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EDITORIAL

Back and forth: cybernetics interrelations and how it spread in Latin America

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Abstract
Cybernetics is a science characterized by the utopian search for new relationships between different areas of knowledge. After the Second World War, the best-known references in Western academia were Norbert Wiener's approaches to this new discipline. However, there is another little-known hemisphere of this development that remains understudied and we claim is key for its history which refers to the pioneering work of scientists, engineers and cultural practitioners in Latin America, as well as the materialization of specific experiences that lead us to reflect on the role that some regional milestones could have had in the global context. This volume of *AI & Society* covers points of view that were structured in the various most emblematic stages of these trajectories with the participation of agents that went beyond the assimilation and interpretation of external models, transforming themselves into fundamental and pioneering experiences, among others, the work of Mexican scientist Arturo Rosenblueth, or the impact of the concept of *Autopoiesis*. Through this article we introduce the outcome of the research—presented in great length in the contributions of this volume—on some of the main stages and trends that constituted the evolution of cybernetics in Latin America. The particular contributions of the authors in this issue have helped to reconstituting these contexts while developing a continuous horizon which also explores future practices.

Keywords Cybernetics · Latin America · Epistemology

1 Cybernetics: concepts and definitions

Andrés Burbano and Everardo Reyes tell that us the concept of cybernetics emerged in a conversation between Arturo Rosenbleuth, Norbert Wiener and others, at Café de Tacuba, in Mexico City, while they were eating tamales (Burbano and Reyes, in this issue) in the late 1940s, before the term became popularized by Wiener's *Cybernetics: Or Control and Communication in the Animal and the Machine* (Wiener 1948).

However, this term had already been used in France a century earlier by a physicist and founder of electrodynamics, André-Marie Ampère, who defined cybernétique as "the science of the government of men" (Ampère 1843). Even before that, Plato had used the term κυβερνητική (from the Greek kubernêtikê, from kubernân, to govern) to refer to the piloting of a ship. In *The Republic*, Plato used the term to refer to the steersman who directs sailors on a ship (Plato 2007). Plato regarded hé kubernêtikê (steersmanship) as an art or techné (Plato 2007). From a philosophical point of view, Hegel later introduced a distinction that may be more closely related to the modern concept of cybernetics. Hegel's distinction can be explained on a dialectical way, namely process whereby information is sent back and forth recursively between two entities to command several properties characterizing those entities or, in Hegel's words, a sich (in itself), für sich (for itself) and an und fürsich (in and for itself). As Maybee (2020) holds in his introduction to

To Ricardo Uribe Berenguer in memoriam.

Introduction: Special Issue: Cybernetics in Latin America

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Hegel's dialectic, "a concept or form is 'in and for itself'" when it is doubly 'for itself,' and in this sense 'for itself' is not thought only in terms of content—insofar as it embraces its content—but also in terms of a form or a presentation." In other words, what is presented depends exclusively on the content that makes this presentation possible.

This double idea 'for itself,' was also exposed in different terms by Polish philosopher, Trentoswki Bronisław, writing in 1843, the same year as Ampère's definition. In his *Stosunek filozofii do cybernetyki, czyli sztuki rządzenia narodem* (The Relation of Philosophy to Cybernetics, or the Art of Governing a Nation), Bronisław mentions the term kibernetiki. For Bronislaw, kibernetiki was based on a philosophical natural social and biological system, while he uses the term 'management' to describe the interaction between humans and machines (Zenelný 1987). Ampère and Trentowski's approaches are relevant when we examine Heinz von Foerster's idea that cybernetics is based on both control of the mechanism—or what is called as first-order cybernetics—, and the mechanism managed by itself—or second-order cybernetics (von Foerster 1974).

However, the use of this term in the twentieth century was expanded to other fields. Between 1913 and 1917, Soviet physician and philosopher Aleksándr Bogdánov published *Тектология* (Tektology), where he examined the organizational principles shared by all types of systems. In the English introduction of the term, quoting to Bogdánov, mentioned that 'tektology' is "any system both from the point of view of the relationships among all of its parts and the relationship between it as a whole and its environment, i.e., all external systems" Gorelik (1983). In fact, for Novikov (2016) "Bogdánov anticipated many results of Norbert Wiener and Austrian biologist Ludwig von Bertalanffy. It is not known if Wiener or von Bertalanffy—the latter proposed the General Systems Theory—read the publication since the book was translated to German and published in Berlin by Hirzel in 1926 and 1928 under the title *Algemeine Organisationslehre Tektologie (*General Organisation Theory, Tectology*)*. Another important problem that undermined the recognition of Bogdánov's pioneering contribution was his disagreement with Lenin that put 'tektology' under critical fire until Stalin's death for "consisting in emptying economic and other problems linked to the development of society of their class content, and reducing specifically social laws to those of mechanical motion." (Rosental and Ludin 1959).

