ISSN 0368-492X
Volume 36 Number 9/10 2007

# Kybernetes

## The international journal of cybernetics, systems and management sciences

## Cybernetics and design

Guest Editor: Professor Ranulph Glanville

Selected as the official journal of the World Organisation of Systems and Cybernetics

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Emerald 40 Years in Publishing 1967-2007

Emerald

ISSN 0368-492X

Volume 36
Number 9/10
2007

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**Guest Editor**
Professor Ranulph Glanville

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# Preface

Cybernetics as we know is both trans- and multi-disciplinary. In consequence its fields of interest are wide ranging. The Editorial Advisory Board should perhaps be excused for its failure in the 36 years of existence to commission more papers on "Cybernetics and Design". Our index will show that the area has not been totally neglected although in this time no special issues devoted to this theme have been published. We are therefore extremely grateful to Dr Ranulph Glanville for suggesting that this Special Double issue should be produced and for accepting our invitation to be its Guest Editor.

In his introduction he outlines the scope of the issue and "reaches out to an audience that *Kybernetes* has not previously tried to reach — designers — in an effort to build a bridge connecting cybernetics and design". He and his invited contributors have undoubtedly done this and we look forward to their participation in future volumes of the journal.

The publishers of *Kybernetes*, the EAB and its editors thank all who have contributed to the success of this special double issue.

**Brian H. Rudall**
*Editor-in-Chief*

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# Greeting

Every system has a defining function in a larger system of which it is a part. This function determines the properties the whole should have and these determine the kind of parts the whole requires. This is inculcated in architects who always begin with the function of the building: who it should serve and how; then what parts are required, what their properties should be, and how they should interact. This is why so many architects have graduated to social system designers.

In analysis one begins by identifying the parts of a whole and then assigning properties to them. Then the properties of the whole are derived from those of the parts. In design (which is synthetic, as opposed to, analytic thinking) one begins by identifying the properties one wants the whole to have. One then extracts from the concept of the whole the set of necessary parts and their properties. The properties of the parts are derived from those assigned to the whole, not the reverse as is the case in analysis.

Little wonder that architecture and social system design are close together; design is the *sine qua non* of both social system thinking and architecture.

**Russell L. Ackoff**

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# Guest editorial

## Introduction: special double issue of *Kybernetes* on cybernetics and design

Ranulph Glanville
*The Bartlett School of Architecture, University College London, London, UK and CybernEthics Research, Southsea, UK*

**Abstract**

**Purpose** – The purpose of this editorial is to reach out to an audience that *Kybernetes* has not previously tried to reach – designers – in an effort to build a bridge connecting cybernetics and design.

**Design/methodology/approach** – Provides a brief review of the papers within the issue.

**Findings** – The collection of papers may provoke wonder, enquiry, and a wish not only to respect each field, but also to open up, to find out more and, perhaps, to enter into a symbiotic bridge building operation that might bring valuable theoretical illumination and realm of practice to both fields.

**Originality/value** – This editorial introduces an exploration that begins to develop any relationships that might exist between the two fields of design and cybernetics.

**Keywords** Design, Cybernetics

This special double issue of *Kybernetes* reaches out to an audience that *Kybernetes* has not previously tried to reach – designers – in an effort to build a bridge connecting cybernetics and design.

A number of scholars with meaningful involvements in both cybernetics and design have maintained, for the last half century, that there is a significant connection between the two. Assertions made in public and private have sometimes lead to argued publications including Pask's (1969, 1979), though more often they have surfaced in other publications as comments almost tossed aside in the flow. Other works, such as Schön's (1983), can be seen, today, to involve essentially cybernetic arguments. Speaking personally, I know, I have often used design examples in cybernetics papers and cybernetic concepts in design papers, insisting there is a connection, but I have only recently begun to make a concerted effort to bring the two fields together fully and explicitly in a reasoned and argued manner[1].

It seemed to me that half a century of innuendo rather than argument was enough! That it was time to start an exploration which would be as clear and explicit as possible, beginning to develop any relationships that might exist between the two fields of design and cybernetics. The idea was to build the bridges, to find mutualism. Accordingly, and with the support of the Editor in Chief, Brian Rudall, I proposed a special issue of *Kybernetes* devoted to cybernetics and design. The published announcement of the issue included these questions:

(1) How does cybernetics throw light on design, and lead to developments and improvements in our understanding of and ability to act in design?

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(2) How does design inform us in our understanding of cybernetics and its potential to parallel and throw light on design?
(3) What is the mutualism that may hold between them when questions 1) and 2) are seen as part of the same whole?

The initial results of what I hope may become, in its own right, a significant area of research (and of action) appear in this double issue. The papers presented here should better be understood not as definitive or conclusory, but as an exploration opening a discussion that might continue within this journal, as well as elsewhere.

## Organisation of the issue

One of the responsibilities of an editor is to organise the sequence of material in an issue and to explain this to the readership. While I understand the wish of many editors to impose an interpretative order on material by finding themes by which to group it, I prefer not to do this. I am wary of imposing my order on others, of removing many possible links by promoting the particular links I see. I prefer to let the reader build his/her own links – to design, as it were, his/her own path through the material on offer, leading to his/her own understanding. To this end, I chose to organise content in the arbitrary (but often interesting) sequence provided by first author surname, and I have used that ordering in this issue, with one exception. I have placed my own, very long contribution as the first paper. The reason is that, as editor, I recognised there were two distinct bodies of readers for this issue: designers and cyberneticians. It is neither reasonable not realistic to expect either to be well briefed in the other's field, so the first half of my paper is an exposition of design for cyberneticians and cybernetics for designers. Given that my own work is rooted in second (rather than first) order cybernetics, my introduction to cybernetics may also be seen as an argument introducing second order cybernetics to any cybernetician not already familiar with such arguments. Perhaps I should have separated my paper into two, in order also to place my argument about cybernetics and design arbitrarily amongst the others.

However, in place of editorially chosen groups, I have moved (with the constructive help of the managing editor) to make it easier for readers to select, in an informed manner, papers and sequences of papers they wish to attend to, by duplicating all the abstracts at the start of the issue. I have never understood why abstracts are only placed in the body of the papers they abstract, so that readers have to wade through pages to reach them. Surely, an abstract is the text that allows the potential reader to assess whether to read the full paper or not, and therefore abstracts should appear all together and at the beginning of a collection, to aid our choice making? This is the path I have pursued here.

## Content

An editor is also responsible for maintaining the quality of material published, and for explaining some motivations and particularities surrounding its publication. In this issue, there are more of these than usual.

Firstly, there is the question of what design is. Although, I have given an introduction in my paper (as have others, such as Krippendorff[2], in theirs) there are many interpretations of design. Amongst the authors in this issue there are, I am sure, some who will find my characterisation of design completely unrecognisable. There are certainly papers here which their authors claim to be about design but which, in my opinion, scarcely touch on the central design activity. Design, as a term[3], has moved from its original connection with what were often called the applied arts (including architecture) to become a term added to others, possibly in order to bring a certain status to undertakings and subjects (consider the way that politicians in the West have started using the word design as a basic indicator, although they rarely know what it is an indicator of). Thus, the word design, attached to other subjects in order to add value and status, has been used by some to indicate complexity, by others to refer to systems of action in which there may be (feedback) loops, and so on. The PhD design web based discussion list (E-mail: phd-design@jiscmail.ac.uk) has many discussants who, in my view, neither practise nor understand design and, although they think of themselves as design theorists and researchers, often completely miss the point of what designers do, preferring to impose onto design their view of what design should be (they probably think the same of me). Instead of considering what designers actually do, they run the risk of (accidentally) removing all the advantages of design and the value that comes precisely from its difference. But, as editor of an issue that is aimed to open debate and encourage discussion, I do not regard it as my job to exclude views of what design is which are held to be valid by others, even if I believe them to be wrong and perhaps damaging. A survey should cover the ground.

There is also the somewhat less difficult matter of what cybernetics is. The world of cybernetics can often be divided into those who would practise and extol first, and those who would practise and extol second order cybernetics. To many in the former camp, second order cybernetics may seem a trivial pursuit of little value. Second order cyberneticians might retort by talking of blindness. There is a wide range of views of cybernetics presented in this issue, and, in the case of some of the authors coming primarily from design, we see early, tentative attempts to explore their world through a cybernetic lens. But at least there is a general agreement that cybernetics involves circularity, at some level and in some manner.

Our anonymous, peer referees understood this in their reviews. One of the common points raised in the reviews was that papers were not original. Certainly, several are, in at least one of the two fields we are trying to bridge, quite conservative – and it might be argued there is little or no contribution to knowledge in the cybernetic, or the design content of many papers published here. But this misses the point and certainly does not mean there is no original contribution: the originality of contribution is in the building of the bridges (and the consequent importing into each field of some of the great resources and strengths of the other field), rather than in one or both fields, themselves. Many of the authors show courage in their attempts to build such bridges and in offering them to us to consider; and the personal learning they have gone through can be found, often discretely hidden, in their papers.

As to the style of presentation, *Kybernetes* is a scientific journal and it may be assumed that readers understand the range and conventions that are to be expected in such a journal. However, publishing in the academic community of designers often takes a more varied form. The structure and expression of the argument may seem alien to those whose background is more normatively scientific. In the refereeing process I attempted to create some movement towards a mutually recognisable and shared centre ground, but not all the papers in this issue originating in one tradition will be easily read by people whose practice is in the other. This is, of course, a weakness, albeit an inevitable one. But it is also a strength. If there is to be a bridge built, the builders who originate in one tradition will need to understand, accept and value the means of expression of those originating in the other; in this issue, we can see some of this difference. Margaret Mead (1968), one of the founders of cybernetics, in proposing a cybernetics of cybernetics (which later became known as second order cybernetics) reminded us that cybernetics is intended as a language, making it possible for people from different disciplines to talk meaningfully with each other. Cybernetics is, therefore, not primarily a technology or even a science, but a meta-subject[4] and an approach. It is often argued that design is the same: that it is a way of thinking that sits in the position of a meta-subject to other subjects: hence its general applicability as shown in its suffixation to other subjects. Meta-subjects are, of course, also subjects: and this is how recursive and reflexive concepts such as the cybernetics of cybernetics and the design of design (and even the language of language) necessarily enter.

**Those without whom**. . .

First, let me thank Russell L. Ackoff for generously agreeing to write us a greeting to the project. Professor Ackoff, who first trained as an architect and often talks in public about the value of the way architects solve problems, is also one of the founders of systems theory and operations research. It is particularly encouraging that Professor Ackoff has found the time to support our endeavour in this publication.

