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Research

Dealing with Information, Complex Dynamics and Organizations: Notes on Architecture, Systems Research and Computational Sciences

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Abstract. Similarities can certainly be found between systems research and computational sciences, and architecture and design. The first pair deals with information, complex dynamics and organizations; the second pair is often understood as synthetic and systemic. Postwar history recalls a sequence of exchanges between these fields; the aim of this paper is to highlight the relevance of some exchanges and their contemporary legacy. In this connection, the first part briefly outlines the meaning and history of the former disciplines, highlighting the strict circular models and how first-order cybernetics evolved towards a second order. The second part points to some exchanges between systems research, computational sciences and art forms, as well as to its architectural legacy. To a large extent, the current architectural interest in new sciences of emergence and complexity is rooted in the early systems research approach. Both areas are possible root sources of a future, effective built environment.

Introduction

The present text was prepared as an introductory presentation to the session at Nexus 2010 entitled "Architecture, Systems Research and Computational Sciences".[1] The session was dedicated to exploring the exchanges between architecture and the fields of systems research and computational sciences. The session's main areas also included: second-order cybernetics, architectural morphogenesis and sustainability. Presentations focusing on topics such as complex systems, self-organization, emergence, topology, Cad-Cam, virtual environments and cyberspace, as well as on architects, designs and buildings which illustrate the relationship between architecture and mathematics, were included.

Regarding the present paper, it should be acknowledged that the computational connection with telecommunications, which led to cyberspace, has constituted an architectural challenge at the level of urban building and design practice. More recently, architecture's interest in the new sciences of emergence and complexity, which Jencks even associated to a 'New Paradigm in Architecture' has became noticeable. However, the current digital architectural culture is rooted in early systems approach; an area which tended to view 'organization' from an approach of complexity.

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Notes on systems research, and computational sciences: from the circular model to a second-order

The term “Cybernetics” was first used in 1948 by Norbert Wiener to define “the science of control and communication in the animal and the machine” [Wiener 1948]. It evolved into a discipline dedicated to the study of systems, offering tools for dealing with complex dynamics and organizations. I recall, in this connection, that Claude Shannon and Warren Weaner’s [1949] Information Theory and the interdisciplinary efforts of the American Macy’s Foundation Conferences (1946-53),[2] chaired by McCulloch, were crucial to cybernetics’ early development. Also important since 1954 were Von Bertalanffy’s Society for General Systems, and the broad trans-disciplinary emphasis of Systems Theory is mentioned by Heylighen and Josyln [1992].

In fact, after World War II, cybernetic notions such as information, control, system (i.e., an assemblage of interdependent interacting entities) and feedback (i.e., the idea of reintroduction of outputs in the system), became extremely influential. And in the 1960/70s the field of systems research operated by abstracting interconnected components and goals, actions and feedbacks, into a descriptive scheme of an organized complexity. It enabled, for example, Forrester’s attempt to model the world, which influenced Meadows’ research on the global problem and its ongoing evolution, followed by the ambitious Club of Rome planetary ecological systemic attempt [Forrester 1961].

With continued advances, around the early 1970s, a second-order cybernetics arose. This trend acknowledged the observer’s participation and developed as a kind of applied epistemology. More recently, new sciences of complexity emerged; but to a certain extent they continued to have their roots in cybernetics and systems thought.

In parallel, it is also of importance to recall that the scientific concern with complex dynamics and organizations was also paralleled by a broader intellectual shift from determinacy to the acknowledgement of “indeterminacy” or uncertainty. Scientific occurrences of such a history include the astronomic “three-body problem”, developments of quantum physics or the areas of emergent complexities, of which brief descriptions were provided, for instance, by Rosmorduc and L’Echat [2004]. The acknowledgement of “uncertainty” had a broader cultural meaning, as highlighted by David Peat, for it constituted “…a major transformation in human thinking … [and] while our millennium may no longer offer certainty, it does hold a new potential for growth, change, discovery and creativity in all walks of life” [Peat 2002].

It is also important to recall the parallel history of computation and “artificial intelligence”, which progressively developed its capacities becoming increasingly available.