Meanwhile, during the next decade of the twentieth century across the Atlantic Ocean, and in the USA specifically, in the late 1930s, a multifocus discipline evolved. Alfred Korzybski, a Polish engineer, conceptualized the theory of "general semantics," and initially introduced it to the scientific community in his *An Outline of General Semantics*, published in 1935. This theory straddles several disciplines, including mathematics, logic, physics, biology, neurology, psychology, and psychiatry, and focuses on human evaluations and orientations of definite neurological mechanisms present in all humans. For Rapoport and Shimbel (1949), the theory of general semantics aims at providing insights to "understand the events in the nervous system and analogous systems as determined by their structure (which) is fundamental for the understanding of abstraction, evaluation, and communication." This theory was catalyzed by Gregory Bateson who participated in the Society for General Systems Research, created in 1955 by von Bertalanffy, which William Ross Ashby and Margaret Mead also joined, a group which emerged from Macy Conferences done a decade before. Significantly, the modern 'cybernetic' term evolved principally in the USA, in the post-war era, when universities played a public service role, in contraposition to the conception of the university as a sanctuary for independent and critical scholarship and the pursuit of learning for its own sake. This political agenda gained importance during the 1940s, when the USA joined the Second World War. Many US universities were, and still are, places for research projects funded by the military industrial complex. For example, Wiener, who had worked at the Department of Mathematics of the Michigan Institute of Technology since 1919, during the Second War devoted himself to researching on automatic aiming and firing devices for anti-aircraft guns. Also working for the military was Claude Shannon, a mathematician, electrical engineer, and cryptographer who in 1948 published *A Mathematical Theory of Communication*. Shannon's theory of communication gives us our modern notions of 'information' and 'noise,' "made possible due to the statistical structure of the original message and due to the nature of the final destination" (Shannon and Weaver 1949). Connections between Shannon and Wiener are apparent, as Shannon used the ergodic theorem, "generalized by Wiener" in 1948, and developed the concept of message as information, just as Wiener had used in his book (Dubberly and Pangaro 2015; von Foerster 2003).

Since the 1950s, cybernetics stopped being criticized as an American reductionist concept based on mechanical models (Gerovitch 2002). It then became possible to counter previous ideological criticisms and redeem it in the public domain. In July–August 1955, Sergei Sobolev, Alexey Lyapunov and Anatoly Kitov published *Вопросы философии (*Problems of Philosophy*)* and *Основные черты кибернетики* (The Main Features of Cybernetics), and Ernst Kolman published in *Behavioral Science, What is Cybernetics?* (1959). Peters (2012) writes that during a period of relaxation on Khrushchev's scientific policy, the Council on Cybernetics was launched as an umbrella organization to conduct research on formerly suppressed topics, including such subjects as non-Pavlovian physiology ("physiological cybernetics"), structural linguistics ("cybernetic linguistics"), and genetics ("biological cybernetics").

Encouraged by this new policy vision, A. A. Markov developed his idea of probabilistic causal networks, which defined cybernetics as the effort to address the synthesis of causal systems, i.e., the construction based on given elements of causal systems which respond in a fixed manner to external influences (Semkov 1962). Along this line of thinking, Viktor Glushkov, who founded the Институт кибернетики (Institute of Cybernetics) in Kiev in 1962, proposed the first model of what would later come to be known as "the Soviet internet", called National Automated System for the Administration of the Economy (Obschegosudarstvennaya Avtomatizirovannaya Sistema Upravleniya, OGAS). Although planned to encompass the whole territory of the USSR, this network did not come into operative existence.

Cybernetics failed to prosper in the Soviet Union, as Gerovitch (2008) comments, because "cyberneticians envisioned an organic, self-regulating system, but paradoxically they insisted on building it by decree from above. They argued against gradual growth from below because individual parts would not function efficiently without a comprehensive nationwide system, and a piecemeal approach would only conserve existing practices." In this view, a nationwide management system addressing any individual components was not viable in itself. Paradoxically, this idea was opposed to Stafford Beer's, who introduced the management cybernetics in Latin America during Salvador Allende's socialist government in Chile, as we will see later.

Regardless of the context and who first coined the term cybernetics, a renowned group of academics from different disciplines worked on what today is defined as a 'universal discipline,' fostering new forms of interdisciplinary practices (Bowker 1993). Scholars focused on cybernetics, positing that any given causality could modify the entity's functioning and its own operations (Vallée 1990). As a meta-discipline, it also brought together contributions from a diverse number of epistemologies interested not only in computation, information, control, and feedback, but also in art, culture, management, philosophy, psychology, medicine, and anthropology, among others. To highlight all those undetected connections and developments, it was also necessary to identify forgotten pioneers and little-known historical contributions. Such is the case of the histories of cybernetics in Latin America, which were scattered, but whose trajectories traversed different fields, and evolved along also crucial moments of the social and political life of the region.

2 Expanded origins

In 1943, the Mexican physician and physiologist Arturo Rosenblueth, along with Norbert Wiener and Julian Bigelow (mentioned in the order of their contributions), co-authored *Behaviour, Purpose and Teleology*, considered a seminal and "first great paper" on the new cybernetics inter-discipline (Bowker 1993; Brand 1976). The paper's two main contributors were "(first) to define the behaviorist study of natural events and to classify behavior. The second (…) to stress the importance of the concept of purpose" (Rosenblueth et al. 1943). Drawing on the psychological experiments done by Rosenblueth in Mexico along with Wiener's and Bigelow's wartime research, the paper proposes a general and unified classification of behavior, as well as a description of purposefulness and the character of self-correcting mechanisms through the study of both machines and living organisms.

Debates, conferences, and papers followed, bringing researchers from different disciplines into cybernetics as a 'unified language' which offered a 'triangulation effect' in which scientific research from one field could be pointed to support research from another field (Star 1989), a doctrine first posited by the Vienna Circle as a unified science. Between 1946 and 1954, the Josiah Macy Jr. Foundation sponsored a series of conferences aiming to bring together a diverse, interdisciplinary community of scholars and researchers who would join forces to lay the groundwork for the new science of cybernetics. Organized as the Macy Conferences, and chaired by the neurophysiologist Warren McCulloch, they allowed the transfer of ideas from biology to physics and the dissolution of discipline-specific dominance, and in which Rosenblueth and Wiener were part of the core group who participated in the first conference in 1946.[1]