Any project such as this special issue depends on the good will and hard work of very many people who deserve credit and thanks. In the first instance, if there are no volunteers to write, there is no issue. So first thanks go to our international band of authors who willingly submitted to considerable demands and a very tight schedule in order to create this volume. Next, of course, come our referees. We had a wide ranging panel of nearly 100 anonymous referees who, as always, gave generously of their time, wisdom and expertise to help us evaluate and improve the papers. Coming from both fields, they lent us their time, experience and knowledge, helping us both produce a publication of quality, and to recognise and work with the traditions of the acceptable from both fields. It is no easy job to referee across fields.

On the administrative side, we received unstinting and positive advice, encouragement and support from the editor in chief, Brian Rudall, and from the staff at Emerald, publishers of *Kybernetes*, though Managing Editor Diane Heath and her team. I am particularly thankful for Emerald's special efforts to accommodate a difficult publication schedule caused by several factors including my own vagrant lifestyle, and their willingness to publish an issue with the abstracts duplicated at the start of the issue. I am grateful, too, for their relatively enlightened copyright and access policies which help make quality work available where many publishers seem set on doing the opposite. We were also very fortunate in the generous loan of a co-ordinating computer program written by Dr Alexander Riegler of Centre Leo Apostel, at the Free University, Brussels. Alex and I recently edited a festschrift for Ernst von Glasersfeld (Glanville and Riegler, 2007) published in the refereed web journal he founded, "Constructivist Foundations" (Vol. 2, Nos 2/3) for which Alex wrote a co-ordinating program so we could better work together. He graciously made this available for this special double issue of *Kybernetes*.

On the support front, I was enormously fortunate to be awarded a grant by the Architecture Research Fund of the Bartlett School of Architecture, University College London (UCL), enabling me to employ a research assistant to help in the editing tasks. Without this grant, and the help it bought, I would not have been able to complete the

commissioning and editorial aspects necessary to bringing this issue to publication. I gratefully acknowledge this support.

Which leaves me with just the greatest debts of thanks. Without the help of Ben Sweeting, who acted as my editorial assistant through the Bartlett's generous funding, there would have been no issue. The other editors, the contributors and the referees will all have discovered, through communicating with and through Ben, what a good job he has done, with such grace. I can honestly say that his help and advice has been invaluable and we all owe him the greatest debt of thanks. And, at home, my wife Aartje Hulstein has been prepared to give up many days we could have spent together in favour of this project that she judged to be worthwhile, and to give me personal support at those inevitable moments when such a project is in one of its insufferable phases.

Finally, there is a wish for you, the reader. I hope that this collection may anger and inspire, irritate and amaze: but above all, that it will provoke wonder, enquiry, and a wish not only to respect each field, but to open up, to find out more and, perhaps, to enter into a symbiotic bridge building operation that might bring valuable theoretical illumination and realm of practice to both fields.

## Notes

1. However, Jascia Reichardt's epoch marking "Cybernetic Serendipity" exhibition at the Institute of Contemporary Arts in London, 1968, did build the relationship with design's near cousin, Art.
2. Krippendorff, along with Dubberly and Pangaro, and I are amongst the few people, and the even fewer authors in this issue, who were educated in and who teach/pactise both design and cybernetics. It is not surprising, therefore, that our views are often sympathetic.
3. The origins of the word design, according to the Oxford Dictionary of the American Language on my Mac, are in the Latin "designare" to designate. It was brought into English via both French and Italian, with the added sense of drawing. It was certainly current in the early 1600s, witness its use by the English architect, Inigo Jones (1573-1652) in his 1613 annotations of Palladio's "I Quattro Libri Della Architectura" (Glanville, 2007). Corte-Real (2007) shows us that Jones's use was not novel, in his examination of Shakespeare's use of the word design.
4. The best known and most notable meta-subjects are, probably, mathematics and linguistics.

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# Abstracts

## Try again. Fail again. Fail better: the cybernetics in design and the design in cybernetics

*Ranulph Glanville*

**Keywords** Analogy, Circularity, Conversation, Cybernetics, Design, Novelty

**Purpose** – The purpose of this paper is to explore the two subjects, cybernetics and design, in order to establish and demonstrate a relationship between them. It is held that the two subjects can be considered complementary arms of each other.

**Design/methodology/approach** – The two subjects are each characterised so that the author's interpretation is explicit and those who know one subject but not the other are briefed. Cybernetics is examined in terms of both classical (first-order) cybernetics, and the more consistent second-order cybernetics, which is the cybernetics used in this argument. The paper develops by a comparative analysis of the two subjects, and exploring analogies between the two at several levels.

**Findings** – A design approach is characterised and validated, and contrasted with a scientific approach. The analogies that are proposed are shown to hold. Cybernetics is presented as theory for design, design as cybernetics in practice. Consequent findings, for instance that both cybernetics and design imply the same ethical qualities, are presented.

**Research limitations/implications** – The research implications of the paper are that, where research involves design, the criteria against which it can be judged are far more Popperian than might be imagined. Such research will satisfy the condition of adequacy, rather than correctness. A secondary outcome concerning research is that, whereas science is concerned with what is (characterised through the development of knowledge of (what is)), design (and by implication other subjects primarily concerned with action) is concerned with knowledge for acting.

**Practical implications** – The theoretical validity of second-order cybernetics is used to justify and give proper place to design as an activity. Thus, the approach designers use is validated as complementary to, and placed on an equal par with, other approaches. This brings design, as an approach, into the realm of the acceptable. The criteria for the assessment of design work are shown to be different from those appropriate in other, more traditionally acceptable approaches.

**Originality/value** – For approximately 40 years, there have been claims that cybernetics and design share much in common. This was originally expressed through communication criteria, and by the use of classical cybernetic approaches as methods for use in designing. This paper argues a much closer relationship between cybernetics and design, through consideration of developments in cybernetics not available 40 years ago (second-order cybernetics) and through examining the activity at the heart of the design act, whereas many earlier attempts have been concerned with research that is much more about assessment, prescription and proscription.

## Cybernetic embodiment and the role of autonomy in the design process

*Argyris Arnellos, Thomas Spyrou and John Darzentas*

**Keywords** Autonomy, Second-order cybernetics, Design process, Functionality, Closure, Representational content, Anticipation, Interaction, Cybernetics, Design

**Purpose** – This paper aims to develop the role of autonomy in the emergence of the design process. It shows how the design process is facilitated by autonomy, how autonomy is enhanced through the design process and how the emergence of anticipatory and future-oriented representational content in



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an autonomous cognitive system provides the functionality needed for the strengthening of both its autonomy and the design process, in which the autonomous cognitive system purposefully engages.

**Design/methodology/approach** – Initially, the essential characteristics of the design process and of the cognitive systems participating in it will be identified. Then, an attempt to demonstrate the ability of an enhanced second-order cybernetic framework to satisfy these characteristics will be made. Next, an analytic description of the design process under this framework is presented and the respective implications are critically discussed.

**Findings** – The role of autonomy is crucial for the design process, as it seems that autonomy is both the primary motive and the goal for a cognitive system to engage in a design process. A second-order cybernetic framework is suitable for the analysis of such a complex process, as long as both the constructive and the interactive aspects of a self-organising system are taken under consideration.

**Practical implications** – The modelling of the complex design process under the framework of second-order cybernetics and the indication of the fundamental characteristics of an autonomous cognitive system as well as their interrelations may provide useful insights in multiple levels, from the purely theoretical (i.e. better understanding of the design process and the conditions for each creative fostering), to the purely technical (i.e. the design of artificial agents with design capabilities).

**Originality/value** – The innovative aspect of the paper is that it attempts an analysis of the design process under a framework of second-order cybernetics, by attempting to analyse and explain the emergence of such a process from the point of view of an autonomous cognitive system. This results in some interesting implications regarding the nature of the design process, as well as regarding its "mechanisms" of emergence and evolution, with respect to the characteristics of the participating autonomous systems.

## The origin of modelling

*Phil Ayres*

**Keywords** Observer, Model, Modelling, Black box, Design, Circularing, Architecture

**Purpose** – This paper aims to explore the relationship between modelling and design from a cybernetic perspective.

**Design/methodology/approach** – Cybernetic understandings of the notions "modelling" and "design" are developed initially. The derived understandings are used to define an outline specification for a speculative design project based on an analysis and re-interpretation of an account from Pliny the Elder. The account is re-interpreted to address a long tradition of partial appropriation in which only the two-dimensional representation of three-dimensions by projection on to a plane is considered. The project seeks to re-adjust the focus of this account to an activity that employs two-dimensional representation as a means for subsequent spatial synthesis. It further proposes to make the relationship between model and modelled circular.

**Findings** – There are two findings. First, an understanding that context is constructed by the observer. Second, the need to implement a meta-model to permit circularity between the model and the modelled.

**Research limitations/implications** – This paper presents the conceptual underpinning for a project and design strategy that is yet to be investigated.

**Practical implications** – The design strategy presented suggests the introduction of circularity into the world of built artefacts, allowing the potential for the continual expression of variety over time.

**Originality/value** – This paper introduces the original notion of the "persistent model" as a design strategy complementary to existing practices. The "persistent model" establishes and maintains circularity between the model and the artefact as constructed, in order that the two continually inform each other.

## Towards a virtual architecture: pushing cybernetics from government to anarchy

*Ana Paula Baltazar*

**Keywords** Design process, Virtual, User autonomy, Interface, Anarchy, Process-oriented design

**Purpose** – This paper aims to discuss the possibility of joining cybernetics and architecture as a continuous and open process, bridging design, construction and use, in that which is called cyberarchitecture.

**Design/methodology/approach** – It develops the hypothesis that cyberarchitecture can benefit from taking the virtual into account in the design process, so that the architect is no longer the author of a finished architectural product, but of a set of instruments with which users can design, build and use their own environments simultaneously.

**Findings** – A set of design principles is systematised and examined in three practical realms of design: urban, building, and relational, showing cyberarchitecture's embryonic feasibility.

**Practical implications** – Cyberarchitecture implies that architects are no longer authors of finished products and users, becoming designers of their own spaces.

**Originality/value** – Cyberarchitecture avoids the usual cybernetics approach based on control-system, indicating a less predictive and, ultimately, anarchic path for architects and users. It focuses on architecture's intrinsic value as an event, indicating the possibility of a process-based system, which only exists (or is organised) in present-time, when users and instruments (or structures) interact.