Broader accounts of computation are included in books such as that of José Terceiro [1997]. These histories include some well known events. First there was the ENIAC, which was the first electronic computer created by J. Presper Eckert and John Mauchly in 1943-46. It was used for the calculation of flight paths of rockets and missiles and later for weather forecasts. Second came Von Neumann’s crucial idea of “software”, that is, the idea of a stored computer program, which was introduced in 1945 with the EDVAC.[3]

It is also important to point to the first commercially available computer, the UNIVAC 1, created in 1951 by Remington Rand.[4] In this connection, I highlight that the transistor was invented by Shockley, Brattain and Bardeen in 1948, and that the microprocessors dated from the early 1970s; these achievements went some way towards the dissemination of computation in society.

In fact, the 1970s were an exciting decade for more than disco and postmodernism. Despite the oil and economic crises, it was also a decade marked by strong technological progress. The effects of developments in computation were strongly felt, for instance in the areas of automatization and robotics (see Jasia Reichardt's account of robots in this respect [1978]). In addition, a look at popular books for collectors of the 1970s, such as the memorabilia of Higgins, demonstrates the explosion of electronic gadgets in that decade. They are filled with achievements and artifacts in the areas of electronics computation and the like, including the 1970 IBM floppy disc, the 1972 LCD watches, the 1972 IBM laser printers, the mid-1970s' video games, the 1979 Sony Walkman, etc. As Higgins states, the 1970s were linked to the dissemination of microelectronics and computation:

> The 1970s saw an explosion in electronics innovation…. At the forefront of change was the world's first microprocessor, the legendary 4004, launched by America's Intel Corporation in 1971. Many could hardly believe that a chip the size of a thumbnail was as powerful as the world's first electronic computer, ENIAC (1946), which had filled an entire room. As less expensive, more powerful chips followed, so did electronic gadgets [Higgins 2001: 44-47].

The Intel 8008 microprocessor dating from 1971 was followed by the launch of the first personal computer, the Altair 8800, in 1975. That same year, microcomputers went on sale in the US; the PC prototype of Bill Gates (who later founded Microsoft) was developed; and Apple, the first computer with a plastic case and color graphics came out; whereas the IBM PC was only announced in 1981.

In short, we understand that electronics enabled microprocessors and the accessibility of personal computers, after the mid-1970s and especially in the late 1970s. These advancements were largely promoted by popular magazines in the 1980s.[5] Today, we have undoubtedly ended up living in an Information Society. In 2003, computational scientist and architect John Frazer stated: "I toast the new millennium and declare myself post-digital … " [Frazer 2005: 43].

Let it be recalled that a particular area that benefited from computational sciences and the cybernetic equation of man-machine was Artificial Intelligence (AI).

A historical overview of AI, its aims and areas of development, is provided for instance in Simons' *Introducing Artificial Intelligence* [1984]. Several important phases can be recalled. For example, Alan Turing conceived his evaluation test of machine intelligence in 1950. In the same year, at the Dartmouth conference, in which many pioneers participated, McCarthy coined the term "AI". Other historical moments in the "Automata Studies" were Shannon's 1956 publication, as well as Von Neumann's work. The latter's work was extended to areas of computer sciences such as AI; he worked with self-replicating systems and conceived the "Cellular automata" concept (see especially [Von Neumann 1966]. In fact, Pierre Marchal [1998] highlights Von Neumann's role as "the Founding Father of Artificial Life"; and his cellular automata concept later inspired John Conway's "Game of Life" [Gardner 1970]. In addition, Oliver Selfridge and Marvin Minsky, of course, also conducted well known research at MIT's outstanding AI Laboratory. (The Laboratory was founded in 1959; see Minsky's account on "Computation: Finite and Infinite Machines" [1967].)

Regarding AI, two important languages were McCarthy's "Lisp", from 1960, and Alain Colmerauer's "Prolog", from 1972. Regarding AI research methods, these included parallel processing, neural networks, fuzzy and genetic procedures.