The Macy Conferences debates spread from the USA to England thanks to Gordon Pask and Ross Ashby who participated in those conferences. Ashby along with John Bates, Alan Turing, Albert Uttley, W. Grey Walter and others founded the Ratio Club, a group which from 1949 to 1958 met to discuss issues in cybernetics. In France, the term *cybernétique* was expanded thanks to the Mexican Enrique Freymann, director of publishing house Hermann et Cie., in Paris, which published in English the first edition of Wiener's *Cybernetics or Control and Communication in the Animal and the Machine* in collaboration with The Technology Press and John Wiley and Sons (Burbano and Reyes, in this issue). Thanks to this book, the term cybernetic, extended in France through several contributions including those by Pierre de Latil, a science journalist who worked with Freymann and published *La Pensée artificielle* (1953), Albert Ducrocq a journalist, who wrote *Decouverte de la Cybernétique* (1955) and Geroge Lanrgod, a researcher at

[1] For more information about Macy Conferences and its participants, see SUMMARY: *The Macy Conferences*, https://www.asc-cybernetics.org/foundations/history/MacySummary.htm. Reviewed September 23, 2021.

the French National Center for Scientific Research who published *The Applications of Cybernetics to Public Administration* in 1958 (Johnson 2015).

Although early French reflections on the word 'cybernetic' were focused on governance, the notion took a lexical turn when Johnson (2015) established how "the process of linguistic accommodation—from English to French—was seen to create an independent corpus of reflection on technology that in many ways is closer to a systematic turn of its definition, classification, and clarification." This lexical turn will be dedicated to the demystification of technology and the formalization of its structure and function via operational resources of the language and in turn influenced several French intellectuals such as Gilbert Simodon who proposed to change the word cybernetics to organologie (organology) or étiologie (etiology), because the being comes from the cuasi-su or in other words from the effect of its own causality (Simondon 1953).

Cybernetics also expanded the debate on living systems. In 1956, Ashby published *An Introduction to Cybernetics*, introducing the notion of homeostasis. Ashby's Law of Requisite Variety argues that for a system to regulate itself and maintain stability between its boundary and its environment, the variety in the system must be equal to or greater than the variety in the environment. From this perspective, the greater the variety of a system, the greater is its ability to reduce the effect of variety in its environment through regulation. Ashby's Law had an important influence on organizational studies and scientific management, as variety represented a way to maintain viability in a system. This must be balanced as the British researcher and consultant Stafford Beer wrote in *Cybernetics and Management* (1959), he was not interested in building a system for national or international control of human action, rather he was interested in building a balanced system for human comfort, security and dignity. As we will read in the next sections, Beer had an enormous influence in the conception of the *Cybersyn* project, during the administration of Salvador Allende in Chile.

During those days, Heinz von Foerster founded the Biological Computer Lab (BCL) in 1958 at the University of Illinois at Urbana-Champaign, where both Ashby and Pask were visiting professors. Between 1967 and 1968, Chilean biologist Humberto Maturana visited BCL and later wrote *Biology of Cognition* (BCL Technical Report 9.0), in which Maturana appreciated the collaboration of Harvard's student, Francisco Varela. The ideas of von Foerster and Maturana consider the position of the observer rather than the processing device, "The brain is not an information processing device, but rather a machine that creates and maintains correlations between sensor and motor activities in a world that is unknowable in its essence to any observer " (Letelier, in this issue).

Cybernetics was seen as a new means to prevent nuclear warfare dealing simultaneously with politics, technology, and new models of society (Bowker 1993). It also influenced the countercultural engagements with computer research, communications media, and artistic experimentation during the early 1970s. Inspired by narratives of architectural modernism and its emancipatory claims as well as the power of information and the means to disseminate it, researchers from diverse disciplines brought alternative visions of social justice. Many of those ideas were motivated by a utopian faith that science and technology could create a better and united global society (Scott 2015).

3 Cybernetics in Latin America

3.1 First pioneering efforts

This first 'cybernetic force' not only expanded its meanings in the USA, where Arturo Rosenbleuth started to work with Norbert Wiener and Julian Bigelow, but also in Europe and the Soviet Union. It also generated significant developments in Latin America, developments that started in Mexico with Rosenblueth, who worked in a laboratory in Harvard University during the 1930s, where he received some Latin American students such as the Chilean neurophysiologist, Joaquín Luco, (Luco later became the first Chilean to specialize in neuroscience and later became the Director of the School of Medicine of the Pontificia Universidad Católica de Chile), and the Argentinean neurophysiologist Alfredo Lanari. Lanari was also interested in developing these ideas in Argentina and established El Círculo Filosófico (The Philosophical Circle). Members of the group included two philosophers: Hernán Rodríguez Campoamor, who published in 1958 *Psicología y cibernética* (Psychology and Cybernetics) and Manuel Sadosky, computer scientist, mathematician, who wrote a preface for the book and Manuel Sadosky, computer scientist, mathematician, who wrote a preface for the book, a book that has the same name of an article written by Rosenbleuth in 1954[2] and a book published in UNAM in 1955; and Mario Bunge, who later wrote *Causality—The Place of the Causal Principle in Modern Science* in 1959 published by Massachusetts and Harvard University Press.

During the same decade, Rosenblueth returned to Mexico to head the Physiology Laboratory of the National Institute of Cardiology (NIC). Wiener worked with Rosenblueth under the auspices of the Rockefeller Foundation until 1952. In 1945, Wiener attended the Mexican Mathematics Society's Annual Congress in Guadalajara. In fact, their relation

[2] See, Cuadernos Americanos Año XIII, Volumen 75: http://www.cialc.unam.mx/ca/CuadernosAmericanos.1954.3/CuadernosAmericanos.1954.3.pdf. Reviewed in September 23, 2021.

was so close that Wiener's *Cybernetics: Or Control and Communication in the Animal and the Machine* (1948) was dedicated to Rosenblueth, a book that was written during his stay in Mexico where he worked at the NIC in which Rosenblueth was the manager. "For many years my companion in science," he wrote. In 1949, through an article in Time magazine, Chilean Raimundo Toledo learned of Wiener's work and wrote to him to solve a mathematical calculation problem related, according to Medina (2011), to the development of Toledo's own computing machine, a motivation that was similar to Sadosky's in Argentina.