## Designing cybersystemically for symviability

*Gary Boyd and Vladimir Zeman*

**Keywords** Sustainable design, Cybernetics, Design

**Purpose** – The purpose of this paper is to encourage professional designers of many kinds, and especially those of the entertainment media, to understand themselves as actually being partners in a common educative enterprise, which is through artistry, predictive knowledge, non-dominative legitimative discourse and technology, helping people everywhere to learn to desire to, and to be able to, survive reasonably pleasantly on Earth for a very long time to come.

**Design/methodology/approach** – This paper puts forward three theses: collapse of civilisation is immanent unless people can be educated to live symbiotically with one another and Gaia; all designs have educative and mis-educative importance; designers need to learn to use higher level cybersystemic approaches to be beneficial. Then it argues for the plausibility of these theses from philosophical educational to practical perspectives. In particular, it argues for the importance of modifying cultural propagation so that all our main cultures can become "symviable" – that is can come to live symbiotically with one another and with the ecosystems of Earth. And it is argued that, in order to facilitate this enterprise, a cybernetic understanding of the processes and actions of the complex historically emergent higher level cybersystems in which the authors are all embedded, and which are embedded in us, should become the basis for designers' actual practice.

**Findings** – By reviewing designers' functional levels historically the paper finds that many different kinds of influential designers have actually functioned at the higher cybersystemic levels the author advocate and hence can be guiding exemplars in this newly precarious situation.

**Originality/value** – A deeper cybersystemic understanding of just how people are all parts of one mutually educating and mutually surviving Earth-life system changes the value of everything. Designers who manage to use such understanding should be both more successful and more satisfied with the value of their work.

## An indeterminate project for architecture in Brazil

*Jose dos Santos Cabral Filho*

**Keywords** Design, Cybernetics, Brazil, Feedback, Architecture

**Purpose** – This paper seeks to describe an experiment carried out in the 1980s by a small practice called Céu do 3o. Mundo (C3M) relating to the application of cybernetics principles to a design process with special regard to house design in Brazil.

**Design/methodology/approach** – After discussing the peculiarities of architectural practice in Brazil, the paper presents C3M's design methodology, which is based on the creation of three models ("conceptual model", "analogical model", and "scale model"); a case study is presented and the results of the application of the methodology to several projects are discussed.

**Findings** – The paper shows that cybernetics principles are relevant for dealing with the Brazilian housing shortage, especially because it is an adequate framework to deal with the Brazilian culture, known for its informality, its social plasticity and its playful nature.

**Originality/value** – The correlation of cybernetics principles to the design of affordable houses is articulated through the concept of "indeterminate project," intended as a project that would allow for flexibility, interpretation and adaptation.

## Self-observing collective: an exemplar for design research?

*D.P. Dash*

**Keywords** Cybernetics, Design, Problem solving

**Purpose** – This paper sets out to provide arguments and examples supporting the idea that some "wicked" design problems may be usefully approached through the process of bringing forth a self-observing collective, i.e. a community of observers capable of generating and dynamically adjusting a collective standpoint from where new observations can be made.

**Design/methodology/approach** – Interactions within a community of observers can be designed to generate a collective standpoint from where new observations can be made and fed back to the interacting observers, thus ensuring that the collective standpoint also extends the observers' capacity to observe. Instances of this process are discussed to demonstrate its contribution towards dealing with some wicked design problems.

**Findings** – The paper suggests that one's capacity to observe, feel, reflect, communicate, and act can be systematically harnessed in a self-observing collective in order to strengthen each member in the face of complex and unstructured problem situations. However, the continued success of the process depends on the effective construction and dynamic maintenance of the collective standpoint that gives the self-observing collective its unique power.

**Originality/value** – The paper borrows certain insights from second-order cybernetics to suggest a way of dealing with ill-structured (and wicked) design problems by facilitating a process of interaction within a community of observers who must be enabled to live with the wickedness of the problem with minimum harm.

## It's all about communication: graphics and cybernetics

*Simon Downs*

**Keywords** Cybernetics, Design, Knowledge creation

**Purpose** – The paper seeks to serve a dual process, first, to raise awareness of the epistemological weaknesses inherent in the ways that visual communications designers address their own practice, and, second, to suggest that cybernetics has some of the answers to these weaknesses.

**Design/methodology/approach** – These objectives of this paper have been addressed through an examination of the cybernetics, critical theory and visual design theory. A comparison of the points of convergence (often of aims) and those points of divergence (often in its ontological reading of the world) is illuminating, especially when post-structuralist semiotics – as a system of knowledge exterior to both design and cybernetics, yet capable of commenting on both – is used as a point of triangulation.

**Findings** – The literature analysis carried for this paper indicates that in both visual communications design and cybernetics there are areas of overlapping interest (concerns with the cyclic nature of coding and decoding information) and areas that might at first seem divergent but are in fact often complementary (the role of the observer as controller and participant in a system). The paper proposes that cybernetics uncovers principles at the heart of communication that in turn inform visual communication practices, which in a circular fashion informs cybernetics.

**Practical implications** – The paper suggests that new areas for cyberneticians to use in their study of second-order cybernetics may be found in the product of visual communications design. It also suggests areas where designers may begin to search for tools that may be useful in evaluating their working practices.

**Originality/value** – The paper notes that an external investigation of visual communications artefacts presents cybernetics with a potential test-bed on which to test its theories, in practice, on a global scale. Cybernetics has the potential to define and offer constructive guidance to visual communications design in examining its own practice.

### Cybernetics and service-craft: language for behavior-focused design

*Hugh Dubberly and Paul Pangaro*

**Keywords** Cybernetics, Design, Politics, Service

**Purpose** – This paper aims to describe relationships between cybernetics and design, especially service design, which is a component of service-craft; to frame cybernetics as a language for design, especially behavior-focused design.

**Design/methodology/approach** – The material in this paper was developed for a course on cybernetics and design. Work began by framing material on cybernetics in terms of models. As the course progressed, the relevance of the models to design became clearer. A first focus was on applying the models to describe human-computer interaction; later another focus emerged, viewing cybernetic processes as analogs for design processes. These observations led to a review of the history of design methods and design rationale.

**Findings** – The paper argues that design practice has moved from hand-craft to service-craft and that service-craft exemplifies a growing focus on systems within design practice. It also proposes cybernetics as a source for practical frameworks that enable understanding of dynamic systems, including specific interactions, larger systems of service, and the activity of design itself. It also shows that development of first- and second-generation design methods parallels development of first- and second-generation cybernetics. Finally, it argues that design is essentially political, frames design as conversation, and proposes cybernetics as a language for design and a foundation of a broad design education.

**Research limitations/implications** – The paper suggests opportunities for more research on the historical relationship between cybernetics and design methods, design research on modeling user goals.

**Practical implications** – The paper offers tools for understanding and managing the complicated communities of systems that designers increasingly face.

**Originality/value** – Suggests models useful for practicing designers and proposes changes to design education.

## The dynamics of design

*Natalie Ebenreuter*

**Keywords** Second-order, Cybernetics, Design

**Purpose** – This paper seeks to develop the argument that a cybernetic framework will enable designers to act as an observer and participant in the process of designing. The dynamic nature of the design process will be discussed in order to better understand how these aspects impact on a designer's ability to act effectively in design.

**Design/methodology/approach** – A second-order cybernetic framework is offered as a means to facilitate a designer's capacity to act as an observer-participant in the co-creation of a design solution. It characterizes the design process as a conversation to enhance a designer's ability to conceptually develop novel design solutions in participative situations.

**Findings** – The significance of the designer in the design process and the design solution is established. A second-order cybernetic framework provides an explanation for a designer's actions by acknowledging their presence in the design process. This makes possible the collaborative development of a design situation and its solution between various participants in this process through negotiation and mutual understanding.

**Practical implications** – It is envisaged that the value of cybernetic concepts as a means to augment interaction, reflection, mutual understanding, creativity and innovation to facilitate designerly ways of knowing, thinking, and acting, is realized.

**Originality/value** – The main value of this framework is for designers who struggle with finding an appropriate framework to facilitate and rationalize the subjective nature of human-centred design methods and the complexity of design.

## How to design a black and white box

*Stephen Gage*

**Keywords** Cybernetics, Design

**Purpose** – Delight, and the possibility that an observer might continually delight in the same thing, is difficult to deal with in a rigorous way. Very little has been written recently about this subject. The purpose of this paper is to offer insights about this vital subject with reference to design work being undertaken at UCL.

**Design/methodology/approach** – It is the contention of this paper that arguments taken from constructivism and second-order cybernetics can help in this. The cyberneticians who have most significantly dealt with cybernetics and physical architecture are Pask and Glanville. They offer significantly different and contradictory insights. Techniques for conceptualising an interactive performative architecture are discussed, based on work undertaken with postgraduate students at the Bartlett Interactive Architecture Workshop, UCL.

**Findings** – Glanville and Pask can be reconciled. When physical architecture can be considered as contributing to physical performance both sets of insights can exist in a common theoretical frame.

**Practical implications** – Designers should consider creating work that contains rich variety and the cues for observer construction, while also offering the possibility of ambiguity where different distinctions are equally possible. It is possible to utilise the differences that arise from changes in the external environment to manipulate the latter.

**Originality/value** – The paper suggests ways of creating places that offer continual delight to their observers.

### Systemic environmental decision making: designing learning systems

*Ray Ison, Chris Blackmore, Kevin Collins and Pam Furniss*

**Keywords** Cybernetics, Research, Learning, Decision making

**Purpose** – This paper, written for a special issue of *Kybernetes* devoted to cybernetics and design, aims to focus on case studies that are both informed by cybernetic and systems thinking and constitute a form of second-order design praxis.

**Design/methodology/approach** – The case studies exemplify reflective practice as well as reporting outcomes, in terms of new understandings, from an action research process.

**Findings** – The paper describes what was involved in course design, from a cybernetic perspective, to effect systemic environmental decision making as well as developing and enacting a model for doing systemic inquiry (SI), which enabled situation-improving actions to be realised in a complex, organisational setting. The paper lays out the theoretical and ethical case for understanding first- and second-order designing as a duality rather than a dualism.

**Research limitations/implications** – There is a danger that readers from an alternative epistemological position will judge the paper in terms of knowledge claims relevant only to their own epistemological position.

**Practical implications** – The main outcomes suggested by this paper concern the possibility of transforming the current mainstream identity of educators, project managers and researchers to a position that offers more choices through both epistemological awareness (and pluralism) and the design of learning systems, including SI, as second-order devices.

**Originality/value** – The case studies are based on both novel settings and theories in action; the concept of the learning systems as both a design and systemic practice as well as an epistemological device is novel. The paper is potentially of relevance to any practitioner wishing to use systems or cybernetic thinking. It is likely to be of particular relevance to education policy makers and public sector governance.

