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Gordon Pask and the origins of design cybernetics

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Chapter 3
The Origins of Design Cybernetics

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Abstract This chapter introduces the subject of design cybernetics from the perspective of its origins in conversation theory—interweaving descriptions of cybernetic artefacts, cybernetic design concepts, their socio-cultural implications, and their possible consequences for a cybernetic theory for design. Conversation theory was developed initially by the British cybernetician Gordon Pask, and later by his students Ranulph Glanville and Paul Pangaro. With a view to opening up strands and avenues for design education and design practice, this chapter positions the act of designing as an embodied conversation between designers, the subject matter and the object to be designed. An introduction to cybernetics and design is followed by a discussion of machines developed by Pask, including *Musicolour* and *Colloquy of Mobiles*. The chapter then offers an overview of Pask's conversation theory as based on circularly-causal, interactive, feedback-based epistemological processes. It constructs and explicates a design reality of interaction, learning and design education. Pask explained *conversation theory* rhetorically, arithmetically and graphically. Pask's *entailment meshes*, n-dimensional cyclical network graphs describe conversation topics, paths, attributes and partners of interaction. They are examined and related to contemporary digitally driven systems and societies. The chapter concludes by discussing design cybernetics in view of socio-cybernetic ecologies and the shifting paradigm of design authorship.

3.1 Origin and Etymology: What is Design Cybernetics?

> The cybernetic theory can also claim some explanatory power insofar as it is possible to mimic certain aspects of architectural design by artificial intelligence computer program (provided, incidentally, that the program is able to learn about and from architects and by experimenting in the language of architects, i.e. by exploring plans, material specifications, condensed versions of clients' comments, etc.). — Gordon Pask [18, p. 496]

During the last decade, the term *cybernetics* has regained visibility. Despite its truly interdisciplinary involvement, cybernetics has, until the second half of the 20th century, been associated with navigation, warfare, electronics and control theory; and, albeit less prominently so, with biology, the social-sciences, anthropology, political governance and interaction between humans. The term *cybernetics* appeared in the design context as early as during the 1950s, for example in conjunction with works such as Gordon Pask's *Musicolour* in 1953, and Nicolas Schöffer's *Premeière Tour spatiodynamique, cybernétique et sonore* in 1954.

The term *cybernetics* had been used before the twentieth century. In the fourth century B.C. Plato described the act of regulating a population with reference to helmsmanship using the phrase αρετής κυβερνητικής (i.e. virtue of government). In the early 1800s, André-Marie Ampère referred to *cybernétique* as the art of governing or the science of government. It was Norbert Wiener, who popularised the term with his book "Cybernetics: Or Control and Communication in the Animal and the Machine" [42]. Wiener was aware of the term having been used in the context of the Greek meaning 'steersman', but less of its application to politics as promoted by Ampère. He later commented that "until recently, there was no existing word for this complex of ideas, and in order to embrace the whole field by a single term, I felt constrained to invent one. Hence 'Cybernetics,' which I derived from the Greek word kubernetes, or 'steersman,' the same Greek word from which we eventually derive our word "governor." [43, p. 15] In the 1960s, pioneers in computer art, such as Max Bense (exhibited at the 1968 *Cybernetics Serendipity* exhibition [30] in London), the Vera Molnar and Frieder Nake, amongst others, began to explore the relationships between art, design, science and cybernetic principles. Their computer graphics represented rationalised art and describe it formally abstract, rather than figurative. Their work explored the continuous process of generative iterations rather than fixed states.

Such early connections can be seen as one origin of design cybernetics. Today, design cybernetics stands as a maturing field in its own right, as a reflective philosophy of acting and understanding [10]. Ranulph Glanville (1946-2014) retraces the intertwined and inevitable relationship between design and cybernetics in his 2007 paper 'Try again. Fail again. Fail better: The cybernetics in design and the design in cybernetics'. The paper was published in a special issue of the journal *Kybernetes* on design cybernetics—edited by Glanville himself—and is reproduced as chapter 1 of this collection. Glanville describes a) cybernetics as a way of thinking, and b) design as a verb rather than as a noun to describe problem-solving [8, pp. 1173-1174].