In the late 1960s, cybernetics spread further in Latin America, in fields from biology to the arts. In 1969 Humberto Maturana returned to Santiago, after working at the BCL in 1968 and wrote his most known paper with Dr. Jerome Lettvin on retinal visual responses from MIT's laboratory headed by Warren McCulloch. Later in 1970, the biologist Francisco Varela returned to Chile after earning a PhD from Harvard University with his thesis *Insect Retinas: Information processing in the compound eye* and started to work with Maturana at the Universidad de Chile. That same year, Maturana published *On Biology and Cognition* (Maturana HR 1970) and with Francisco Varela and Ricardo Uribe programmed protobio. Maturana, Varela and Uribe approached the notion of Bateson's difference from the standpoints of biology and engineering. They were interested in defining how we can specify inputs and outputs for highly cooperative, self-organizing systems such as brains. Maturana coined the concept of structural coupling, which determines the constitution of the structure of the system. The concept of structural coupling in this sense delves into the abstract image proposed by Bateson, as a way "to connote the configuration of relations between components that define the class identity of a composite unity or system as a totality or singular entity. And in what follows I shall consistently use the word 'structure' to refer to the components of and the relations between them that realize a system or composite entity as a particular case of a particular class." (Maturana 2002).

The discussion in Chile about cybernetics was enriched by the course taught by Beer, Maturana, Varela, and Herman Schwember at the School of Engineering of the Universidad de Chile. The course assessment was published as *The Cybernetics of Cognitive Process* in Biological Computer Laboratory Report No. 9.2 which provided the background for the publication of *El Árbol del Conocimiento* (The Tree of Knowledge) in 1983.

Maturana, Varela and von Foerster proclaimed second-order cybernetics (von Foerster 1974) as a state of steady internal, physical, and chemical conditions maintained by living systems. This idea emerged from Humberto Maturana's Theorem Number One "Anything said is said by an observer" when he added a corollary which he called "Heinz von Foerster's Corollary Number One": Anything said is said to an observer" (von Foerster 2003). From this point of view, if the distinction between regulation and self-organization was made in first-order cybernetics, in the second one the focus is on cognition and self-reference. Both theories agree that there is a circular process that establishes the difference with the classical, Newtonian science where causes are followed by effects, in a simple linear sequence. Second-order cybernetics more closely applies to quantum mechanics, because it is interested in processes where an effect feeds back into its very cause; the observer and the observed cannot be separated, and the result of observations will depend on their interaction. The observer is—in a cybernetic system—trying to construct a model of another cybernetic system. In other words, the observed agent of a social system interacts with the observer agent through self-application and self-organization to open and close looping feedback cycles.

Finally, it is worth mentioning that the Belgian administrator Charles François founded the Grupo de Estudio de Sistemas Integrados (Integrated Systems Study Group) in 1973 in Buenos Aires and opened the Argentine chapter of the International Society for the Systems Sciences. François published *Phénoménologie, Cybernétique et Prospective* (Phenomenology, Cybernetics and Prospectivity), in 1975 at the Association Internationale de Cybernétique (International Cybernetics Association), the Belgian cybernetic association created in 1957. Later, he edited *The International Encyclopedia of Systems and Cybernetics*, the first edition of which was published in 1997 in one 450-page volume, with a second edition published in 2004 in two volumes comprising 741 pages. Both editions were published by KG Saur, in Munich.

3.2 Cultural and artistic application of cybernetics

Toward the end of the 1960s, art critic and entrepreneur Jorge Glusberg set up the Center for Art and Communication in Buenos Aires, or CAyC, as an interdisciplinary and experimental art forum which explored the relationship between art, science and social studies. Deeply influenced by the Cybernetic Serendipity exhibition displayed at the Institute of Contemporary Arts (ICA) in London in 1968, Glusberg organized in 1969 the exhibition Arte y Cibernética (Art and Cybernetics) at Bonino Gallery in Buenos Aires that brought together Japanese, British, North American and Argentine artists to explore the creative possibilities of using computers. *Art and Cybernetics* went later to Córdoba, Santa Fe and Tucumán in Argentina and then to Montevideo (1970)[3]

[3] In June 1970, the exhibition traveled, under the auspices of the National Commission of Fine Arts of Uruguay to the National

and Lima (1971),[4] as well as to Minneapolis, San Francisco, New York, London and Tokyo (Glusberg 2007; Mariategui, in this issue).

During the 1960s, in the USA, several art activities involving the notion of cybernetics were organized. Chilean artist Juan Downey's drawings provided the elements for interactive art performances in an installation at the Mayflower Hotel in Washington D.C. in 1968, based on control, communication and feedback that was presented again in the Corcoran Gallery of Art, in Washington D.C., in 1969. That same year, Peruvian artist Teresa Burga won a Fulbright Scholarship to study a master's degree in fine arts at the Art Institute of Chicago. Over the next and following decades, both Downey and Burga became influential active artists in the avant-garde art scene in Chile and Peru. Burga also developed information systems that laid down the foundations of the first computer systems for a Peruvian government agency. The politics of some of those computerized systems were already present in Burga's artistic explorations associated with representation and control mechanisms through the organization and management of personal information (Arca and Mariategui 2020).

