspective of societal development up to the information age. Both De Vree and Stonier were active in the Foundations of Information Science community when it started over a decade ago.

In addition, there are several approaches that aim at theories of a global brain (e.g. the Principia Cybernetica Project group around Francis Heylighen, see for instance (1995) or (1997), from a cybernetics point of view) or a Collective Intelligence (Lévy, 1997; in French 1994), from a philosophical point of view), or draw parallels between super-organisms and mankind (Stock 1993) or between biotic and cultural developments in general (see e.g. the living systems theory of James Grier Miller from (1978) and the article Miller and Miller (1992) or Peter Corning's Synergism Hypothesis from (1983) or share an evolutionary perspective without referring to biology (e.g. Malaska 1991, Artigiani 1991).

There has been and currently still is a significant amount of advanced theoretical work being done related to the scientific study of information as a science. Wolfgang Hofkirchner (1998) at the Vienna University of Technology edited a landmark book summarizing the current theoretical work on *The Quest for a Unified Theory of Information*. Hans Christian von Baeyer

(2005), physicist at the College of William and Mary, published a Harvard University Press Book entitled *Information as the New Language of Science,* which suggests that information is poised to replace matter as the primary stuff of the universe. His research was based on work by the Dean of American Theoretical Physics John Archibald Wheeler and Anton Zeilinger of the University of Vienna.

In the beginning of the 1990's, biologist Pedro Marijuán from the University of Zaragoza, Department of Computer Science and Michael Conrad from Wayne State University initiated the *Foundations of Information Science* community in which scientists from all over the world and from all disciplines have been gathering to discuss the concept of information and the possibility of a transdisciplinary perspective. So far they have held three international face-to-face conferences (1994 in Madrid, 1996 in Vienna, and 2005 in Paris) and one virtual meeting (an electronic conference 2002). In the aftermath of the Vienna conference, a mailing list was established, and since 2002 there has been an ongoing series of moderated focused discussions on the web (http://fis.icts.sbg.ac.at/main.html).

4 THE NEW SCIENCE OF INFORMATION INSTITUTE

Now, efforts are on the way to create an organization to focus, develop, and promote transdisciplinary approaches to information. A group of scientists met in Paris in July 2005 for the 3rd International Conference on the *Foundations of Information Science* (FIS). At the end of a business meeting, the participants consented to extend the work of the FIS-Group and to form a new International Institute to assemble, coordinate, and correlate the past and current theoretical work on *information*. The participants agreed to call the new expanded field *Science of Information*, not to be confused with the older term *Information Science,* which sometimes is understood as advanced "library science," and to take into consideration a newer and larger perspective encompassing many academic disciplines and new fields of interest. This new Information Institute hasl been established as an international and transdisciplinary web-connected organization with its initial headquarters in Washington, D.C. The *Science of Information Institute* (SOII) will examine information as META science, rather than just from the individual theories, based on various academic and special applications. For further information visit http://www.soii.info.

This organization will examine information theoretically as a fundamental element of the universe, not just as a traditional human or cultural artifact seen primarily as a carrier. It will be based on a larger scientific concept where information is a fundamental part of each of the other physical and social sciences plus the arts, humanities, and consciousness developments. Coherent new perspectives will result from a number of characteristics such as information as an element in the creation of matter as well as a manager and carrier. This larger perspective will help to expand and deepen not only the *Science of Information* but also science in general and its applications to society. In setting up this formal organization, we empower all those who are doing work in the field by creating an organizational mechanism to secure cooperative support and funding.. To be more inclusive, the *Science of Information Institute* plans not only to assist in developing the theoretical basis of the new field of information as a science but also then proposes to suggest societal, political, and commercial service applications of the theoretical work. The Institute proposes to extend the works of the societal, political and commercial

applications to individuals for their own personal use in order to improve their own effectiveness, comprehensive participation in civilization, enjoyment, and enrichment. Few historical scientific developments have proposed to extend their theoretical work to this extent to both society and the individual.

5 SCIENCE OF INFORMATION

Because of the complexity and ever-changing nature of the *information research field*, transdisciplinary approaches, theories and methods are required.

We define transdisciplinarity as a cooperative research concept that includes scientists from both natural and engineering sciences as well as from social sciences, the arts, and humanities. Furthermore it integrates stakeholders from outside academia, such as decision-makers, politicians, businessmen, activists, and (non-governmental) organizations. In terms of what makes science *scientific*, there are three aspects that have been distinguished in the literature so far:

- first, a context of application in which scientific knowledge is used for solving problems and is transformed into technologies, whether material or ideational;
- second, a context of justification in which scientific knowledge is critically exposed to possible refutations and corroborated in as far as it is not refuted and theories are comparatively assessed;
- and, third, a context of discovery in which scientific knowledge is conjectured and theoretical assumptions are formulated in relation to empirical findings.