The term *cybernetics* derives from the Greek word *kybernetes* meaning steering, regulating or governing. The term design stems from the Latin word *designare*, *de-* meaning *from* or *out*, *signare* meaning *mark* or *sign*. Hence, *design cybernetics* can be understood as the process, of *steering* and the *marking* or the *signing*, or, as Glanville points out with reference to Spencer-Brown [2], the drawing of a distinction [8, p. 1180][1]. *Signare* implies *semiotics*, referring to the theory of signs, originally investigated by Charles Peirce at the end of the 19th century. Pierce's theory points towards the relation design and design cybernetics have with human interactions that involve meaning. Signs are codes "carrying information" between communicating senders and receivers. Both need to encode, decode and interpret, to arrive at a shared understanding of subject matters referred to[2]. The resulting conversational process is dynamic, non-trivial and intrinsically related to the process of designing. To *design* implies a creation process in which the designer is actively involved and the final result is not clear at the beginning of this process. The designer engages in a circularly-causal conversation (the design process) with the artefact to be manifested. In cybernetic terms, the act of *designing* implies an involved participant observer initiating a process that eventually results in something unforeseen and new, emergent and unplanned. When this occurs, the system *designer-design* is operating in a second-order cybernetic mode [7]. Varela refers to second-order cybernetics as "the cybernetics of observing systems" [37, p. xviii]. Designing can be defined as an act of self-organisation and con-struction of two or more elements through which their specific properties transform into properties not inherent in the original elements [3, 12].

Since the 1940s, cybernetics has experienced fundamental re-conceptions. Formative discussions of what would eventually coalesce to form the new discipline of cybernetics took place during the *Cerebral Inhibition Meeting* in

[1] Editors' note: See also page 34 in this volume.

[2] Editors' note: See figure 1.4 in this volume.

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1942, and during the *Macy Conferences* between 1946 and 1954, both taking place in New York City. The discipline developed along various milestones including the publications of Ashby's *An Introduction to Cybernetics* [1] and of Maturana and Varela's *Autopoiesis* [33], the formation of *radical constructivism* on the basis of von Glasersfeld's cybernetic interpretation of the work of Piaget and own experiences [39], as well as von Foerster's proclamation of *second-order cybernetics* — a cybernetics that recursively applies to itself [35]. The abstract language of cybernetics applies to all systems regardless of whether they are technical, biological or social in nature. In the second-order context, technical interest is less concerned with utilitarian application than with the modelling of cognitive and social processes, typically for purposes of understanding and speculative exploration as they occur, for example, in the subjectively driven process of designing. To establish a basis for my description of Gordon Pask's cybernetics later in this chapter, I will first explore selected milestones relevant to the understanding of cybernetics in general and of design cybernetics in particular.

1. The *Macy Conferences* (1946-1954) allowed for initial encounters between researchers from varying disciplines to explore their shared interest in feedback systems. The interdisciplinary exchanges between the hard sciences and the humanities—including anthropology (Margaret Mead, Gregory Bateson), computer science (John von Neumann), neurosciences (Walter Pitts , Warren McCulloch), physics (Heinz von Foerster), psychology (W. Ross Ashby), mathematics and philosophy (Norbert Wiener)—occurred under the conference theme *Circular Causal, and Feedback Mechanisms in Biological and Social Systems*. The sixth Macy Conference was the first one joined by Heinz von Foerster, who suggested to name the field *cybernetics*, based on the title of Wiener's book.
2. The proposal was adopted [38, pp. 300-301] and the term added to the beginning to the conference theme for subsequent meetings [7, pp. 1380, 1385]. Conversations between the conference attendants, bringing together different ideas, research methods, and partially contradicting definitions, orchestrated a beautiful exuberance of variety and possibilities (documented in [28]) —a cybernetic repertoire provided the roots for design cybernetics. Seeing the world and 'listening' to the world in a cybernetic way offers scope for conversation and learning. "Listening", Glanville states, "gives us entry to conversation and thus to the prototypical embodiment of interaction." [6] It provides a basis for conversation and approaching the world cybernetically.
3. Ashby's *Introduction to Cybernetics* explains the subject based on the notions of *variety*, *stability* and *equilibrium*, and points out *difference* as a fundamental concept of cybernetics. The mathematician George Spencer-Brown (1925-2016) emphasised *difference* as the result of an action, rather than a found state. In *Laws of Form*, first published in 1969 in the UK, Spencer-Brown establishes the first law of forms the *drawing a distinction* [2]. This introduces marked space, in which *difference* is established, e.g. between an exterior and an interior space, differentiated from each other by a physical distinction, a wall.
4. Pask was strongly influenced by Ashby's *Introduction to Cybernetics* [1], and its predecessor *Design for a Brain (Ashby, 1954)* and presented many of the principles developed by Ashby in his 'cybernetic pocket-book' *An Approach to Cybernetics* [17].
5. The notion of *Autopoiesis* was developed by Humberto Maturana, Francesco Varela and Ricardo B. Uribe in 1974 — partly at the Biological Computer Laboratory (BCL), founded by Heinz von Foerster. The cybernetic concept of *autopoiesis* relates to self-organisation and self-creation in biological and social systems. Following Leduc's 1911 *The Mechanism of Life* [14], *autopoiesis* provided a new theory for the concept of all living organisms. Cognition and biology were discussed as intimately coupled. The definition of