In Brazil, the notion of cybernetics also emerged early. In 1956, then Executive Director of the Museu de Arte Moderna do Río de Janeiro (Museum of Modern Art of) Rio de Janeiro, met in Europe , Argentine artist and designer Tomás Maldonado, both from the Ulm Hochschule für Gestaltung Ulm, or HfG. (Ulm School of Design) Maldonado was appointed rector of the HfG in 1957. Since its foundation in 1953, the HfG had adopted a multidisciplinary approach that pursued a closer relationship between design, science and technology, using the German concept *umwelt* or environment, taking the ideas of biologist Jakob Johann von Uexküll "(…) our environment is a system of artifacts: on the one hand, artifacts to operate (Werkzeuge*)*; on the other, artifacts for perceiving (Merkzeuge)" (Maldonado 1972). Cybernetics theory became central to building a "technical school of creation" (Fernández 2003). In Germany, the notion of cybernetic was introduced by philosopher Max Bense in his *Kybernetik oder die Metatechnik einer Maschine* (Cybernetics or the metatechnics of a machine) (Bense 1951), where he interpreted cybernetics as a modern technique called metatechnik (Leopold, in this issue). Inspired by four journeys to Brazil, Bense wrote the *Brasilianische Intelligenz* (Brazilian intelligence) in 1965, subtitled *Eine cartesianische Reflexion* (A Cartesian Reflection). The booklet's short paragraphs like a travel diary's featured works exhibited by Brazilian concrete poetry artists at the Studiengalerie (Study Gallery) of the Stuttgart University's Technical School since 1967. Bense's work integrated the Shannon–Weaver theory of communication in design (Leopold, in this issue). The importance of Bense's influence, as Leopold adds, is because it "stimulated many artists, poets, designers, architects (…) in their experiments and works through theoretical inputs in the field of information theory, esthetics, and semiotics, which had been in close relationship to mathematical and cybernetic methods as described" (Leopold, in this issue).

Meanwhile, Brazilian artist and art critic Waldemar Cordeiro formulated a 'semantic' version of concrete art, which, in his view, implies a 'qualitative leap' in relation to historical concrete art, in the conviction that his works construct new spaces and meanings. Cordeiro organized the seminal exhibition Arteônica (1971) at the Fundação Armando Álvares Penteado, which presented interdisciplinary works, inspired by psychology and convergent computing in art, but also highlighting the complexities of mechanical and electronic reproductions, where information tends to be lost or reduced. For this project, together with engineer Giorgio Moscati from the University of Sao Paulo and using an IBM/360-44 computer with a memory of 32 kbytes, he relied on algorithms and mathematical principles to create a new visual gestalt (Arantes, in this issue). Another perspective of cybernetics in Brazil is the case of the philosopher Alvaro Vieira Pinto. Vieira Pinto developed the idea of a social cybernetic in his book *Conceito de Tecnologia* (Concept of Technology) published in 2005, but written in 1973. In that book, Vieira Pinto developed the concept of a social homeostasis, an idea that was exemplified in a book published in Chile during 1973: *El pensamiento crítico en demografía*[5] (Critical thinking in demography). In this publication, Vieira Pinto establishes a dialectical relation between the individual and the collective, involving biological, social, political and philosophical implications and also considering data for demographic research.

In 1951, Max Bill was awarded the international prize during the First São Paulo Art Biennial. A few years later, the graphic designer Alexandre Wollner, who had returned to Brazil after earning his degree at HfG, became a leading figure in the planning for the Escola Superior de Desenho Industrial (School of Industrial Design) (Wolfson, in this

Footnote 3 (continued)

Museum of Fine Arts in Montevideo, directed by Angel Kalenberg. The catalog was prepared in cooperation with IBM Uruguay S.A.

[4] The exhibition was presented at the IAC (Instituto de Arte Contemporáneo) on the 19th October, 1971 with the support of IBM Perú, and a panel on *Arts and Cybernetics* was held on the 27th October. Correspondence between Alfonso Castrillón and Glusberg dated 31st August, 1970 discussed the plan to organize a "Symposium on Art and Industry"; however, that idea apparently never materialized (Alfonso Castrillón personal archive, Lima).

[5] See CEPAL repository: https://repositorio.cepal.org/handle/11362/9753. Reviewed September 24, 2021.

issue). Bense also got in contact with Brazilian writer Haroldo de Campos and the group of concrete writers in 1959 (Leopold, in this issue). Later, throughout the 1960s, their thinking revolved around government and academic concerns on the transformation of the nation's traditional agrarian basis to build an industrialized country (Ioris and Ioris 2013). In his travels to Brazil, Bense visited the new capital, Brasilia. As Fernández writes (2006), "the program and the values of the HfG marked the strongest influence in the origin of design in Latin America, principally in those countries where consciousness of design as an economic factor was most developed." Fernández underscores the work done by HfG's graduate Gui Bonsiepe, who was later hired by the government of Salvador Allende to head the Committee of Technological Research (INTEC) to prepare the proposal and methodology for the Cybersyn project (Bonsiepe with Maulen's introductory, in this issue).

During the late 1960s, artists were at the forefront of the struggle and discontent against authoritarianism: in Argentina, it was the case of Tucumán Arde and in the USA by counterculture video magazine Radical Software, where Chilean Juan Downey wrote several articles in 1973, highlighting new art forms using video, technology and communications and proposing a new way of education.[6] Regarding video as a new expression medium, it is important to mention Gene Youngblood's *Expanded Cinema* in 1970 which—taking a definition previously coined by US filmmaker Stan Van Der Beek—gives an account of early audio–visual experiments using computers and mentions the influence of Heinz von Foerster and Humberto Maturana's second-order systems theory. Also worth mentioning are the telecollaboration models by Kit Galloway and Sherrie Rabinowitz (Youngblood 2020). Youngblood underscores that Maturana's theory of autopoiesis was used by Heinz von Foerster to derive the theory of second-order systems, and the critique made by Niklas Luhmann of the second-order thinking, and its relation to a "cybernetics of cybernetics," made in *Die Realität der Massenmedien* (The Reality of the Mass Media*)* (Luhmann 1999).