The first context concerns aims that guide each scientific endeavor. In the second context, the scope of the theories about reality is determined. The third context is about the tools of the methodology used. So each scientific endeavor can be described in terms of aims, scope, and tools:

- What are the *aims* of a science of information?
- What is the *scope* of a science of information?
- What are the *tools* a science of information is to make use of?

To start with the first question, it is no surprise that the need for a science of information is expressed now that the old forms of control and regulation of societal development have proven obsolete, and new forms have to be investigated, invented, and introduced. Global challenges threaten a civilization that needs information more than ever to cope with these challenges and help society organize so as to choose a path of sustainable development. Without conscious, intelligent interventions, the system humanity inhabits seems to be doomed to break down. Thus a science of information will have to serve the practical purpose of providing society with means of enhancing its problem-solving capacity regarding the challenges it is confronted with.

According to the above, it is clear that the domain of this science of information is made up of everything that makes sense from the perspective of the generation of information. Each real-world system, whether natural, social, or artificial, involves information processes. It is

important to deal with and theorize in order to understand the information processes that may help improve the collective intelligence of society. Information can be seen as something overarching, the whole bandwidth of different and diverse systems in our universe and manifests itself in a variety of phenomena.

The science of information will operate within a more inclusive approach as contrasted to a reductionist approach. This will correlate to modern sciences' efforts to show more permeable, rather than absolute, boundaries between individual scientific disciplines and indicate interconnections, intercontributions, and interdependencies.

Information itself needs to be seen also as an object itself as well as the action of informing and move beyond the confines of the past tendencies to categorize it only as a descriptive and conveyance technique and system and because the investigation has to comprise as wide a range of matter. A science of information cannot, with reference to the tools, afford to neglect any methodological means of study that might be fruitful and elucidating. Likewise, it must not fail in putting the puzzle of findings together and in synthesizing the manifold analyses, thus transcending the borders of disciplines and aiming at the unity of science by a unifying approach without all thinking imposing uniformity.

Having said this, it becomes clear that the new Science of Information is a transdisciplinary endeavor to bridge not only the gap between the so-called two cultures of (natural) science, on the one hand, and humanities and arts, on the other, but also the gap between physics (and chemistry) and life sciences. Furthermore, it is to include and re-conciliate formal-scientific and quantitative as well as qualitative accounts (by means of philosophy-of-information considerations).

Figure 1 below gives a glimpse of how the internal structure of the new science of information may look, from the science of the information society to the philosophy of science, which are linked via different levels of abstraction:

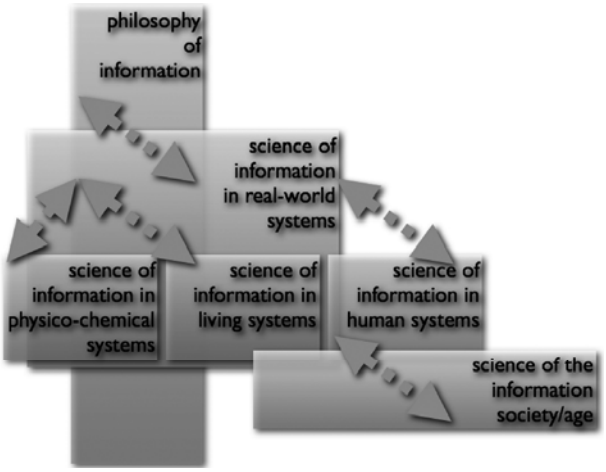

Figure 1. A conceptual structure of the new Science of Information, from the science of the information society to the philosophy of science.

6 CONCLUSION

In this article we explained the necessity for a new *Science of Information*. Because of the complexity and ever-changing nature of the research field *information*, transdisciplinary approaches, theories and methods are required. We define *Science of Information* as a cooperative research concept that includes scientists from all scientific branches. It integrates pure basic (grounded) research and applied research (use inspired basic research). Furthermore it includes stakeholders from outside academia, such as decision-makers, politicians, businessmen, activists, and (non-governmental) organizations. The need of such a cooperative research has emerged with the increase in global problems, issues and questions that because of their complexity cannot be solved anymore within disciplinary boundaries. Such an understanding has, in opposition to traditional disciplinary approaches, the capacity to increase the exchange of knowledge and information and to go beyond academic boundaries in order to solve real-world problems.

The newly established *Science of Information Institute* (SOII) provides the necessary organizations and conditions for the integration of science and academia, stakeholders from governments, NGOs, private enterprises, and the general public.

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