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terms such as *structure*, *organisation* and *systems* became crucial for further discussions on the behaviour of systems. In 1997, McMullin and Varela revisited the computational modelling of autopoiesis, applying a swarm simulation algorithm developed by the Santa Fe Institute to program for "realizing dynamic cell-like structures which, on an ongoing basis, produce the conditions for their own maintenance." [34, p. 39].

6. *Computational autopoiesis* is now used to simulate complex rule-based behavioural formations of large groups of agents, as seen e.g. in swarms of bees, schools of fish or human crowds. The application of multi agent algorithms entails cybernetics inherently and suggests that "the architect is no longer a designer of discrete objects, matter and space, but a designer of systems with complex components and multi-layered relationships" [41, p. 288]. It suggests a strand of design cybernetics addresses evolutionary algorithms in the design of ecologies for social systems, e.g., human, animal and robotic [40].
7. *Second-order cybernetics* was coined and developed by Heinz von Foerster alongside with Humberto Maturana, Gordon Pask and more recently, by Ranulph Glanville and Paul Pangaro, among others. *Second-order cybernetics* acknowledges the observer as actively involved in the observation of, and the conversation with, observed systems as they occur in design processes. Varela [37, p. xviii] distinguishes:

   > First order cybernetics: the cybernetics of observed systems;
   > Second order cybernetics: the cybernetics of observing systems.

   Second-order cybernetics originates in cybernetic research between 1968 and 1975 and theoretically in Margaret Mead's paper *The Cybernetics of Cybernetics* [15]. The paper was "presented as the inaugural keynote address at the founding meeting of the American Society of Cybernetics (ASC), [...] at a point in the history of cybernetics that can be seen, in retrospect, to have been a turning point" [7, p. 1379]. Mead suggests a model of engaging with the world through acting cybernetically: in response to the systems observed, based in feedback, navigating circularly-causal relationships, while aiming for goals. In the context of design cybernetics, design research as the study of the circularly-causal cybernetic process of designing provides a similar second-order level of observation.

3.1.1 From Cybernetic Systems to Design Cybernetics

In his article *The Cybernetics of Design and the Design of Cybernetics* Klaus Krippendorf [13] describes cybernetics "in the dialectic between science and design", and adds [13, p. 1381]:

> Whereas scientists [..] insist on causal explanations, excluding themselves as causes of the phenomena they explore, designers intend to cause something by their own actions, something that could not result from natural causes, defying causal explanations in effect.

The dialectic Krippendorff describes[3] shows two ways of working and operating that involve the creation of the new within individual and overlapping domains.

According to Heinz von Foerster, Gordon Pask "distinguishes two orders of analysis. The one in which the observer enters the system by stipulating the *system's* purpose. We may call this a 'first-order stipulation'. In a 'second-order stipulation' the observer enters the system by stipulating *his own* purpose" (see von Foerster's the re-phrasing of Pask [19] in [29, p. 186] as well as in the audio

[3] Editors' note: See page 120 in this volume.

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recording of [36, 47:50–48:40]).

This difference illuminates two very different ways of designing that also relate to design education. Glanville refers to "[d]esign as a conversation with the self (and with others)". He stresses that the central act in designing is a form of (Paskian) cybernetic conversation held with oneself" [8, p.1189].
While the terms and tools underlying *Design Cybernetics* have been developed over the last 50 to 60 years, a central question now may be of how to develop it for contemporary demands and developments. Design cybernetics embraces and integrates all kinds of systems featuring interaction and self-organisation—analogue and digital, machinic and human. Its historical origins can be found in a number of places, of which the most significant are listed in the following paragraphs.

In the United States, early digital cybernetic systems were designed by architects and scientists alike.

In 1953, the architects Charles and Ray Eames illustrated Claude E. Shannon's *Mathematical Theory of Communication* with flowcharts and models, presented in the 23 minutes long film *A Communications Primer* for IBM and on a promotional flyer a year later [4]. This led to the commission to design the interior of the IBM pavilion at the World Fair in New York 1964-65. The Eames' role was to design interfaces that featured IBM's novel technology inviting the general public to engage with computers.