3.3 Cybernetics models for a new society

During the 1960s, against the backdrop of the Cuban revolution, a group of young philosophy scholars of the University of Havana launched *Pensamiento Crítico* (Critical Thinking) that became one of the most important confrontational voices on social science, philosophy and politics, in response to Third World realities. In July 1969, *Pensamiento Crítico* dedicated its 30th issue to cybernetics, in an intent "to offer a theoretical picture of this science through one of its most important and most researched epigraphs today: artificial intelligence." It was, according to the editors, information that was usually contained in books and specialized journals that had little diffusion in Spanish. The issue starts with a contribution by Russians A. A. Liapunov and S. V. Yablonskii titled *¿Qué es la Cibernética?* (What is Cybernetics?), where, unlike the scientific studies of A. A. Markov, they seek to study the interrelation of science with other branches of knowledge, as well as information theory and its acting mechanism. It is important to underline that Yablonskii was a contributor to the magazine *Проблемы кибернетики* (Problems of Cybernetics), published in the USSR, since 1958. The volume also includes texts on artificial intelligence and cybernetics by both American and Cuban scholars. In December 1970, issue no. 47 is dedicated to cybernetic systems, models, and theories, including contributions by Cuban scholars Eramis Bueno Sánchez, Luciano García Garrido, Hilda Sosa Saura and Marta Blaquier Ascaño. Two major contributions are an article on *Teoria General de Sistemas y sus Implicancias Filosóficas* (General Theory of Systems and its Philosophical Implications, by Anatei Rapoport, and *El papel de los modelos en la ciencia* (The Role of Models in Science) by Weiner and Rosenblueth. Both issues were prepared in collaboration with the Grupo de Lógica del Departamento de Filosofía de la Universidad de La Habana (Logic Group of the Department of Philosophy of the University of Havana), revealing significant interest on the subject that resulted in original local research.[7]

Cybernetics is not a technical tool which can be used for specific purposes; on the contrary, it functioned as an operator that could articulate different biological mechanisms mainly from cognitive elements, which allowed to evaluate not only the semiotic formalities, but also the reaction to them in a given circumstance. This idea scaled and in the 1970s, the conceptual framework was erected based on large-scale models informed by administrative theories. During those years, original multidisciplinary development perspectives for Latin America were based on mathematical models applied to the social sciences. Throughout the region, researchers, such as Darcy Ribeiro, José Luis de Ímaz, Óscar Varsavsky, Amílcar Herrera, Carlos Senna Figueiredo and Stefano Varese, among others, contributed to alternative political and social models and national projects (Senna, in this issue) in Uruguay, Chile, Perú and Venezuela. Such pioneering history of computing in Latin America is still poorly documented, as it is both a technical and creative space for the definition of a new national and regional project.

[6] See the online number at Radical Software's website page: https://radicalsoftware.org/e/volume2nr5.html. Reviewed August 22, 2021.

[7] See University of Florida Digital Collection: https://ufdc.ufl.edu/results/?t=pensamiento%20critico. Files reviewed on August 22, 2021.

Another case worth mentioning is that of Chilean architect Jaime Garretón, who published in Buenos Aires (1975) *Una teoría cibernética de la ciudad y su sistema* (A Cybernetic Theory of the City and its System) published by Nueva Vision, a publishing house founded by Tomás Maldonado. Gordon Pask had previously contributed to that discipline with his *The Architectural Relevance of Cybernetics* (Pask 1969), where he highlights that architecture is a compilation of active systems, in contrast to the perception of a building as simply a static material object (Menges and Ahlquist 2011). Garretón proposed a combination of Shannon's communication theory with urbanistic and architectural dimensions, where the population of the city provides the potential to articulate neighborhoods or communities (Araneda, in this issue). Using a similar background afterward, the Mexican architect Alvaro Sánchez published in 1978, *Sistemas arquitectónicos y urbanos: introducción a la teoría de los sistemas aplicada a la arquitectura y al urbanismo* (Architectural and urban systems: introduction to systems theory applied to architecture and urban planning).

In 1972, British cybernetician Stafford Beer published the *Brain of the Firm* (1972), presenting a model which can be used in all organizational structures and consisting in any system organized in such a way as to meet the demands of surviving in the changing environment he called the viable system model (VSM). This model had a huge impact in Latin America, as in the Cybersyn project (a neologism combining the words "cybernetics" and "synergy") which proposed a complete reorganization of the public sector economy in Chile. The project was conceived by Beer and influenced by Winston Churchill war rooms, as a real-time decentralized management system for the national industries during Salvador Allende's government, the worlds' first democratically elected socialist president. It included a control room which contained several elements of designs by Gui Bonsiepe, to communicate, record and analyze the information acquired.

Espejo comments "Stafford arrived in Chile with a manuscript of his book *Brain of the Firm*, the first of four books he wrote about the VSM and passed it for translation, copying, and distribution to all the early participants in the project" (Espejo, in this issue). The system based on Beer's VSM and Cybersyn, financed by the Corporación de Fomento a la Producción (National Development Corporation), was sponsored by Empresa Nacional de Computación (National State Enterprise for Computing) and Instituto de Investigaciones Tecnológicas (Technological Research Institute) between 1970 and 1973, but never materialized due to the coup d'état. The control system's design was destroyed.

But regardless of the tragic end of the Cybersyn project, a dynamic was generated from the academic world in Chile. Maturana and Varela had published *Máquinas y seres vivos* (Machines and Living Things) in 1971, discussing the concept of autopoiesis, a term describing the analogies between the machine and all living things. The prologue to the book's 1995 reedition mentions "An autopoietic machine is a machine organized as a system of processes of production of components concatenated in such a way that they produce components that: (i) generate the processes (relations) of production that produce them through their continuous interactions and transformations, and (ii) constitute the machine as a unit in physical space." A protobio software based on John von Neumann and Arthur W. Burks' *Theory in Self-reproducing Automata* (1966), was programmed by Ricardo Uribe with suggestions of Francisco Varela and Humberto Maturana. Protobio was a closed functional mechanism which contrasts with Varela's enacción (enaction) (Villalobos and Razeto-Barry 2020) concept that involved metabolic regulation, sensory–motor coupling and inter-subjective regulation (Varela et al 1992). In 1988, Varela introduced a new version in 1991 and renamed Bittorio code that considers structural coupling and the origin of meaning in a simple cellular automata (Ojeda 2001).