Currently, the polemic debate on AI continues. In this connection, I would like to state that the concern of a new paradigm in AI, which took into account the evolutionary character of human beings and the observer, was acknowledged by Pedro Medina Martins (see [Medina-Martin and Rocha 1992]).

As mentioned in the introduction, systems research and computational sciences deal with information and complex dynamics and organizations.

At this juncture I would like to point out to the distinction between the perspective of second-order cybernetics and Artificial Intelligence or first-order cybernetics.

At the outset, it should be recalled that after the discipline of cybernetics's boom in the 1960s, it experienced a certain decline in the 1970s. In relation to the systems perspective, accounts even emerge that provide a critical review of it, such as Lilienfeld's *Rise of Systems Theory: An Ideological Analysis* [1978]. However, progressively and in what concerned cybernetics, a second-order-cybernetics was arising, which acknowledged observer participation in the observed system, shifting the focus from control to interaction. Later on, the new sciences of emergence acknowledged and explored the system's recreation of boundaries and so on. Putting it briefly, Second-order cybernetics denominates a shift within the discipline. It goes back to ideas such as Mead's *"Cybernetics of Cybernetics",* or Von Foerster's *"Observing Systems"*, which advanced the notion that the system also included observer participation [Von Foerster 1974, 1981]. Putting it briefly, there was an awareness about the question concerning self-referentiality and the idea that the researcher is part of the system that he or she constructs in order to investigate or to relate himself to something.

Heylighen and Josyln provided a historical account and distinction between first and second-order-cybernetics, highlighting the development of the discipline in the post-war period. They stated that second-order cybernetics arose in the 1970s from a trend that wished to distinguish itself from a more reductive climate or mechanistic orientations:

> Cybernetics had from the beginning been interested in the similarities between autonomous, living systems and machines. …In the post-war, the fascination with the new control and computer technologies tended to focus attention on the engineering approach, where it is the system designer who determines what the system will do. However after the control engineering approach had become fully independent, the remaining cyberneticians felt the need to clearly distinguish themselves from these mechanistic approaches, by emphasizing autonomy, self-organization, cognition, and the role of the observer in modeling a system. In the early 1970s this movement became known as second-order cybernetics. …[A] 'first-order cyberneticist', will study a system as … an objectively given 'thing' … A second-order cybernetician … recognizes that system as an agent in its own right, interacting with another agent, the observer… [Heylighen and Joslyn 2001].

To a large extent, it can be understood that second-order-cybernetics have a philosophical stance, and that this approach can be associated with challenges to more conventional scientific positions.

In fact, embracing the presence of the subject has a huge impact on science and on life, to a broader extent. In this connection, Glanville's paper "Chasing the Blame" [1995] not only provided a clear explanation of what "cybernetics of cybernetics" is but also added to its deep human meaning. In his own words:

> What characterizes cybernetics of cybernetics is the inclusion of the agent that is determining the system under consideration. …When cybernetics considers its own subject matter cybernetically, it is being cybernetic. Then we have cybernetics of cybernetics.

The involved explanation provided by Glanville further on enables one to understand its deep human meaning:

> The cybernetics of cybernetics is, as its name suggests, full of circles. Circularity is one of its major characteristics…, and the cybernetics of cybernetics is full of involvement. By this, I mean the involvement of the observer in his observing…, of the knower in his knowing…, of the conversationalist in his conversing, of that which is alive in his living. …What we can understand from this is that the observer is responsible for both his observing and its frozen version, which we like to call observation…. By not accepting that our observation is ours, we exteriorize and reject it. Thus, we make cause and effect, for cause is the mechanism that explains why we are not (often, in general) responsible for the effect (that is, excuses our willingness to accept our responsibility) [Glanville 1995].

Exchanges with the art forms and its architectural legacy

The paper's first part briefly outlined the meaning and history of Systems Research and computational sciences. In the following part, I would like to point to some exchanges between the aforementioned fields and art forms, as well as to their architectural legacy.