The Architecture Machine Group (AMG) founded by Nicholas Negroponte and Leon Groisser at MIT in 1967–absorbed into the MIT Media Lab in 1985–, the Biological Computer Laboratory (BCL) at the University of Illinois in Urbana-Champaign (1958-1974), founded and led by Heinz von Foerster, Carnegie Mellon University and the University of California, Berkeley, among others immersed in cybernetic research. Projects were largely funded through governmental grants to further advanced communication technologies, computer-aided simulations, training systems, intelligent control, command and navigation systems. Designs of ground-breaking adaptive systems included AMG's software *Urban5* for the simulation of urban growth, and *Sketchpad*, a human-machine graphical communication system for designers, developed by Ivan Sutherland in 1963, or the BCL's algorithm modelling *autopoiesis*, designed by Uribe and Maturana in 1974. The latter was a predecessor for contemporary algorithms simulating the behaviour of self-organising multi-agent organisations.

In the UK, cybernetician Gordon Pask designed *Musicolour* (1953) and *The Colloquy of Mobiles* (1968, see figure **??**). As a cybernetics consultant, Pask joined architect Cedric Price and amusement park owner Joan Littlewood in the design of *The Fun Palace* (1964). Alongside Julia and John Frazer, Pask was also a consultant for his design of another high-profile manifestation of cybernetics in architecture, *The Generator Project* (1976-1979). *The Fun Palace* proposed an analogue spatial learning system, as part of which Paskian machines provided first steps into architecture driven by a human-machine relationship.

The projects outlined above drew from the notion of feedback, the concepts of causality and recursivity and human participation, and can be regarded as essential ingredients for (design) cybernetics.

Feedback and communication had begun advancing technologies around World War II, and became drivers of the journey form early automation to our contemporary computationally-governed world. The rise of the computer and its distribution beyond the boundaries of computer laboratories and the context of navy, army and universities has offered a wealth of opportunities and applications. To these developments, Gordon Pask has contributed key innovations and theories, which are outlined in the following sections.

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3.2 The Cybernetics of Gordon Pask

Gordon Pask (shown in figure **??**) was born in Derbyshire on the 28th of June in 1928. He initially studied mining engineering at Liverpool Polytechnic and geology at Bangor University, before receiving an MA in Natural Sciences from the University of Cambridge in 1952, a PhD in psychology from the University of London in 1964, a DSc in cybernetics from the Open University, and an ScD from the University of Cambridge in 1995. Pask was strongly influenced by the cybernetic pioneers Norbert Wiener and Ross Ashby. Bernard Scott, a student of Pask, describes how first reading Wiener's (1948) classic *Cybernetics* had an emotional impact on Pask as a young Cambridge medical student. To Pask, who had a diverse background and interests "the book brought fully to consciousness a sense of unity in nature and man's endeavours that, thus far, had been latent in his own eclecticism. [...] Here was the vision and the final justification for the generalist: the twentieth century version of the Renaissance man was born." [31, p. 327]. Pask characterises man-system interaction, decision-making processes and cybernetic systems as goal-directed. In *Future Prospects of Cybernetics*, Pask outlines in which man-made organisations or disciplines cybernetics could be applied and stresses to reconsider cybernetics in light of man's involvement in a system. Addressing fruitful future directions of cybernetic research in 1976, Pask defines cybernetics as a science, a method, an approach, a characteristic of a (cybernetic) system and a theory [25, p. 3]:

> Although the mathematical theory of engineering Cybernetics is more sophisticated than that of the other branches it is interesting to observe that the theory is underutilised by industry and commerce. [...]. The fact is that in view of the nature of man, society and the economic system automation (computerisation, mechanisation etc.,) is frequently undesirable. In one sense this is disappointing to the professional, in another, it suggests that as a general rule insufficient attention has been given in the past to man machine relationships, cognition and the character of the social organisations in which all Cybernetic systems are ultimately employed. Hence, I am inclined to the view that the most exciting and fruitful directions of research are those that involve human beings as part of the system.

Pask was passionate about creating machines that could communicate and interact with their environments as well as their human users by observing, learning and understanding. Apart from Pask designing and building interactive 'intelligent' 'thinking' robots like the *Colloquy of Mobiles*, he also developed learning machines for radar training from the 1960s to the 1980s. Pask integrated principles of computer science and biology with concepts of learning and behaviour. Working in the context of architectural education, Pask understood architecture as form and result of conversation between the architect, the subject to be designed, the client, design tools and so forth, and highlighted the intimate relationship between cybernetics and architecture [18, p. 494].