### Research through DESIGN through research: a cybernetic model of designing design foundations

*Wolfgang Jonas*

**Keywords** Design, Cybernetics, Evolution, Learning, Research, Knowledge management

**Purpose** – The paper seeks to make a substantial contribution to the still controversial question of design foundations.

**Design/methodology/approach** – A generic hypercyclic design process model is derived from basic notions of evolution and learning in different domains of knowing (and turns out to be not very different from existing ones). The second-order cybernetics and evolutionary thinking provide theoretical support.

**Findings** – The paper presents a model of designerly knowledge production, which has the potential to serve as a genuine design research paradigm. It does not abandon the scientific or the hermeneutic or the arts & crafts paradigm but concludes that they have to be embedded into a design paradigm. “Design paradigm” means that “objects” are not essential, but are created in communication and language.

**Research limitations/implications** – Foundations cannot be found in the axiomatic statements of the formal sciences, nor in the empirical approaches of the natural sciences, nor in the hermeneutic techniques of the humanities. Designing explores and creates the new; it deals with the fit of artefacts and their human, social and natural contexts. Therefore foundations for design (if they exist at all) have to be based on the generative character of designing, which can be seen as the very activity which made and still makes primates into humans.

**Practical implications** – The hypercyclic model provides a cybernetic foundation (or rather substantiation) for design, which – at the same time – serves as a framework for design and design research practice. As long as the dynamic model is in action, i.e. stabilized in communication, it provides foundations; once it stops, they dissolve. The fluid circular phenomena of discourse and communication provide the only "eternal" essence of design.

**Originality/value** – "Design objects" as well as "theory objects" are transient materializations or eigenvalues in these circular processes. Designing objects and designing theories are equivalent. "Problems" and "solutions" as well as "foundations" are objects of this kind. This contributes to a conceptual integration of the acting and reflecting disciplines.

### The cybernetics of design and the design of cybernetics

*Klaus Krippendorff*

**Keywords** Cybernetics, Sciences, Design

**Purpose** – The purpose of this paper is to connect two discourses, the discourse of cybernetics and that of design.

**Design/methodology/approach** – The paper takes a comparative analysis of relevant definitions, concepts, and entailments in both discourse, and an integration of these into a cybernetically informed concept of human-centered design, on the one hand, and a design-informed concept of second-order cybernetics, on the other hand. In the course of this conceptual exploration, the distinction between science and design is explored with cybernetics located in the dialectic between the two. Technology-centered design is distinguished from human-centered design, and several axioms of the latter are stated and discussed.

**Findings** – This paper consists of recommendations to think and do things differently. In particular, a generalization of interface is suggested as a replacement for the notion of products; a concept of meaning is developed to substitute for the meaninglessness of physical properties; a theory of stakeholder networks is discussed to replace the deceptive notion of THE user; and, above all, it is suggested that designers, in order to design something that affords use to others, engage in second-order understanding.

**Originality/value** – The paper makes several radical suggestions that face likely rejection by traditionalists but acceptance by cyberneticians and designers attempting to make a contribution to contemporary information society.

### Design and prosthetic perception

*Ted Krueger*

**Keywords** Design, Cybernetics, Perception

**Purpose** – The paper aims to consider competing accounts of perception and to examine their potential to support design activity that seeks to extend and enrich perception using interface technologies. The interfaces will enable the direct perception of electromagnetic phenomena that are not now considered to be directly available to humans.

**Design/methodology/approach** – Two models are considered. According to one, the standard view, perception is of an external world known by means of information flowing into an organism from it as conditioned by the organism's biological sensory modalities; according to the other, the enactive view, perception occurs by means of learning to differentiate oneself from the world by undertaking activities, by learning and mastering sensorimotor contingencies.

**Findings** – The paper presents preliminary results of design work based on enactive cognition and argues that the results, in turn, re-inform and reinforce the theory by the introduction of novel perceptual phenomena that cannot be accommodated within the standard view of perception.

**Practical implications** – The project, rather than seeking an instrumental utility, though this may occur, instead strives to enable the bringing forth of a richer world. Its objective is epistemic rather than pragmatic.

**Originality/value** – The paper presents a reflection on the role of design in the construction of theory.

## A sociocybernetic approach to wayfinding map studies: the systems of people-map-space interactions

*Christopher Kian Teck Kueh*

**Keywords** Design, Research, Cybernetics, Feedback, Information research, Sociocybernetics

**Purpose** – This paper seeks to apply a systemic approach to study human-map-space interactions that will benefit the design of a wayfinding map.

**Design/methodology/approach** – This paper presents a case study that was based on Van Bockstaele *et al.*'s sociocybernetic theory as a research framework to map study. Van Bockstaele *et al.*'s theory suggests that an individual's behaviour derives from a cognitive system that consists of latent (background thinking process) and patent (amplified language or action that communicates with the public) action. To observe and understand an individual's action, the observer must also consider cognitive systems. Applying this theory, the process of individuals using maps to solve wayfinding tasks within the City of Fremantle, Western Australia was observed. The study involved observing 30 international students who use three maps, each of which presents iconic, symbolic, and iconic and symbolic representations, to locate four destinations in the city.

**Findings** – Findings suggest that external systems such as maps and the actual environment affect an individual's latent and patent actions, while their behaviour affects the way they perceive the external systems.

**Research limitations/implications** – This paper addresses the complexity of systems involved in the process of an individual using maps to solve wayfinding tasks in the actual environment.

**Practical implications** – This study provides graphic and information designers with a substantial understanding of human-map-space interactions based on systemic perspectives.

**Originality/value** – The application of sociocybernetics is uncommon in map studies. This paper provides a link between the two disciplines.

## Complex built-environment design: four extensions to Ashby

*Terence Love and Trudi Cooper*

**Keywords** Design, Cybernetics, Social environment, Control, Man-machine systems

**Purpose** – This paper sets out to report on research by the authors into the development and application of four extensions to Ashby's Law of Requisite Variety (LoRV) that increase its utility in the arena of unplanned changes in hegemonic control of designed complex socio-technical systems/digital eco-systems in the built environment that are structurally dynamic or emergent.

**Design/methodology/approach** – Research on which the paper is based focused on exploration of classical systems approaches to the design of complex socio-technical systems in which ownership, power, control and management of structure and benefit generation and distribution are distributed, dynamic and multi-constituent. Support for development of these four extensions to Ashby's Law comes from observation of four decades of socio-technical systems development along with critical thinking that combined systems analysis theories with theories and findings from fields of hegemonic analysis, design research, management, management information systems, behaviour in organisations and sociology.

**Findings** – The paper outlines application of four new extensions to LoRV in relation to unplanned changes in distributions of power, ownership, control, benefit generation and benefit distribution in complex socio-technical systems/digital eco-systems in the built environment that are emergent or have changing structures. Three of these extensions have been outlined earlier in relation to the design of learning object-based e-learning systems. The fourth extension builds on these via application of Coasian analysis. The paper also describes a suite of five guidelines to assist with the design of complex socio-technical systems derived from the four extensions to Ashby.

**Research limitations/implications** – The four extensions of Ashby's Law that underpin the design guidelines in this paper are deduced from observation and critical analysis rather than being "proven" empirically. They are derived from observation of the behaviour of real-world complex systems together with critical analytical thinking that integrated theory and research findings from a range of disciplines where each informs understanding of hegemonic aspects of emergent complex socio-technical systems involving multiple, changing constituencies, and evolving system structures.

**Practical implications** – A design method is derived comprising five design guidelines for use in pre-design and design of complex socio-technical systems/digital eco-systems in the built environment.

**Originality/value** – The paper describes the application of four new extensions to LoRV that extend the analytical role of Ashby's Law in diagnosis of changes in power relations and unintended design outcomes from changes in the generation and control of variety in complex, multi-layered and hierarchical socio-technical systems that have multiple stakeholders and constituencies. From these, a suite of five new design guidelines is proposed.

## The magic of three

*Johann van der Merwe*

**Keywords** Autopoiseses, Cybernetes, Constructivist, Identity, Inter-relational

**Purpose** – This paper aims to combine several modes of thought based on systems organization and observing systems in order to construct a model for a "designerly way of thinking".

**Design/methodology/approach** – The approach is to regard design as a "groundless field of knowledge" that may source methodological insights from cybernetics, systems theory, cognitive studies and complexity theory, among others.

**Findings** – The focus of this research is to model an adaptive frame-of-reference that design students may use in order to construct their own autopoietic identity systems. The semantic question "How does a student obtain information about design?" is changed to a structural question "How could students acquire a structure enabling them to operate innovatively in a modern design environment?" With the backing of cybernetic principles, it is apparent that this process is not only feasible but also preferable.

**Practical implications** – While the practical use that can be made of any design theory is not within the remit of this paper, it is nonetheless the goal of theory to enhance the individual's analytical and communicative skills.

**Originality/value** – This paper suggests an autopoietic model-for-becoming that can have the virtual potential of bringing one to understand the grey areas of human-object relationships.

## Architecture as a verb: cybernetics and design processes for the social divide

*Anja Pratschke*

**Keywords** Cybernetics, Public policy, Brazil, Design, Sociocybernetics, Economic cooperation

**Purpose** – This paper aims to draw on current research in public policy, and more specifically about a collaborative design process for a poor suburban community in São Paulo, Brazil and its relation to social cybernetics as the "science of effective organization." The research project in public policy, online-communities, has been financed by the state-sponsored agency FAPESP since 2003, and involves four research groups from the Architecture and Computer Science Departments at the University of São Paulo, and various public and non-governmental organizations under the coordination of Nomads.usp Research Center (Center for Studies on Interactive Living, www.eesc.usp.br/nomads).

**Design/methodology/approach** – The design methodology includes three premises: an organization of the team which considers multidisciplinary and multicultural aspects; the involvement of potential users as creators of the virtual community and of its concrete space; and the concern that the process will be organized so that autonomy and evolution take place.

**Findings** – Special interest in the comparison of architectural methods and cybernetics is to understand how information and communication are dealt with using a design process to promote active exchange of knowledge and competences, and to improve interaction and conversation in a local context of large social differences, affected by lack of opportunities and regulating structures.

**Practical implications** – Owing to its constant questioning of viability, adaptability and recursion, cybernetics should be able to make the designer team constantly revise the proposal to change conditions during its process of implementation and later autonomy.

**Originality/value** – The paper discusses the actual relevance of the use of the cybernetic theory as a way to improve information and communication between designers and the population in poor communities.