In terms of what concerns the history of post-war architecture, an important moment was the establishment of modern architecture In this connection several accounts could be highlighted: Legault and Goldhagen [2001] provided an understanding of the Modern Movement's that is worthy of note, pointing to its intrinsic complexity and its process of evolution ([Montaner 2001] alluded to the idea of "the Overcoming of Modernity"). To a certain extent, designers were anxious to overcome the rigid planning and architecture of modernism by acknowledging the role of users and representing the dynamics of time; as described in Ewan Branda's paper "Programming the Utopia of the Present" [2003]. Many events and protagonists contributed to the so-called "overcoming" of modernity. For example, Rouillard's *Superarchitecture: Le Future de l'Archietcture 1950-70* [2004] described three tendencies that resulted in the crisis of modern architecture, while MoMA's *The Changing of the Avant-garde* exhibited occurrences that constituted "… the roots sources of our architecture today" [Riley 2002: 14].

At this juncture, the existence of a specific atmosphere in the 1960s and 1970s should be highlighted (see the catalogue of the Pompidou's exhibition "Les Anées Pop" [Francis 2001] and the March-April 2005 issue of *Architectural Design* edited by Hardingham which focused on the following decade). The atmosphere was characterized by a desire for flexibility and technological optimism; such desires were highlighted at the time in several magazines, especially in *Architectural Design*'s monthly section on "Cosmorama" published in the 1960-70s, and the *Archigram Magazine* published between 1961-1974. In relation to these magazines, the occurrence of many important avant-garde architectural practices as well as events should also be acknowledged. Among the radical practices developed in Europe, we could highlight the relevance of *Archigram* in the UK, GEAM in France, Metabolists in Japan, Superstudio in Italy, among others. Regarding events, I could recall the International Dialogue of Experimental Architecture, which took place in Folkestone in June 1966, and the World Design Science Decade inspired by Fuller, which took place in the 1970s. To a large extent the late-modern "Megastructural" movement, analyzed by Reyner Banham [1976], was fuelled by such desires of flexibility and technology.

More important, is that the modernist crisis led to a postmodern shift, which must be identified in conceptual-philosophical terms, rather than merely associated with a historical style. In this connection, many accounts could be referred to, including Hal Foster's outstanding book *Postmodern Culture* [1985], which provides a multidisciplinary discussion of the postmodern shift. Architecture's theoretical agenda from 1943 to 1995 has also been covered by a sequence of anthologies authored by Joan Ockman [1993], K. Michael Hays [1998] and Kate Nesbitt [1996].

Concerning the exchanges between systems research and architecture, I would like to highlight the relevance of British cybernetician Gordon Pask.

Pask was an important figure of second-order cybernetics and a seminal promoter of cybernetics within art forms. In this connection, I would like to note that he developed interactive art pieces beginning in the 1950s (for example, "Musicolour", "The Colloquium of Mobiles"), and he worked in the architectural milieu (for example, as a consultant to Cedric Price's Fun Place and the Architectural Association). He has also published original pieces in the 1960s and 1970s in *Architectural Design*.[6] In 1969, in an article in *Architectural Design*, Pask described "The Architectural Relevance of Cybernetics" at various levels. This outstanding article appeared in an issue edited by Landau, which included articles such as Greene's "Cybernetic Forest", M.I.T.'s "Computer Aided Design" and Negroponte's "Architecture Machine".[7] Later Pask wrote about "Complexity and Limits" [1972], establishing a parallel relationship between the topics of language, codification and the observer, and architecture.

In addition, I would like to recall other important protagonists and contributions. For example, the importance of Christopher Alexander's *Notes on the Synthesis of Forms* [1964], which revealed his work on design patterns; Haissman's papers on "Five Dimensional Concepts and Architecture" [1967], and Abel's 1973-1974 conception of the design device "Architrainer" at MIT, should also be recognized. Another important issue of *Architectural Design* was that edited by Andrew Rabeneck in 1976 (vol. 46, no. 5, May 1976) which raised the alarming question "Whatever Happened to Systems Approach?" at a time when architectural postmodernism was on the rise and included articles on Price, Seagal and Fuller. In the editorial introduction to Rabeneck's article (pp. 298-303) it explicitly stated that:

> The system approach once held to be the key to a panacea for all humanity's ailments, has recently been discarded in the latest quest to improve the quality of life – this time by less overtly technical means. With the help of editorial consultant Andrew Rabeneck, this issue of *AD*

asks 'Whatever Happened to Systems Approach?' and find answers for the architects featured (p. 267).