His article, *The Architectural Relevance of Cybernetics,* published in the journal *Architectural Design*, describes a cross-fertilisation between cybernetics and design [18]. It illustrates the application of the novel tool computer programming assisting the architect, to show that design "is a 'cybernetic' method and there are several instances of its application to architecture" [18, p. 494]. He argues that "architectural designs should have rules for evolution built into them if their growth is to be healthy rather than cancerous. In other words, a responsible architect must be concerned with evolutionary properties; he cannot merely stand back and observe evolution as something that happened to his structure." [18, p. 495]. While holding positions at the Architectural Association in London and the Centre for Systems Research and Applied Epistemology, Concordia University in Montreal, Pask suggested a unifying theory for architecture based on cybernetics, which he outlined in his note *Towards a unification of Architectural Theories*

[26].

Pask's understanding of architecture as a discipline dealing with systems, and architects as designers of dynamic and relational systems gave him a particular position within both, architecture and cybernetics. In his 1976 paper *Future Prospects for Cybernetics* he distances himself from a cybernetic concept that merely engages with "*authoritarian or 'automation-like' systems"* [25]. Instead, Pask offers a new, conversational cybernetics in which human and machine interact with each other. Disappointed with the lack of cybernetic applications, Pask envisioned increased attention to "man-machine-relationships, cognition and the character of the social organisations in which all cybernetic systems are ultimately employed." by extending the computer's capability to co-operate with men [25, p. 4].

He continued to investigate human learning and the man-machine relationship in conversations between humans and machines. He examined the nature of conversations, how they take place and how conversations can be distinguished from pure information transfer. Pask published a vast number of papers as well as three major books on the subject, *Conversation, Cognition and Learning* [22], *The Cybernetics of Human Learning and Performance* [21] and *Conversation Theory, Applications in Education and Epistemology* [23].

Following on from Pask, Ranulph Glanville developed and established conversation as a central mechanism of design cybernetics further, arguing that "design and cybernetics reflect each other" [11]. In Glanville's approach, conversation underlies novelty generating design processes, such that (design) cybernetics provides a theory for design, whereas design is the action of (design) cybernetics. Glanville emphasises Pask's pivotal role as a cybernetician reaching out to design: "Already in the 1960s Pask had understood there were close parallels to be explored between cybernetics and design. [...] Pask's *Musicolour* outreach was long-term and committed: he worked with arguably the most radical architect of the second half of the Twentieth Century, Cedric Price." [8, p. 1177][4] Pask's teaching activities at the Architectural Association significantly increased awareness and interest in cybernetics within architecture: Among his class of twelve doctoral students, eight were indeed architects who "realised that cybernetics had something special to offer them" [8].

3.2.1 Musicolour: Man-Machine Co-Creation

Developed in Cambridge in 1953, *Musicolour* was the brainchild of Gordon Pask and his best friend and colleague Robin McKinnon-Wood and the first of Pask's more speculative devices. It exhibited the capability of "learning" by allowing people to freely interact with it. It was a theatrical and jolly creature, an installation, and an orchestra partner, much unlike the seriousness of government-funded devices. The musical colour machine generated changing coloured light through a conversation between musicians and the machine, interfacing auditory input with visual output. It was installed in various theatres featuring the *Musicolour Fantasy-Play "Moon-Music'.* Despite the excitement of its creators, audiences in Llandudno (North Wales), the Valerie Hovenden's Theatre Club in London, the Boltons and the Mecca Locarno on Streatham reacted sparsely to the abstract conversation and changing light show. The music played by one or more musicians was amplified through a filter system and activated the light machine, which reacted to the music by displaying varying visual projections. Musicians then adapted play in reaction to the projections, thus generating feedback to the machine. The visual color pattern of *Musicolour* was generated through an early special-purpose computer. Light projections, output by the computer, were projected through colored filters and acted as input for the musicians. The

[4] Editors' note: See page 31 in this volume.

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dynamics of the musician(s) play then triggered the computer program to adjust its light output. If rhythms and tones played remained the same for a while, the computer would "get bored" and delay activating the electrodes. Subsequently the colour play would show long reaction time, such that the musician(s) would be prompted to innovate and adjust their mode of playing. *Musicolour* essentially acted as a reactive/interactive construct to enable performance architecture in an information environment involving learning. For Pask, the aim of *Musicolour* was primarily the learning capabilities of this interactive cybernetic machine [20, p. 78]:

> Musicolour was not synaesthesia but the learning capability of the machine. Given a suitable design and a happy choice of visual vocabulary, the performer (being influenced by the visual display) could become involved in a close participant interaction with the system. [...] In this sense the system acted as an extension of the performer with which he could co-operate and achieve effects that he could not achieve on his own.