## Drawing a live section: explorations into robotic membranes

*Mette Ramsgard Thomsen*

**Keywords** Cybernetics, Design, Robotics, Textiles, Architecture

**Purpose** – This paper aims to discuss the conceptualisation, design and realisation of a robotic membrane. Presenting research taking place between the cross-over among architecture, technical textiles and computer science, the paper seeks to explore the theoretical as well as the practical foundations for the making of a dynamic architecture.

**Design/methodology/approach** – The project employs an architectural design method developing working demonstrators. The paper asks how a material can be described through its behavioural as well as its formal properties. As new materials such as conductive and resistive fibres as well as smart memory alloys and polymers are developed, it becomes possible to create new hybrid materials that incorporate the possibility for state change.

**Findings** – The paper presents the first explorations into the making of architectural membranes that integrate systems for steering using traditional textile technologies. This paper presents a series of architectural investigations and models that seek to explore the conceptual, computational and the technological challenges of a robotic membrane.

**Originality/value** – The paper presents original thinking and technical innovation into the making of textile spaces.

## Second-order cybernetics, architectural drawing and monadic thinking

*Peg Rawes*

**Keywords** Cybernetics, Design, Architecture, Geometry

**Purpose** – The purpose of this paper is to examine shared principles of "irreducibility" or "undecidability" in second-order cybernetics, architectural design processes and Leibniz's geometric philosophy. It argues that each discipline constructs relationships, particularly spatio-temporal relationships, according to these terms.

**Design/methodology/approach** – The paper is organized into two parts and uses architectural criticism and philosophical analysis. The first part examines how second-order cybernetics and post-structuralist architectural design processes share these principles. Drawing from von Foerster's theory of the "observing observer" it analyses the self-reflexive and self-referential modes of production that construct a collaborative architectural design project. Part two examines the terms in relation to Leibniz's account of the "Monad". Briefly, developing the discussion through Kant's theory of aesthetics, it shows that Leibniz provides a "prototype" of undecidable spatial relations that are present in architectural design and second-order cybernetics.

**Findings** – The paper demonstrates that second-order cybernetics, architectural design and metaphysical philosophy enable interdisciplinary understandings of "undecidability".

**Practical implications** – The paper seeks to improve understanding of the geometric processes that construct architectural design.

**Originality/value** – The paper explores interdisciplinary connections between the disciplines, opening up potential routes for further examination. Its examination of the aesthetic and geometric value of the Monad (rather than its perspectival value) provides a particularly relevant link for discussing the aesthetic production and experience of spatial relations in second-order cybernetics and contemporary architectural design.

## Cybernetic principles for learning design

*Bernard Scott, Simon Shurville, Piers Maclean and Chunyu Cong*

**Keywords** Cybernetics, Learning, Design

**Purpose** – This paper aims to present an approach from first principles to the design of learning experiences in interactive learning environments, that is "learning designs" in the broadest sense.

**Design/methodology/approach** – The approach is based on conversation theory (CT), a theory of learning and teaching with principled foundations in cybernetics. The approach to learning design that is proposed is not dissimilar from other approaches such as that proposed by Rowntree. However, its basis in CT provides a coherent theoretical underpinning.

**Findings** – Currently, in the world of e-learning, the terms "instructional design" and "learning design" are used to refer to the application of theories of learning and instruction to the creation of e-learning material and online learning experiences. The paper examines the roots of the two terms and discusses similarities and differences in usage. It then discusses how the processes of learning design fit into the larger processes of course, design, development and delivery. It goes on to examine the concept of a "learning design pattern".

**Originality/value** – The paper contends that, whilst learning design patterns are useful as starting-points for individual learning designs, learning designers should adopt the cybernetic principles of reflective practice – as expressed in CT – to create learning designs where received wisdom is enriched by contextual feedback from colleagues and learners.

## Conversations with the self-knowledge creation for designing

*Kaye Shumack*

**Keywords** Design process, Knowledge management, Learning, Knowledge creation, Narratives

**Purpose** – This paper aims to draw links between the circularity of second-order cybernetics, and constructive, reflective conversations with oneself in design practice. The paper argues that a structured use of internal conversational dialogues with oneself can assist the design process, enhancing creativity and transformative approaches to design projects.

**Design/methodology/approach** – Theories about the emergence of new knowledge, and the causal nature of internal conversations, are used to present a case for the value of a structured self-reflective conversational process in designing. Emergent knowledge is described in terms of flows across domains of public and personal knowledge, through dynamic processes of semantic absorption, codification and diffusion. The structure and agency of the internal conversation are discussed as a practical way to interpret and locate the emergence of project directions, as a kind of meta-language for design production. This is demonstrated through an action research case study, where an internal dialogue about teaching visual communication design is described.

**Findings** – On the basis of the action research described, the use of a structured internal dialogue can be of benefit to designing, as it provides a mechanism for locating and mapping the flows and developments of emergent semantic concepts and design project directions.

**Practical implications** – The model for internal conversations is a way for designers to acknowledge their dual role as both participant ("subject" self) and observer ("object" self). The paper argues that this can help in locating oneself within a design process.

**Originality/value** – This paper contributes to the debate about knowledge of design and for design. A constructive conversational model is presented, which acknowledges the significant role of experiential, cultural and semantic contexts in framing emerging knowledge for designing.

## Design of the netgeneration: streaming the flow of design and science in the educational practice of the creative industry

*Aukje Thomassen*

**Keywords** Cybernetics, Design, Education, Creative thinking, Young adults

**Purpose** – This paper sets out to provide insight into the current debate on art, science and the new net generation of young professionals with the usage of the conceptual framework of cybernetics that will look into the dynamics of this netgeneration.

**Design/methodology/approach** – Literature review will set the stage of the current debate on design education in the creative industries, which aims to provide a reflection. The theory and approaches are then applied to a case study in which the conceptual framework of cybernetics will be unfolded. These concepts are then evaluated in order to provide a proposal for continuing research.

**Findings** – The paper provides insight into the mechanisms of knowledge management systems in particular for the context of design-making processes by the netgeneration. The findings are reviewed and concluded by proposing a method for continuation of research. The case study will benefit from the findings and as such design education itself.

**Research limitations/implications** – It is not an exhaustive scope of literature review as the literature chosen is in particular very applicable to the case study in this paper. However, the point of departure is the current debate within the creative industries on design education and the netgeneration.

**Originality/value** – This paper interconnects different elements which are the subject within different venues such as within design, science, pedagogy, and knowledge management. Therefore this paper might be applicable within these different articulated venues.

## A framework for designing sustainable urban communities

*Shann Turnbull*

**Keywords** Cybernetics, Economics, Governance, Property rights, Urban areas, Communities

**Purpose** – The purpose of the paper is to show how the sustainability of urban settlements can be improved by treating as a variable the design of property rights: to realty, corporations, and currencies, and the communication and control architecture of communities.

**Design/methodology/approach** – System science shows how the resulting increases in the richness and variety of communication and control channels improve the governance of urban precincts. The new variables also provide a way to integrate the design of the built environment into the design of its governance architecture. The scope of orthodox economic analysis is extended to include the value of assets and liabilities to provide additional feedback signals. This more holistic economic framework increases the richness of the "semiotic" channel of social communication and control that complements those based on senses, words and prices.

**Findings** – The analysis reveals self-reinforcing feed-forward and feedback channels between the use and maintenance of the built environment and its governance architecture not available in less holistic design frameworks.

**Practical implications** – The paper identifies the need for urban planners to extend their discipline to become governance architects and how the knowledge of system scientists can be applied to improve the design of capitalism.

**Originality/value** – A new design paradigm is identified that allows improvements to be introduced in the ability of towns or suburbs, to become self-financing, self-governing political units. The paradigm identifies how capitalism can be designed to become more efficient, equitable, responsive, and democratic.

## Informing design praxis via 2nd-order cybernetics

*Randall Whitaker*

**Keywords** 2nd-order cybernetics, Biology of cognition, Design, Matorana, Varela

**Purpose** – This paper aims to present lessons learned in applying 2nd-order cybernetics – specifically Maturana and Varela's "biology of cognition" – to the actual design of interactive decision support systems.

**Design/methodology/approach** – This consists of a review of the rationale and bases for applying 2nd-order cybernetics in interactive IT design, the challenges in moving from theory to praxis, illustrative examples of tactics employed, and a summary of the successful outcomes achieved.

**Findings** – The paper offers conclusions about the general applicability of such theories, two sample applications devised for actual projects, and discussion of these applications' perceived value.

**Research limitations/implications** – The applications described are not claimed to represent a complete toolkit, and they may not readily generalize beyond the scope of interactive information systems design. On the other hand, the examples offered demonstrate that 2nd-order cybernetics can constructively inform such designs – advancing the focus of discussion from theory-based advocacy to praxis-based recommendations.

**Practical implications** – The paper presents illustrative examples of the exigencies entailed in moving 2nd-order cybernetics ideas forward from theory to praxis and specific tactics for doing so.

**Originality/value** – This paper addresses the persistent deficiencies in both concrete examples and guidance for practical applications of 2nd-order cybernetics theories. It will hopefully stimulate similar attempts to demonstrate such theories' practical benefits.

**Rethinking the cybernetic basis of design: the concepts of control and organization**

*Theodore Zamenopoulos, Katerina Alexiou*

**Keywords** Organization, Control, Complexity, Design theory, Category theory, Emergence

**Purpose** – Even though design as a purposeful activity naturally fits into the realm of cybernetics, the emphasis on control has limited the scope of using cybernetic principles in design. The idea of organization, another fundamental concept in cybernetics, has received less attention in design research and seems worthy of further exploration. The purpose of the paper is to review the two concepts and clarify their role and meaning in design. Overall, using insights from complex systems science, the paper attempts to recast the relationship between cybernetics and design.

**Design/methodology/approach** – The treatment uses category theory as a language and methodological approach in order to formally express the concepts of "organization" "control" and "design" and then study the relations between them.

**Findings** – Organization is defined using the mathematical concept of sketch, i.e. as a characterization of the complementary relation between theories and models. The paper demonstrates that the peculiarity of design rests on the fact that the distinction between theories and models is an anticipated but emergent state. In contrast, control-based representations assume that the theory-model distinction is given in advance, as an intrinsic characteristic. The paper demonstrates that design is a distinct paradigm in relation to control, yet it falls within the domain of cybernetic and complex systems enquiry.

**Originality/value** – The paper contributes to the understanding of design as a distinct type of problem in cybernetics by exposing differences between control and design problems. The paper also further lays the foundations for developing a cybernetic theory of design based on the concept of organization.