I would like to pause here and state that from the late 1960s – especially in the 1970s and 1980s – another important research platform on computation was Negroponte's "Architecture Machine Group" in the USA [Negroponte 1970, 1975]. Pask was among those who interacted with Negroponte's group.[8] I have detailed this elsewhere [Furtado 2009b], as well as the fact that the elevation of "Conversation Theory" to a unifying status within architectural thought was attempted in detail by Pask [ca. 1980s]. His papers from the 1980s, including "Architectural Systems" [1982], "Architecture of Knowledge" [1984]], "Space Time Frames" and "The Reality of History" [1985], expressed other important topics that related to his future work.

In addition, it should also be mentioned that in the mid-1980s, Pask and architect Cedric Price developed another project – Japan Net – as a competition entry for the city of Kawasaki. Elsewhere I have provided a complete account based on the material available at the date of my research visit to the Cedric Price Archives at the Canadian Centre for Architecture [Furtado 2009c]. I noted that the character of the proposal for Kawasaki reflects Price and Pask's architectural and second-order cybernetics stances.

Regarding the exchanges between architecture and computational sciences, I would also like to recall the accessibility of personal microcomputers since the 1970s, and their connection with 1990s telecommunications leading to cyberspace. Digital space and life constituted a huge architectural challenge at the level of the city's building and design practice,

Nowadays, we have undoubtedly ended up living in an Information Society. There are many definitions and accounts of IS; for example, Flusser's [1998] definition of I.S. expresses the ubiquity of information.[9] It has become mankind's "Third Environment" according to Echeverria [1999], turning the prognostics of McLuhan's "global village" [1962] and Gibson's vision of "cyberspace" into a reality [1884]. In this context, we can state that our lives are supported by the "Internet" and the "virtual". The virtual has its own complex nature, as analyzed by Quéau [1995] and Maldonado [1994]. The same applies to the Internet, as referred by Trejo [1996].

Let me note that the earliest architectural approaches to digital space date back to the early 1990s. Michael Benedikt's seminal multidisciplinary book, *Cyberspace: First Steps* [1991], and the 1993 *ANY* issue on "Electroculture" edited by Taylor, must be acknowledged here. As Michael Hensel pointed out, "architecture and media are both ... shapers of environments" [Lootsma and Rijken 1998: 80]. In such a context, a new series of practices concerning digital architecture emerged, as stated by Peter Zellner in *Hybrid Space* [1999]. This new stance of digital architecture followed the architectural engagement with Derrida's deconstruction and Deleuze's fold.

In addition to the impact of the digital in the urban environment, the manifold applications of computers also parallel their impact on the practice of design and building. There were many protagonists and the developments focused on the relationship between computation and design, as well as on computation and building. Regarding the former, Pellegrino, for example, has researched the relations between informatics and architectural design [1999], and developments in the design field were described in Morgan and Zampi's *Virtual Architecture* [1995]. Regarding the latter, for example, an approach to the field of intelligent buildings is provided in *Arquitectura i Maquina* [Florensa 1996].

I would like to note that architecture's technological engagement goes on further to encompass other technologies. For example, Prof. Neil Spiller (at Bartlett's Unit 19), among others, conducted some leading research on responsive and "reflexive" environments, attending to nano and bio technologies. The same happens with the new contemporary architectural interests in the new sciences of emergence and complexity. To a large extent, it expresses architecture's new desire for an evolving environment.

In fact, it is noticeable that in recent years contemporary professionals (such as Gausa), have privileged "processes" rather than "occurrences" in the search for a more dynamic "understanding of architecture" [Moreira dos Santos 2003: 54]. Accordingly, new sciences also impact architecture. I highlight the importance of the 1997 *Architectural Design* issue edited by Jencks, consisted of revealing articles on the impact of "New Science" on a "New Architecture". There, Cecil Balmond stated that "the paradigm is one of emergence" [Balmond 1997: 88], and Jencks provided a definition of "complexity" pointing out that in such a process "… quality emerges spontaneously as self-organization …." [Jencks 1997: 8].