Since *Musicolour* required a physical space to function as *Musicolour*, it underpinned architecture as event, as interaction and as conversation between humans and their environments. It was a "musicon", converging music, space and information exchange. It pioneered a novel theatrical experience in which the machine became an actor equal to and alongside the musicians, whereas the musicians also became part of *Musicolour*.

3.2.2 The Colloquy of Mobiles: Computer-Mediated Social Transformation

In 1968, one year before publishing his article titled *The Architectural Relevance of Cybernetics*, Pask was invited to exhibit at the exhibition *Cybernetic Serendipity*. Curated by Jasia Reichardt [30], the exhibition was shown at the ICA London between August 2nd and October 20th 1968. It focused on the use of computers and the digital in arts, graphic design, generative aesthetics and music. Pask's exhibit *The Colloquy of Mobiles* was a further development of *Musicolour* in as far as the electronically controlled mobiles interacted with each other and the audience. It consisted of a large suspended structure with five mobiles, two males and three females, as shown in figure 3.2. The structure exceeded human scale and hence extended to the size of an architectural intervention. Each of the five mobiles was equipped with a specific program, mirrors and spotlights and could mechanically rotate. In addition, the bars that supported the mobiles could rotate.

The mobiles both produced and responded to visual and audible signals, resulting in an interplay amongst each other, as well as with exhibition visitors. Their behaviour was, as most of Pask's machines, designed and presented through diagrams, such as relationship diagrams showing physical spatial relationships between objects used. Process diagrams described behaviour as 'what-if' scenarios. Digital programs interpreted the above categories of information and enabled a "competition", a conversation between the mobiles. The *Colloquy* simulated the behaviour of a social system through communication. In case of inactivity of the male mobiles, they would activate rays of light, that eventually hit mirrors on the female fibreglass structures. Once the reflected rays of light hit the light-sensors attached to the male mobiles, a moment of satisfaction would be reached and stop rotating. Based on the concept of learning through conversation the mobiles optimised their relational behaviour over time to decrease the time span until the moment of satisfaction. Visitors could interfere with this process, thus changing the overall interactive dynamics. For Gordon Pask [20, p. 88] the *Colloquy of Mobiles* was

> A socially oriented reactive and adaptive environment. Even in the absence of a human being, entities in the environment communicate with and learn about one another. But a human being can enter the environment and participate; possibly modifying the mode of

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conversation as a result.

Stephen Gage, co-organiser of the 2008 exhibition *Pask Present*, emphasises the enduring relevance of the *Colloquy of Mobiles*: "They (the mobiles) had the observer in mind and held the observer in a conversation. It is this aspect of Pask's work that makes him extremely relevant to today's architects. [..] Pask's underlying message reminds us that Architecture is a time-based art."

Despite that Pask's public presentations as part of exhibitions, lectures and seminars were difficult to understand, his audiences—including architects, students, biologists, computer scientists and yet others—typically left impressed and inspired. What started with Pask's cybernetic machines eventually morphed into the design of larger reactive, cybernetic buildings, spaces and environments. In his work, Pask created the notion of the information environment (IE), environments that could adapt, change, understand and grow, and in which designer and user were linked in complex relationships. Pask's inclusion of the human as an actively shaping part of any environment demonstrated and established architecture as cybernetics and cybernetics as architecture.

3.2.3 Conversation Theory: A Tempting Attempt

This section discusses Gordon Pask's *conversation theory (CT)*, a theoretical foundation of *design cybernetics*. CT provides a model for how conversational exchanges– circular-causal interactive process–between conversing entities can generate agreement on meanings as well as learning. Conversation theory grew out of Pask's realisation that communication in the form of exchanges of coded messages, as proposed by Shannon and Weaver [32], lacked key aspects of conversation as it takes place between human beings. In Pask's *CT*, conversation starts from diverging points of view that are negotiated among conversing participants until agreements are reached. Pask argued [27, p. 999] that conversation can include communication:

> Communication and conversation are distinct, and they do not always go hand in hand. Suppose that communication is liberally construed as the transmission and transformation of signals. If so, conversation requires at least some communication. But, enigmatically perhaps, very bad communication may admit very good conversation and the existence of a perfect channel is no guarantee that any conversation will take place.

Shannon's model, conceived in 1948, addresses linear one-directional machine to machine communication. It does not address feedback and excludes questions of meaning. Instead it utilizes statistics for the reconstruction of signals where channels are compromised by noise, or where signals require protection from eavesdropping by means of encryption.