Debates on computational models' relation to cybernetics are ongoing. Maulen validates the use of the autopoiesis conceptual behavior as model for bio-digital architecture term and cites the study by Miguel Giacaman and his "Virus Detection" software (one of Maulen contributions, in this issue). Rodríguez Gómez argues Bittorio opens new ways to using "metaphorical devices and tools for thinking" using "structural coupling and enaction, with other relevant fields such as *self-centered (umwelt) biosemiotics* research and cognitive landscapes in neurodynamics, and to advance and explore the concepts of structurally coupled categorization and generalization" (Rodríguez Gómez, in this issue).

After the coup d'état in Chile, Gui Bonsiepe fled to Argentina, Stafford Beer went to Wales, Raúl Espejo got established in London, Senna Figueiredo flew to Lima to work in a project led by the Revolutionary Government of the Armed Forces, and Fernando Flores—Finance Minister of Allende at that time—went to California to pursue a PhD in management. Flores later co-wrote with Terry Winograd *Understanding Computers and Cognition: A New Foundation for Design*. (Winograd and Flores 1986; Letelier, in this issue) Later, the idea of "heuristic design" postulated by Jakob Nielsen will be referred in evaluations for the human use of interfaces and computers, (Human Computer Interfaces or HCI) as an alternative to the one proposed years earlier by the HfG that was based rather on the interrelationship between the machine and the human rather than in the information transmitted, thus redirecting the information-centered design to an interaction-focused design (Vehlken, in this issue).

Beer's VSM model was then extended and adapted to the Latin American and further developed by Espejo and his firm Syncho in the UK and later by Victor Ganon in Uruguay. Sadosky recommended to Ganon study Beer's

theories during the 1970s. Later Ganon met with Beer, and created URUCIB in 1986, as a management system for the state, during Uruguayan President Julio María Sanguinetti's administration (Ganon, in this issue). Ganon in 1992 published *URUCIB: un proyecto, un software, un sistema de información ejecutivo, Presidencia de la República, OPP y PNUD, Montevideo* (URUCIB: a project, a software, an executive information system, Presidency of the Republic, OPP and UNDP, Montevideo). It was later rolled out in Argentina by the Presidency of the Republic and the Budget and Planning Office, as well as in Nicaragua, where the government installed the model. Unfortunately, no record or scientific paper has been found about this implementation. Beer's influence was not limited to Uruguay. In his visit to Mexico, as Javier Cantú, a student who worked with Beer in those years, mentioned, he "tried unsuccessfully to get the Mexican government to apply the concepts of administrative cybernetics to its own organization" (Cantú 2003).[8] Interestingly, Cantú also published *Cibernética, estado y derecho,* (Cybernetic, State, and Law; Gerninka, Mexico City, 1986).

3.4 Recent developments

Based on Beer's VSM, in 1989 Raúl Espejo and Roger Harnden developed *VIPLAN*, a method focused on organizational studies published as *The Viable System Model: Interpretations and Applications of Stafford Beer's Model* (Espejo and Harnden 1989). *VIPLAN* was tested by the Colombian government during the 1990s under the guidance of physicist and computer and systems engineer Alfonso Reyes with a view of determining "how to model the complexity of the enterprises, and how to transform the auditors" and providing "views of their relations with people in public entities, (transitioning) from one focused on requesting information, to one focused on communications." (Espejo, in this issue). Reyes, was also interested in how "organizations may improve the quality of the relations with their clients by transforming environmental agents into new suppliers" (Reyes, in this issue), considering existing capabilities resulting from social development in communities. Leonardo Lavanderos proposed a subsequent stage of Beer's VSM, which he called a relational viable system. This proposal is based on the relations between cooperation and reciprocity and is thought for heterarchical structures which have limited or scarce material energy resources (Lavanderos, in this issue). Lavanderos (2005) has argued that the relationship of systems—the social and natural environment—is not enough, because it considers the subjects as external things to the system. These researchers propose to change the concept of interaction design for that of relationship.

The turn of Nicaragua and Colombia governments was in the 1990s (1991 and 1995, respectively) and in departments like Registraduria and Caja Agraria—Colombian, National Registry and Agriculture Bank. Starting in the 2020s, a proposal was made by Ricardo Rodríguez Ulloa in Peru (Rodríguez, in this issue) drawing on previous efforts by Stafford Beer, Fernando Flores and Raúl Espejo among others in Chile: and in Uruguay, Buenos Aires and Nicaragua by Victor Ganon, and then in Colombia by Raúl Espejo, Alfonso Reyes and German Bula. This management and productive model was not only used by governments, but also rolled out by several private European companies, as the Plastic's Division of Hoechst AG in Germany, Hydro Aluminium in Norway and 3M (Espejo, in this issue) or institutions such as Colombia's Universidad de Ibagué in 2015 (Reyes, in this issue).