In addition, I would like to mention Abel's outstanding "Visible and Invisible Complexities" [1996], which criticizes the common tendency for an interest in a merely superficial, visual and formal complexity, while in contrast, the era of information technology and complexity' affects Architecture, from conception to production, at a distinct level. The importance of Raoul Bunschoten's outstanding architectural event on "Chaos and Order" and others at the AA should be acknowledged.

As an aside, my hero Gordon Pask was also involved in occurrences and events close to the topic during the 1990s. He was involved in Raoul's "Risk and Transgression", and intended to organize an event on the time-architecture relationship with Farhad Toussi alluding to architecture's organization of time and to "an architecture of temporality" [Pask 1991 ca]. Pask also supervised and examined some academic works on the issues mentioned, at a time when it did not coincide with mainstream interests. For example, he supervised James Bradburne's 1988 thesis on "The Strange Attraction of Chaos" (see [Pask 1988]), and reviewed a 1993 thesis on "Chaos, Architecture and the Strange Attractor".[10] Pask pointed out that "… great architects … know that space is a malleable … commodity … ." Elsewhere [Furtado 2007] I have noted and described that at the AA school of architecture a complex perspective on architecture continued to be promoted by Pask throughout the last years of his life. For example, Pask contributed to Frazer's AA unit, which developed outstanding achievements and exhibitions.

A summarized description of the work developed by Frazer's AA unit was provided in a 2005 *Architectural Design* issue [Frazer 2005] and was detailed in a 2001 *Kybernetes*. Frazer mentioned Pask and Price's contribution to the unit in interviews that I conducted with him on 22 March and 5 October 2005. Regarding his achievements, I suggest Frazer's paper co-authored with Rastogi and Graham [1995], which explains the "Interactivator" data structure, cellular growth, and genetic search of the model in *Architects in Cyberspace*. The interactive version of the evolutionary model is on-line at Ellipsis [Frazer 1995]. In regards to the exhibitions, there are several reviews. The one by Barrie Evans highlighted its complexity and benefits [1995]. Another review in the *AA Files* provided a critique of Frazer's vision saying "… Evolutionary Architecture may just excel in the very thing that it does not profess to do: the modeling of solutions to particular architectural problems …" [Bettum 1995]. Interestingly, the second phase of Frazer's unit's experiment, concerned with real-world situations, consisted of the development of an urban model. It was described by John and Julia Frazer in the sequel to the magazine *Architects in Cyberspace* [Frazer and Frazer 1998]. In particular, Frazer and Rastogi's text "The New Canvas" [1998], included in the aforementioned publication, described aspects of the evolutionary approach and models of co-evolving environments, such as a city. Regarding Pask, as I have stated elsewhere, he expressed his intention to conceive texts and designs expressing his later ideas on an evolving informational environment.

Concluding notes

Similarities exist between systems research, computational sciences, architecture and design. The aim of this present paper was to highlight the relevance of some exchanges between those areas and its contemporary legacy. The text's first part briefly outlined the meaning and history of the former disciplines; and the last part pointed to some exchanges and their architectural legacy.

As described, systems research goes back to the war period, and it is concerned with "organization" from an approach of complexity. The history of the field recalls an expansion of attention at the level of the planet with the Club of Rome's systemic approach to the global problem (see especially [Rosnay 1978]). However, dealing with issues of complexity was also paralleled by the acknowledgement of "uncertainty".

Systems research, like cybernetics, became influential throughout the post-war period, and it embraced a wide field of application. There was, undoubtedly, a later 'backlash' against the latter; however, as Scott has mentioned in his obituary of Pask [1996], its concepts permeated such areas as AI, systems and emergence Sciences. Moreover, a "second-order cybernetics" arose around the 1970s, acknowledging the presence of the observer in Systems, and leading to theoretical developments such as "Autopoiesis", "Conversation Theory", etc. At the time, computation became ubiquitous, and its later connection with telecommunications led to cyberspace and to the Information Society in which we now live.