By contrast, Pask's *conversation theory* (CT) describes processes of continuous feedback and ongoing learning as a result of exchanges between conversation participants [23]. *CT* models conversations between individuals. Those include M-individuals (mechanical individuals acting as communication interfaces) and P-individuals (psychological individuals acting as the actual conversation partners, teachers and learners, e.g., A and B). Conversations are enabled through L-Languages (languages of different knowledge and conversation levels that M-individuals can understand). CT provides an abstract notation for conversations between two or more conversation partners (A and B) on a topic (R), as shown in figure 3.3 Through the common understanding of a metalanguage L_0 – such as natural language in the case of human beings – A and B can agree on conversing about the topic R. In Pask's model, a conversation is steered by an external observer who "briefs" the participants about the topic and topic-related terms (e.g. topics related to architecture "screed", "damp-proofing" or "surface

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geometry"). Conversation partners learn about the topic and about each other by conversing, negotiating and eventually agreeing.

The goal of CT is to address processes of creating shared understandings and ongoing learning through a systemic and systematic approach. In Pask's theory, conversations are assumed to be goal driven exchanges, navigated through the conversation partners' states, conditions and contexts. In order to reach the goal of a conversation, participants agree over understandings of a topic by adjusting to each other until either all or some goals are congruent. Other possible outcomes of conversations are that there may be no agreement over the understanding of a topic, or that goals cannot be adjusted sufficiently, and the system subdivides into decentralised clusters, which may interact at a later stage. In either case, all actors learn through interacting with each other. Conversation theory allows open systems and processes, such that systems can interact (converse) with other systems beyond their initial boundaries. The result is an ongoing learning process increasing possibilities and thus, cybernetically speaking, variety. Conversations are the *modus operandus* of and for cybernetic organizations. If we consider the recursivity of conversation in a design process, the concepts of cybernetics and design start overlapping and boundaries between the two become blurred, allowing for links between the two in the form of design cybernetics. By their recursive nature, Paskian conversations can be characterised as design processes of design processes.

In this context, Glanville significantly extended the scope of *conversation theory* to include all forms of designing and argued that "design is the action; second-order cybernetics is the explanation" [9]. He observed that agreement was not the most significant outcome of conversations and identified creation of novelty as the central benefit of conversational encounters. Conversations create possibilities through constantly negotiating differences between each conversation partner's understandings, thereby generating learning in participants. Conversations can be seen as key to processes of learning as well as key to the creation of novel ideas.

Gordon Pask developed a way of capturing conversations in emerging networks of conversational domains in the form of *entailment meshes.* As diagrams and models of conversations, they are extensively discussed in chapter 6 of [23] titled *Conversations with Many Aim Topics* and in chapter 7 of [22] titled *Construction of a General Conversational Domain* of *Conversation, Cognition and Learning*. Pask saw *entailment meshes* as structures showing behaviours similar to biological organisms. They included nodes, which could contain algorithms to compute the value of this node and its relevance for the next steps of the conversation. Pask applied "pruning" to entailment meshes; in analogy to a technique used in horticulture where branches of plants are cut selectively to direct growth into a desired direction. By pruning entailment meshes, Pask "directed" the conversation.

He expressed *entailment meshes* as diagrams like the one shown in figure 3.4, and intertwining toroidal constructs like the one shown in figure 3.5, representing conversational syntax and the dynamic and multi-dimensional space a conversation can create. The diagrams in figure **??** above show derivations of topics generated by ongoing conversations:

1.1 topic T derived from topic P and topic Q.
1.2 topic T derived from topic P and topic Q, or from topic R and topic S.
1.3. a correspondence, M, between topics F and G, depending upon D and E.
1.4 a shorthand notation for Figure [3.4]. when interpreted to represent an analogy.

Entailment meshes were designed to respond to environmental influences, depending on the conversation topics, attributes and characteristics. New topics emerging through conversations can agglomerate into new regions and further conversations. Translated into contemporary scripting software used in computational architecture and design, we could refer to classes of entities. What-if functions determine which class or which classes a topic belongs to, and hence how it behaves in a conversation. As models representing second-order cybernetic principles, topics observe and are being observed–a topic can have a *perspective*. The concept of the *entailment meshes* is powerful in offering a strong theoretical guide to multi-dimensional dynamic parametric network structures—found in either materials with complex geometric behaviour triggered by sensorial reception or in the simulation of the morphology of architectural programs through the interaction with different classes of social systems.