Ongoing research on cybernetics includes the work of Roberto Mancilla from the National Autonomous University of Mexico (UNAM) which introduces a basic model of human sociability and alternative frameworks to the idea of the state, the constitution, applicable to the concepts of checks and balances, the separation of powers, the public/private distinction and the concept of constitutionalism, proposing a theoretical management system for the years to come, revealing the continued interactive relation between different epistemologies incorporating the notion of cybernetics (Mancilla 2020). In addition, Eduardo Bayro-Corrochano, a former professor of geometric cybernetics at CINVESTAV (Center for Research and Advanced Studies of the National Polytechnic Institute) in Guadalajara—an institute founded by Artuto Rosenbleuth and Arturo Alvarez Buylla—has published several books on geometric algebra (Bayro-Corrochano 2019) which provides a framework for application of several computer processing and machine learning systems, such as computer vision, graphics or neural computing. Finally, Carlos Vidales, affiliated with the Departamento de Estudios de Comunicación Social de la Universidad de Guadalajara (Department of Social Communication Studies at the University of Guadalajara), also distinguishes semiotics and cybernetics (Vidales and Brier 2021).

4 Conclusion

This introductory paper aimed at establishing the diverse origins and etymologies of cybernetics, confirming there is no single understanding of cybernetics. We aimed to provide a panoramic definition of cybernetics through the research and work done in contexts that are usually underrepresented, including Poland and Russia. In addition, we

[8] This was the second time that a governance system failed to be implemented in Mexico, the first intent was carried out by Russell Ackoff during the 1970s (Vergara Anderson 1996).

tried to elicit the important relations between Wieners' cybernetics with other fundamental ideas, such as Korzybski's Theory of General Semantics, von Bertalanffy's General Systems Theory, Ashby's Law of Requisite Variety and Shannon's Mathematical Theory of Communication.

Establishing such broader view allows us to introduce the developments of cybernetics in Latin America, in particular the pioneering work of Arturo Rosenblueth, who along with Norbert Wiener conducted seminal research and debate during the first years of development of this new inter-discipline, which drew from the psychological experiments on living organisms by Rosenblueth in Mexico and Wiener's wartime research. We want to stress the fact that combining these two perspectives was fundamental to establish the new field.

Rosenblueth and Wiener's work allowed and inspired the work by other researchers in Latin America, such as Joaquín Luco, Alfredo Lanari, Mario Bunge, Manuel Sadosky, Humberto Maturana, and Francisco Varela, among others, who from different scientific and research backgrounds contributed internationally to the subject.

Cybernetics in Latin America was also of great significance for the cultural and artistic practices and collaborations between artists and pioneering figures of computing in the region, namely, Jorge Glusberg and the CAyC in Argentina and his collaborations with Sadosky, as well as Waldemar Cordeiro and his seminal exhibition Arteônica, supported by Giorgio Moscati. Conceptual art also added to a bare bone history of cybernetics that still needs to be studied, including the work of Juan Downey and Teresa Burga. As it was in times of Rosenblueth and Wiener, international exchange and collaboration also enriched the practices. Max Bill and Tomás Maldonado at the HfG enthusiastically adopted cybernetics as a central part of the school's program; in addition, it is also relevant to mention the collaborations among Max Bense and the Brazilian concrete poetry movement.

These international collaborations extended into the 1970s, when the government of Salvador Allende dreamt of implementing a socialist change and had the desire to build a real-time computational system for economic management. Based on Stafford Beer's VSM, the Chilean government aimed at carrying out a structural transformation based on people's participation (Medina 2014). Other countries which pushed fast moving reforms and structural changes also followed this approach, such as Peru, Colombia, Uruguay, and Nicaragua. Stafford Beer and Oscar Varsavsky's theories held that all individuals involved in an organization or state can and should influence it, not only in the hierarchical managerial levels, but also through self-governing and representative participation. Such pioneering history of technology in Latin America is still poorly documented, as it is both a technical and creative space for the definition of a new national and regional project. Medinas' *Cybernetic Revolutionaries* is possibly one of the widest available contributions available in English and has already been translated into Spanish, French and Chinese.

While working on this paper, we consulted the database of the Universidad de Chile, to seek references that apply Beer's model in a State Government outside Latin America. We found two recent contributions: Pérez (2012) has written a code based on Beer's VSM at Valladolid University (Spain), resorting to systems theory and cybernetics to help managers to evaluate and shape organizations by making accessible a trove of knowledge (Pérez 2012). Türke (2008) built a systemic framework that captures social structures based on principles of viability and sustainability to produce better public sector audits. Finally, as Oswald denotes, Beer's model was important to other countries' developments. "Cybersyn project will be a pioneer of dynamic operations research methods and what today is called enterprise software or business intelligence software" (Oswald, in this issue). In addition, Leonid Ototsky, a Russian engineer who worked on Cybersyn, has recently noticed the importance of VSM as a social system for the twenty-first century (Ototsky 2009). Such software was started by integrating the management's main business processes, but today it focuses increasingly on human computer interfaces and human-centered research.

Cybernetics in Latin America should not be seen as a mere technical tool, but as a conceptual framework that acts as an operator inspired by biological and cognitive research to contribute to new political and social models pursuing the construction of national projects. The market for raw materials exposes Latin America to price fluctuations, leaving it out of the manufacturing and knowledge economies. However, we posit cybernetic ideas are still relevant and have a great potential to transform Latin American economies, making them less dependent on commodities' exports and to opening a new path based on education, knowledge, culture, and scientific research. The cases reviewed here give us a view of how Latin America has struggled to take control of its fate and eliminate its cultural and technological dependence on the West. Cybersyn may be the most palpable case of a multinational team devising a new technological system bent on carrying out structural social changes, and integrating political and social values. Thus, a biological approach to computation could serve for new research on and possible adaptations of socio-system administrations in Latin America. This Special Issue seeks to provide evidence on how cyberneticians and researchers have tested their theories within Latin American state organizations, opening a discussion on decolonizing technology. It is necessary to continue debating on how technology is being used and how the region liberates itself from the dogma of imposed technologies which come entrenched with politics of domination.

This special issue of AI & Society aims at narrowing this gap also by incorporating not only the historical and theoretical basis on cybernetics, but also the political and socio-cultural elements, and mapping the diverse approaches that followed.

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