At an early date, systems research, cybernetics and computational sciences went on to interact with the fields of arts and architecture. Early occurrences included the work of Schoffer, Pask, Jones, Alexander and Negroponte, and they were fuelled by a desire to overcome the rigid architecture and planning of modernism, by representing the dynamics of time. Progressively, digital space and life also constituted an architectural challenge at the level of the city's building and design practice. The earliest of such approaches date back to the early 1990s, and more advanced explorations were made by architects such as Novak (on "transvergence") and Frazer (on "evolutionary architecture"). To a certain extent, the current digital architectural culture is rooted in cybernetics, and the systems approach enables a systemic focus of contemporary cities, and the global ecological problem. Today, architecture's desire for a more evolving environment is leading to an interest in the new sciences of emergence and complexity, which Jencks even calls a "New Paradigm in Architecture". In our opinion, both areas are the roots sources of a future, effective built environment that could evolve.

Notes

1. This text is based in part of my Ph.D. [Furtado 2007]; a summary was published in [Furtado 2009a]. Short short excerpts from my paper presented at the last colloquium of WOSC; see

[Furtado 2009b]. My Ph.D. and research were supported by a grant from the Fundação para a Ciência e Tecnologia/POCI 2010. I am grateful to Amanda Heitler, who gave me permission to conduct research in her father Gordon Pask's archive in 2005 and publish the findings. It is possible that some of these materials will be found today at the University of Vienna, where an archive was recently established.
2. As an aside, Foerster was editor of the proceedings of several conferences on cybernetics. The first volume that he edited was that of the sixth conference [1949]. Those that followed were edited by Foerster with H.L. Tuber and Margaret Mead: the seventh in 1950, the eighth in 1951, the ninth in1953 and the tenth in 1955.
3. I digress slightly to refer that a biographical account of Von Neumann is provided by J. A. N. Lee [2002]. The Papers of John von Neumann on Computers and Computing Theory were edited, with an introduction, by Arthur Burkes [Von Neumann 1986]. Lee's biographical account of Von Neumann describes that Von Neumann, like Gödel, was encouraged to move to the US by Morganstern, being appointed Professor at Princeton in 1933. Years later, in 1945, Von Neumann signed the "First Draft of a Report on the EDVAC" [1945] introducing the basis of the first stored program computer. Interestingly, it is also asserted that he knew Turing's 1934 paper on the universal machine, since Turing studied in Princeton between 1936-38, and then moved to the UK and worked at Bletchley Park. After the war, Von Neumann continued to have exchange with Los Alamos relating to computation and the conception of the hydrogen bomb [Lee 2002].
4. SYSTEM RESEARCH LTD, 1962-80. Visitors Book. Gordon Pask Archive. My archival research was conducted at Amanda Heitler's house.
5. For example, Gordon Pask kept some issues of *The Home Computer Course: Mastering your Home Computer in 24 Weeks* (London: Orbis Publications).
6. The importance of this magazine in the dissemination of new ideas ought to be acknowledged, for as Frazer stated: "Whilst mainstream architectural practice was still concerned with modernism, these new preoccupations [of indeterminacy and interactivity] found fertile ground in schools of architecture and by the mid-60s… Architectural Design … was carrying increasing coverage of these new ideas" [Frazer 1993: 44].
7. The issue includes articles by Pask, Green, Negroponte; it also includes an article by Cedric Price. See [Pask 1969; Green 1969; Negroponte 1969].
8. See for example [Pask 1975], "Artificial Intelligence: A Preface and a Theory", which was originally prepared for Negroponte's *Machine Intelligence in Design* [1973]; it became *Soft Architecture Machine* [1975], in which Pask published "Aspects of Machine Intelligence".
9. Aguadero [1997], among others, has provided a summary account of this theme, and several political programs have tried to implement it. Following the "American technological plan" of 1993, the European Union created the "Delors Plan" and Bangeman report (both 1994).
10. Evidence exists in the archive that Pask reviewed the unidentified student's paper titled "Chaos, Architecture and the Strange Attractor" in May 1993.

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