3.3 Conclusion

Gordon Pask and Ranulph Glanville took the lead in establishing a cybernetic perspective on architecture and design. In doing so, both, Pask and Glanville conceived of architecture very differently than the conventional understandings of the discipline. In Pask's view, architecture is conversation, and conversation is architecture. A key aspect of Pask's work is his vision of learning environments, which "viewed the human as part of resonance that looped from the human, through the environment or apparatus; back to the human and around again." [16]. Glanville then extended and developed Pask's vision of design activity in a more general sense: cybernetics is design conversation and, conversely, design conversation is cybernetics [8].

Including the human in the loop and integrating human feedback into "intelligent" digital systems is the next step towards integrated *Design Cybernetics*. Today, interactive modes of working have become ubiquitous in many fields. Multimedia, social networks and personalised advertising via the Internet are all based on processes of a potentially conversational nature. As a part of the global digital turn, the future may well be shaped by automated artificial forms of conversation.

The digital turn has, on the one hand, empowered large companies to generate floods of data, based on the profiles extracted from digitally connected individuals, using the Internet or other recordable actions. Yet, on the other hand, it has created spaces in which knowledge can be gained, perpetuated, accessed and used. Collective intelligence and collective design processes use decentralized networked databases. In doing so they slowly mutate categorised knowledge domains and offer new opportunities for distributed and parallel forms of conversations across networks and organizations.

The possibility of a domain belonging to multiple categories proves the building process of entailment structures at work.

In my kind of romantic and at the same time technical understanding I envisage—and it is possible that at the time Gordon Pask did, too—a highly adaptive super-architecture, where matter in space is replaced with bits in time, and atoms amend their structural properties through absorbing bits. The space I envisage is neither material nor virtual, it is both, where thoughts can feed into a cognitive machine of knowledge, a knowledge-manufacturing construct, a kind of Foucaultian dispositif, "a system of relations that can be established between these elements." [5]. Data, to feed the machine, may originate from logs of digital activity such as tweets or mobile phone use, as well as from the usage of services such as the frequenting of restaurants, of train stations and of other public transport through apps or via other means of monitoring. *Design cybernetics* in the built environment may harness dynamic data as a "material" for design, and heuristic design strategies may be used to ensure necessary functions. *Architectural mutualism*, a term invented by Pask, describes the "living" together and intertwining of man (individually as well as collectively) and man-made structures:

> A 'functional' building is contrasted with an 'decorative' building; (see categories above) [...] a building cannot be viewed simply in isolation. It is only meaningful as a human environment. It perpetually interacts with its inhabitants, on the one had serving them and on the other controlling their behaviour. In other words structures make sense as parts of larger systems that include human components and the architect is primarily concerned with these larger systems; they (not just the brick and mortar part) are what architects design. — Gordon Pask [18, p. 494]

With the availability and perpetuation of data, the ubiquity of machine learning, the increase in open source platforms and easy access to digital manufacturing in the digital age, the relevance of *design cybernetics* is on the rise. Design processes now–in 2019–include both, humans and digital machines. We are starting to live in mutual relationships, sharing physical and virtual platforms to participate equally in designing our environments. The idea of *cyberspace*, envisaged in the 1980s as an immaterial realm, has, somewhat ironically, become manifest as a both virtual and material reality: We are physical beings living in a digital world, conversing and learning and teaching with, from and through algorithms and forms. Once a domain belongs to multiple categories it can and does change its relationships to other domains situation and time-based structural coupling. A relationship between domains—and of the agents that inhabit a domain—entails the exchange of information through communication or conversation, constantly creating new subdomains. One could argue that existing knowledge in novel constellations breeds such 'novel' subdomains. They are either the form of the entailment meshes that constructed them or the entailment meshes themselves. As argued earlier in this chapter, *design cybernetics* encompasses conversations of all kinds, using digital, electronic, analogue devices or a mixture of them. Independent of the choice, design *cybernetics* plays a role in steering the information exchange and cannot be separated from any form of conversation.

I conclude this chapter by raising the issue of authorship. *Design cybernetics* before the digital turn implied a rather controlled design environment dominated by a variety of design languages (styles). *Design cybernetics* post the digital turn dramatically increases the volume of data exchange and conversations, which in turn reduces differences within and between design languages (styles). Individual authorship fractalizes and spreads across the grey matter of collective design intelligence. The pressing questions I would like to ask are:

- Can we learn and use *Design Cybernetics* to establish novel design parameters for a man-machine future?
- Can we learn and use *Conversation Theory* to navigate design processes?
- Can we learn and use *Conversation Theory* to navigate research processes in Design Cybernetics?

I think we can.

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