# Try again. Fail again. Fail better: the cybernetics in design and the design in cybernetics

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## Abstract

**Purpose** – The purpose of this paper is to explore the two subjects, cybernetics and design, in order to establish and demonstrate a relationship between them. It is held that the two subjects can be considered complementary arms of each other.

**Design/methodology/approach** – The two subjects are each characterised so that the author's interpretation is explicit and those who know one subject but not the other are briefed. Cybernetics is examined in terms of both classical (first-order) cybernetics, and the more consistent second-order cybernetics, which is the cybernetics used in this argument. The paper develops by a comparative analysis of the two subjects, and exploring analogies between the two at several levels.

**Findings** – A design approach is characterised and validated, and contrasted with a scientific approach. The analogies that are proposed are shown to hold. Cybernetics is presented as theory for design, design as cybernetics in practice. Consequent findings, for instance that both cybernetics and design imply the same ethical qualities, are presented.

**Research limitations/implications** – The research implications of the paper are that, where research involves design, the criteria against which it can be judged are far more Popperian than might be imagined. Such research will satisfy the condition of adequacy, rather than correctness. A secondary outcome concerning research is that, whereas science is concerned with what is (characterised through the development of knowledge of (what is)), design (and by implication other subjects primarily concerned with action) is concerned with knowledge for acting.

**Practical implications** – The theoretical validity of second-order cybernetics is used to justify and give proper place to design as an activity. Thus, the approach designers use is validated as complementary to, and placed on an equal par with, other approaches. This brings design, as an approach, into the realm of the acceptable. The criteria for the assessment of design work are shown to be different from those appropriate in other, more traditionally acceptable approaches.

**Originality/value** – For approximately 40 years, there have been claims that cybernetics and design share much in common. This was originally expressed through communication criteria, and by the use of classical cybernetic approaches as methods for use in designing. This paper argues a much closer relationship between cybernetics and design, through consideration of developments in cybernetics not available 40 years ago (second-order cybernetics) and through examining the activity at the heart of the design act, whereas many earlier attempts have been concerned with research that is much more about assessment, prescription and proscription.

**Keywords** Analogy, Circularity, Conversation, Cybernetics, Design, Novelty

**Paper type** Research paper

The title "Try again. Fail again. Fail better." is taken from Samuel Beckett's (1984) novel *Worstward Ho!* published by the Grove Press in New York. In the author's view, it captures the conversational act at the heart of designing which is the central focus of this paper.

Kybernetes
Vol. 36 No. 9/10, 2007
pp. 1173-1206

0368-492X
DOI 10.1108/03684920710827238

## 1. Introduction

This paper is made up of two-halves, and should, in effect, be seen as two papers in one.

Because this special double issue of *Kybernetes* pursues the intersection of two fields, cybernetics and design, there may be readers who are not familiar with one field or the other. Furthermore, both fields may often be presented in an almost bewildering variety of ways some of which appear to contradict others. It seemed that there was, therefore, a need for an introduction to each field. I present this in the first half of the paper, although I do not attempt a field survey (which would be beyond what is possible in this issue).

Approaches to design cover a wide range. The word design has roots in drawing and in designation. It is used as both a noun and a verb (the preferred use in this paper). There is a long history in the way the word "design" came into English, but studies of the activity are relatively recent. I will distinguish three streams here. Simon (1969) thought of design as a complex but essentially mechanical action (and saw much of how designers actually design as a shortcoming rather than a strength – if he saw it at all). His approach can be typified by the notion of generating a set of alternatives which might be assessed against criteria (assuming the criteria can be specified). In contrast, Rittel and Webber (1984) posited the concept of "wicked problems" as a central feature of designing, while Gedenryd (1998) (with whom I share most sympathy) investigated the relationship between designing and cognition and pointed out that much design research had been concerned with what researchers thought designers should do, whereas he (and I) are more interested in what they do.

Approaches to cybernetics are equally wide ranging. The classical presentation of the subject, deriving from Wiener (1948) and the Macy Conferences (Pias, 2003), is of control, feedback, communication, circular causality. This approach takes various forms, with applications in hard engineering to management, law and so on. Social systems soften the approach, but the radical and contrasting variant is second order cybernetics: the cybernetics of observing (rather than observed) systems, as von Foerster (1974) described it. Second order cybernetics grew out of Mead's (1968) advocacy of the examination of cybernetic ideas and institutions using cybernetic principles and understandings. Second order cybernetics is thus recursive, constructive and very consistent!

My own position in each field (in radical disagreement with many other authors in the issue) is as follows.

### *1.1 Design*

I value what designers actually do: the act that is at the centre of designing, the heart of the design act that is the source of its distinctiveness, and of the creativity, the novelty, with which design is associated. So I take it that the act of designing is a worthwhile act in its own right, and a proper focus for research. Indeed, designing may be so worthwhile that it may not need improvement: and improvement may not be possible. Unlike some of my colleagues, I consider the attempt to force design to be scientific to be ludicrous – for several reasons, including that the whole point of design is that it is design. Design is a way of acting, a way of thinking, and I have argued that design (as I understand it) is the act at the centre of the Piagetian development of the constant objects with which, Piaget claimed, we populate the world we create from the experience we live in. In fact, rather than benefiting from ways in which other areas might be applied to design, it may be it is design that has more to offer to other areas.

*1.2 Cybernetics*

Cybernetics is a way of thinking that bridges perception, cognition and living-in-the-stream-of-experience (the involvement of the observer), which gives important value to interaction and what we hold between ourselves and others – whether animate or inanimate. It is concerned with circular causality and the wish to control in a beneficial manner. It comes from a mechanical metaphor for the animate, which is now partnered by an animate metaphor for the mechanical. While it can be of great use in its traditional business of modelling control systems (and hence in control engineering), for me its interest lies in the significance given to the involved observer and the consequent individuality of and responsibility for his/her actions. My position lies at the radical extreme of second order cybernetics and is unrecognisable to some others in the field.

*1.3 A sketch of the argument*

If the first-half of this paper is concerned with an exposition of the understandings of cybernetics and design that I argue from, the second-half of the paper is concerned with the development of a series of analogies that show how design and cybernetics are so closely related, at least in my exploration of them (which reflects my interests in them). The reason for composing this issue of *Kybernetes* is to explore the (possible) relationship between cybernetics and design. In this last half of the paper I present the analogies I have developed that allow me to claim that cybernetics can act as the theoretical arm of design, while design acts as the practical (active) arm of cybernetics.

This paper works with these particular interpretations of design and cybernetics. Many disagree with these interpretations, and the analogies I build. However, my purpose is not to show I am right and others are wrong, but that something may be held to be shared between cybernetics and design that is worth considering, thus bringing them together.

Some may say my way of considering design is hopelessly imprecise, that design should be more like science, etc. I reply that if design is more like science, why should we bother with design at all (to repeat myself: the whole point of design is that it is design)? It is the difference that makes design interesting and gives it its value, allowing us to have more than one way of acting, more than one set of values. In my opinion, those who cannot see this should think twice before speaking: it is assertive and wishful thinking to claim that because you cannot see something, no one else can and that your blindness should be taken as universally shared. I say this as a scientist as well as a designer.

There will also be those who claim this approach is romantic. But it is not romantic to accept that not everything can be defined and computed, or that there are ways of working that do not depend on such definition: and it is not romantic to value criteria and qualities other than the strictly measurable, or to accept that reality is as we make it. And, for that matter, what is wrong with romantic?

## 2. Cybernetics and design: introduction

### *2.1 Why should we think there is a connection*

The notion that cybernetics and design might have something to tell each other is not new. The history, over the last 60 years, of both has served to bring them together on several occasions and has shown striking parallels in their histories. For instance, in its early days, when technological optimism was at its height, cybernetics was seen as the subject that would help realise this optimistic view. At the same time, design (particularly in the form of architecture[1]) was seen as being unscientific (and hence theoretically inadequate) and began the search it has pursued ever since to find a theory that it could import that would make it properly scientific. Cybernetics (and its near cousin, systems theory)[2] was seen as a likely candidate.

In the late 1950s, there was a profound and serious attempt to turn design into a scientific activity, to rationalise it[3]. This approach originated at the Hochschule für Gestaltung in Ulm, and found as one of its sources of strength the "new" science of cybernetics, which was at the time, in the way in which we humans look for the universal answer, ambitiously promoted as a new science that would allow us to solve all our problems. It was, therefore, obviously significant for design.

At the turn of the 1960s into the 1970s the movement towards explicit scientific rationality as the sole generator of objective design "solutions" (the term is redolent of science) began to wane, and, at about the same time, thinkers in cybernetics began to investigate the paradox that the way cybernetic systems were discussed failed to reflect the nature of cybernetic systems[4]: cybernetic systems were presented using the traditional scientific device of the detached observer, even though they spoke of systems in which the observer (the sensor) is anything but detached: that's the point of feedback[5]!

So at the time that design was retreating from the design methods approach (as so clearly indicated in what I see as the brave volte face of J. Christopher Jones (1980) in the revised edition of his classic, *Design Methods*, in which Jones completely rethought the approach used in the earlier version of the book), cybernetics was also becoming less traditionally scientific, for it began talking of the observing system as well as the observed, of the observer in the system rather than the observer of the system.

The change in cybernetics has scarcely been noticed by many in the field, for a number of reasons I will not go into here, and many approaches, from post modern theory to complexity studies and cognitive science, have suffered from having to re-invent a wheel cybernetics had already invented. Indeed, cybernetic developments are still arguably far ahead of much research in these fields, because cybernetics understood the change in the role of the observer to be so radical that it required a complete re-think[6] – one example of which is von Glasersfeld's (1987) development of a form of constructivist philosophy known as radical constructivism[7].

The change in design was much more apparent both to and in the field. The regular importing into design (and specially architecture) of theories and modes of argument/vocabulary from other fields became absolutely apparent in, for instance, the various "critical" and "theoretical" accounts of Jencks, who has lead (at least in populist consciousness) the import into architecture of several "foreign" theories.

The theories associated with Jencks and others, which continue to dominate much theoretical discourse in design, are theories concerned with the individuality of perception and understanding, which can also be thought of as the unpredictability of the process of design (and its outcome). As cybernetics moved into a study of systems that include the observer rather than standing independent of him/her, design became more quirkily based in the individual as opposed to a general, single "style" of the period – or, rather, it formed schools which followed theories that recognised the presence of the individual (the observer) in such a manner that these theories came to be expressed, literally, as styles. That is, ready made algorithms that simplify the contexts in which we work so that many (design) decisions are already made.

Both cybernetics and design thus accepted the inescapable presence of the observer, who must therefore be understood as active – an actor[8]. It is bizarre that, with this parallel between the two fields, design did not recognise the developments in cybernetic thinking (which became known as second order cybernetics) but took to the earlier, less active version of cybernetics[9], for this newer cybernetics is specifically concerned with understanding systems in which the outcome is unpredictable and individual, and the observer is always present and never ignorable. Nor did cyberneticians generally reach out to design – or, rather, they were all-too-often only prepared to understand design in the manner of so many importers of the word, as a problem solving activity that lives in the world of the complex-yet-definable.

There was one cybernetician, however, who did reach out to design: Gordon Pask. Already in the 1960s Pask had understood there were close parallels to be explored between cybernetics and design. In 1969, (Pask, 1969) he brought his nascent insights into the processes of conversation to the world of design in a paper in which he explored the relationship between the architect and the client. Pask's outreach was long-term and committed: he worked with arguably the most radical architect of the second-half of the twentieth century, Cedric Price, and he taught in architecture schools, particularly London's Architectural Association School. And he created art works and environments. In the world of art and design he is perhaps best known for his "Colloquy of Mobiles" at the Cybernetic Serendipity Exhibition of 1968, but his design of learning environments is probably more important.

More important, still, is the connection to design of his students. At one stage I calculated that of 12 successful doctoral students at Brunel University, eight were architects and six came from the Architectural Association. I was one of those six students. This is an extraordinary accretion of architects who realised that cybernetics had something special to offer them. What is interesting about this cohort is that they were students of Pask at exactly the time when cybernetics began exploring its basic paradox: that it had talked about systems with an involved observer from a position in which the observer of these systems was not involved[10].

Pask died 11 years ago. The link between cybernetics and design was obscured at that time. Today there is a revival of designers' interest in cybernetics. However, most designers who pursue this interest do so – as has been noted – in ignorance of the developments in cybernetic understanding since 1970, which is perhaps the last time designers looked to cybernetics. In a bizarre twist, the result is that designers may be moving back towards an inappropriate determinism which they are seeking to prop up (and mechanise) with ancient cybernetic arguments.

I believe I have shown above that there are parallels between design and cybernetics: in the sorts of approaches they used at various times, and in the sensitivity to the involvement of the active observer. In this paper, I shall explore these parallels, specially using the conceptual framework of second order cybernetics, particularly in the form of conversation theory – the second order cybernetic account of communication. In doing so I hope not only to demonstrate there is an important connection(s) between the two fields, but also that more recent cybernetic thinking offers particular relevance and value to designers. In my mind, the homomorphism between the two is such that, as I said in my introduction, I am prepared to claim cybernetics is the theory of design and design is the action of cybernetics.

But before I can do that, I need to introduce cyberneticians to design (as I intend it in this paper) and designers to cybernetics (in its recent guise).

*2.1.1 Design for cyberneticians*. What is meant by design, in the context of this paper?[11].

Before I go into this question, I should re-assert that there is much disagreement and debate in design and design research over this question, and about whether there is a design process and, if so, how to characterise it. The descriptions I give are my descriptions and reflect my belief, experience and understanding. I believe that most designers, and many researchers who are sensitive to what designers do, will recognise what I describe. I base this statement less on the literature than on personal experience and discussion with many designers and students over a long period.

Let me start with some negatives. By design, I do not mean problem solving, or even a way of facing complexity (though design does that well, as we shall see). I do not refer to an Object, the result of a design process, or even a process, itself also the result of a design process.

Design, in this paper, is an activity that is often carried out in the face of very complex (and conflicting) requirements. We may deal with many of these requirements (functions to be accommodated and other factors) through logical procedures: for instance, an optimal sequence of rooms in the layout of a building may be created using simple network theory.

Yet the interest of designers is generally to create the new. They wish to bring delight to the user (and to themselves as designers), while finding a form that can house the requirements in a manner that is satisfactory, by means of the creation of something new[12]. Sometimes, convenience may even be traded off for added delight: we will on occasion accept the less convenient in order to have the more beautiful. And sometimes the process of bringing all the requirements into a new form leads to a new way of accommodating the requirements that transcends traditional logical procedure, at which point a novel type of arrangement may appear.

What I refer to is design as a verb, not as a noun. The verb, design, indicates a particular process that constitutes the design activity, a particular and relatively little studied process which I maintain is at the heart of design, the whole undertaking generally being included under the one name. I am not talking about evaluation of the outcome of the process, or of situating that outcome within some schema.

This process can be thought of as a conversation held mostly (but not exclusively) with the self. In the most common traditional version, the conversation consists of making a mark with a pencil on paper (equivalent to talking, in a verbal conversation), and then looking at it to see what the mark suggests (equivalent to listening) and, consequently, modifying the drawing. The process goes on and on in a potentially endless circle. Reasons for stopping are that the outcome is good enough or that it fails. As an initial process it may have little or no intention: it is just a sketch or (to downplay the action) a doodle. But the sketch/doodle suggests a form and that is explored, playfully, and requirements are gradually assimilated into the design as form is brought into being.

It is clear that this design process is based around the actions of the designer: to talk of this process as if the designer were not present in it is, clearly, impossible – for there would be no process. It is therefore assumed that whenever this design process is discussed, the process includes the designer.

It is this process of conversation, primarily held with the self (but also with others in, for instance, an office), that indicates a cybernetic process at work: for conversation is perhaps the epitome of second order cybernetic systems[13]. And, like any conversation, it is open and can take us to places we did not expect to be, thus introducing novelty. In looking at the sketch, we see it in ways other than we saw it when we drew it: viewing is an exploratory and constructive act. As I was instructed as a student: "Learn to think with your pencil!".

In this manner, sketching, the central source of creative design action, can be described and explained as and by means of a primary second order cybernetic system – the circle of conversation. And, although this is not all of design, it is a, if not the, key activity at the heart of design: so cybernetics supports design and design supports cybernetics, in a further second order, conversational, cybernetic circle!

Design may be thought of as an inductive process, where science is deductive. Science has problems when it tries to be inductive: design shows a way (and a change in legitimate expectations) by which we may act inductively.

*2.1.1.1 Design and the ill-defined*. The design activity (design as verb) that I have described grows what may later be seen as a unique solution to an ill-defined and under-specified set of problems – some so under-specified that they should not even be considered problems. The lack of definition has many sources. In a sense, what is at the centre of design is scarcely concerned with problems, at least as we have come to think of them. We can think of designing leading to an outcome which can be seen as a solution that defines the problem(s), in contrast to the way we normally think of a problem leading inexorably to the solution. This does not mean that designers fail to "solve" what are quite conventional "problems" but that what makes their work and their approach unique is not this aspect.

This is one reason design is not and cannot be scientific, in the sense of recent Anglo Saxon use of that word. Design is not a science, but, I have argued, science is a specially and particularly limited form of design (Glanville, 1980, 1999b). No scientific experiment just happens, no theory exists without a reworking of the knowledge associated with it (a point made by Popper (1963) (who called himself a constructivist) in *Conjectures and Refutations*); more extremely, still, I have argued that the processes of mentation which Piaget argues are at the centre of our thinking are properly considered as design acts, and therefore design is the primary human activity (Glanville, 2006b).

And when we come to specify the problems a design outcome has been designed to accommodate, we find that these problems are very complex indeed, that their interrelationships lead quickly to vast complexity and to those areas of problem space that the great cybernetician Ross Ashby referred to as the transcomputable: there is simply not enough physical stuff for us to even dream of computing, exhaustively, logically driven solutions, which makes design an effective approach to complexity – for design is not so consequent upon a problem statement, which will often enter into the realm of the transcomputable (Ashby, 1964).

*2.1.1.2 A very brief history of (the word) design*. The use of the word design in English is recent, and until it acquired its application to what have also been called the applied arts, its meaning was not what it is now. The origins of the noun are in the Italian disegno, to draw[14]. But this verb apparently follows another route, coming into English (according to the *Oxford Dictionary of the American Language*) from a Latin root: designare, to designate (via French désigner): this dual route is particularly poignant when thinking of the command "Draw a distinction!" with which Spencer Brown (1968) starts his book, *Laws of Form*. This book had a major influence on cybernetic thinking, and reminds us that every line we draw also designates, bringing the two understandings together in another way.

The intention in using the word design, and the activity it designates, has also changed. But the recent adoption of the word design in areas that have nothing to do with the traditional, central activity I have indicated in my view weakens the concept. Design has become a buzz word appropriated by many fields where, according to my interpretation, it scarcely belongs: it has been colonised. My intention in using it relates to the conversational activity I have described above, and not the post-colonial.

There are two more points to make.

Firstly, as stated above, design always involves the designer. That is, of course, nothing more than an assertion of a grammatical rule: verbs have subjects. But it is important because it shows in another way that design, with its active agent, the designer, fits in with cybernetics (particularly of the second order), which considers circular systems in which the observer is understood to be both present and active.

Second: there are no absolute criteria (there is no clear specification: the criteria emerge after the solution has been found and may be seen as being defined by the solution): design outcomes can only be validated as being good enough (the phrase introduced earlier), not by being best. In fact, it is often difficult to determine that one design outcome is better than another simply because there is no shared standard against which to evaluate. This may be a great, though unexpected extra benefit, difficult for many to appreciate.

*2.1.2 Cybernetics for designers*. Cybernetics is apparently a modern science, though the origin of its name is old Greek (meaning helmsman) and the word has been in occasional use for a long time.

Its modern use is generally taken to originate with Norbert Wiener, whose eponymous 1948 book, *Cybernetics*, was subtitled *Control and Communication in the Animal and the Machine*. However, what is perhaps a better definition is the title of a series of working conferences, "Circular Causal and Feedback Mechanisms in Biological and Social Systems" funded by the Josiah Macy Jr Foundation in New York (1942, 1946-1952) and attended by Wiener, amongst others (including Gregory Bateson and Margaret Mead). The name cybernetics was, after the publication of Wiener's book, taken as summarising the theme of the Macy Conferences by the Conference Secretary, Heinz von Foerster.

The word control, in English usage, has two rather different meanings. Probably the more common is restrictive control, where the controller limits the controlled according to his/her whim. This sort of control is essentially aggressive and destructive, e.g. dictatorial.

The other, Wiener's intended use, is enabling control. This sort of control talks of the benefits of controlled movement in achieving aims: the purpose of enabling control is not to restrict, but to guide towards better performance. Being in control, so that a skier is in control as (s)he speeds down a mountain responding to all the arbitrary surprises in the slope without falling.

Control implies two further things. Firstly, some goal or intention. In Wiener's (and colleagues') first proto cybernetic paper (Rosenblueth *et al.*, 1943) he and his fellow authors talk of teleology: purposive or intentional action. This was a brave move at a time when science was particularly preoccupied with the removal of intentionality from its processes and practice[15]. Secondly, control implies some means by which the intention (and the control action) can be communicated to an effector or actor. Wiener's interest in communication largely concerned capacity, and he is the (unacknowledged) precursor of Shannon and Weaver's (1949) *Mathematical Theory of Communication*, commonly known as information theory[16].

The question arises as to what constitutes control in a system that enables rather than restricts. This was defined by Ashby (1956) in his Law of Requisite Variety. Variety as a measure of the number of states a system either might or does take. In order not to restrict behaviour, Ashby's Law tells us, the system that is to control must have at least as many states as the system to be controlled. That is, the controller must have the requisite variety for control not to be, in principle, restrictive.

A simple example of a cybernetic system is a domestic heating system. This consists, in essence, of two elements: the sensor and a space served by a heat source. The situation in the room being heated can be described (assuming some goal temperature) using only two states: it is too hot or it is too cold. The controller (sensor) needs, thus, only to have two states, which can be easily achieved with a (heat sensitive) on/off switch. The requisite variety is two, the controller (sensor) may have many more states, but they are optional (and unlikely to be of much use).

*2.1.2.1 First order cybernetics*. The sensor in the thermostatic system (strictly speaking, the whole system, maintaining a constant room temperature, is thermally static) observes[17] the room's thermal conditions, distinguishing them into one of two groups (too hot, too cold) that effect one of two actions (respectively, turn heat source off, turn heat source on). The need for this constant monitoring is based on a pragmatic consideration itself as novel and daring as reference to intention: the notion that error is, in itself, neither bad nor good, but endemic – it cannot be eliminated. The cybernetic system constantly drives to achieve its goal. Some attain this and come to a stop, some enter a cycle around the goal as a fixed point, while others pursue a goal that itself moves, so they are always playing catch-up.

Consider the primary cybernetic metaphor of the helmsman: any sailor will attest that simply pointing the rudder will not get you where you want – you have to constantly trim and adjust until you arrive. The difference, in cybernetic terms, between the helmsman of a boat and the thermostatic sensor, is that the helmsman hopes his boat will arrive and stop, whereas the heating system will not achieve this: it goes on forever seeking the desired room temperature in a perpetual loop that merely keeps it adequately near that temperature because error is endemic. (In fact, careful consideration shows it is error that drives the system!)

Even in this simplest of systems (the thermostat), control is effected through a feedback loop, and the sensor is active: it turns the heat source on and off. However, the behaviour of the sensor, itself, is controlled, in turn, by the room heated by the heat source. We will return to this point later in this section: what is relevant, here, is that the (organisational) form of control is circular – as is the causality. The temperature in the room drops below the goal temperature causing the sensor to switch, sending a message to the heat source, which causes it to provide more heat. The heat source provides heat until the temperature in the room exceeds the goal temperature causing the sensor to switch, sending a message to the heat source, which causes it to stop providing heat, and so on, *ad infinitum*. In fact, we can describe this system as having three goals: the over-riding one of maintaining a specified steady temperature, which is made up of two subsidiary ones; to gain heat when below the specified temperature, and to lose heat when above it.

I used the word cause in order to point, in this feedback loop, to the concept of circular causality (remember the Macy definition of cybernetics). This is another radical concept. The aim of traditional science has been to get rid of circularity, yet here is a subject (Wiener, in his book title, was careful not to call it a science, though many have since appended the word as can be seen in earlier usage in this paper) that lives in circularity and turns cause into a circular mechanism: herein lies the radical (and brave) novelty.

In fact, some (I among them) have claimed that circular causality is the norm and the linear causality science espouses is a special case with very weak feedback, so weak that it is taken to be insignificant. Subjects such as chaos theory and its precursor catastrophe theory show us what happens when we consider that we may ignore the insignificant. My point is that circular causality is the more general case, with linear causality as a specific limitation; just as Einstein's mechanics is the more general case while Newton's mechanics is specifically limited. This does not stop Newton's mechanics from being very powerful and very beautiful: the Americans flew to the moon using Newton's mechanics rather than Einstein's.

A legitimate question arises in relation to the nature of control in circular systems: which element controls and which is controlled? In the thermostat example, the sensor switches on the heat source, but the heat source then switches the sensor off. Control is neither in one element nor the other, but between them, shared. It would seem that the general convention is to call that which uses little energy the controller, as if we were dealing with an energetic (and hence physical) system. This was Wiener's position. I believe he was wrong: cybernetics is not focussed on the physical world, but the informational. Which element we call controller and which controlled is arbitrary and our choice, should we chose to make it.

*2.1.2.2 First to second order cybernetics*. In Section 2.1, I outlined the shift from first to second order cybernetics. In a system such as the typically cybernetic one of the thermostat, the sensor (the part of the system that was traditionally thought of as controlling) is not only an observer of the system (it observes the two states – too hot and too cold), but also an observer (actor) in the system. It causes changes in the states of the heat source and, hence, through the action of the heat source (turn off, turn on) the room, in turn, changes the state of the sensor. The sensor, in this description, is an example of an involved and active observer. In cybernetic systems such an observer is the norm.

Mead's (1968) paper (commissioned by Heinz von Foerster) has already been mentioned. In it she asked why cyberneticians did not treat their own systems (in this case exemplified by the American Society for Cybernetics) as a cybernetic system: why not treat a cybernetics society through cybernetics, itself. Hence, the title of her paper, "The cybernetics of cybernetics" that also came to be called the new cybernetics and, more commonly, second order cybernetics. We can generalise from her request: why not treat cybernetic systems through cybernetic understandings and insights?

A way of summarising what makes cybernetic systems different from (I have earlier argued more general than) traditional ones is circularity. Circularity is embodied in the role of the observer in cybernetic systems: the observer cannot be inactive, or there would be no system.

The question, in discussing and treating cybernetic systems, becomes why, if we are going to treat cybernetic systems cybernetically, do we not treat our examination of them in a similar manner, recognising that the observer even in the conventional scientific arrangement can only be remote and detached through a carefully structured deceit. In actuality, the observer is always present, always active in several ways (for instance, setting up experiments, choosing variables, arranging outcomes in the body of knowledge). Consistency demands that we treat the observer of the cybernetic system in the same way that we treat the observer in the cybernetic system; and the observer in the cybernetic system must be active (to effect change), so the observer of the system should be treated as active, in just the same way. The observer, in second order cybernetics, is in the system he/she is describing just as (when, for instance, describing the thermostatic system) the sensor in that system is understood as an observer in the system. We have observers of observers that are observing (their) observing: another cybernetic recursion.

There is, nevertheless, still an irony. In order to talk about the observer in a second order cybernetic system, I have taken the position of an observer of rather than an observer in. This is a consequence of this sort of description. The observer in requires an act of sharing of exactly the sort that happens within a conversation. It can happen in a performance, in a lecture (a special type of performance): we become observers in when we live in experience rather than describing it. For a designer this may be summarised as experiencing total involvement in the act, often thought of as being lost in it.

*2.1.2.3 Subject and metasubject*. Cybernetics is one of those rare subjects (another being mathematics) which, while being a distinct field worthy of consideration in its own right, is also a subject that casts light upon other subjects. It is an abstract subject which has often been applied to enhance our understanding of other subjects. In its incarnation as second order cybernetics it is both its own subject and its own metasubject.

Design is another such subject: a subject in its own right, that can cast light onto other subjects, and which, I have argued, needs to be studied in the light of its own criteria, as a design equivalent of second order cybernetics: the (recursive) cybernetics of cybernetics and the (recursive) design of design (Glanville, 2003).

Cybernetics talks of structure and form, leaving emotion and meaning to the observer's interpretation and insertion. It may be thought of as providing structures within which it is possible to construct the individual meanings and emotions we chose. It does not negate such deeply human areas, but supports structures that in turn support our freedom to enjoy them, leading to another form of second order recursion: the support of support.

*2.1.2.4 Circularity*. As stated in the Macy Conference theme, the central and distinctive feature of cybernetic systems, in contrast with the more traditional systems of science, is circularity: cybernetic systems are circular, whereas scientific systems have traditionally aimed at being linear.

When we look at the cybernetic circle, one key point becomes clear: that the circle is organisational, it is the form. The experience, the passage around this circle, is a spiral. That is, the passage acquires history, and, at least for the cognisant observer, there is a process of learning, of change. On each iteration we act, collecting the history of the iterations in an ever enrichening spiral. We do not experience the same spot (twice), for although the spot may appear the same at least in terms of location, we are not. As Heracleitus tells us, "Upon those who step into the same rivers different and ever different waters flow down". This is another way of expressing what we have been calling recursion.

*2.1.2.4.1 Autopoiesis, Eigen-Forms and Objects*. Second order cybernetics has developed several very particular circular systems. The most famous of these is the Autopoietic system of Varela, Maturana and Uribe (1974). Autopoiesis (literally, self-creation or self-production) is a process described thus:

> An autopoietic machine is a machine organized (defined as a unity) as a network of processes of production (transformation and destruction) of components which: (i) through their interactions and transformations continuously regenerate and realize the network of processes (relations) that produced them; and (ii) constitute it (the machine) as a concrete unity in space in which they (the components) exist by specifying the topological domain of its realization as such a network.
>
> [. . .] the space defined by an autopoietic system is self-contained and cannot be described by using dimensions that define another space. When we refer to our interactions with a concrete autopoietic system, however, we project this system on the space of our manipulations and make a description of this projection (Maturana and Varela, 1980).

A second is von Foerster's Eigen Forms. This is not the term he used, but one I use as an umbrella term to include eigen structures, eigen functions, eigen objects, eigen behaviours and eigen values – terms he did use. Von Foerster wrote of objects – tokens for eigen behaviours – and talks of recursive functions which arrive at a stable and self-reproducing value. Recursion is the act of continuously repeating a process, applying it to the earlier output (consequence) of that same process. Eigen forms provide a model for how, by a process of repeated action (such as observing) we can arrive at a stable and fixed outcome. Von Foerster (1977) used this as a model for the establishment of those stable entities Piaget referred to in his conservation of objects.

A third, less familiar circular system, contemporaneous with autopoietic systems and predating eigen forms is what I have called an "Object". An Object is a self-referential entity (which maintains its form through (circular) action on and in itself). It provides a structure or form for entities that are observable. If entities are to be observable, that is to inhabit a universe of observation, the question is how they come to be in the universe in order to be observable (by others). The answer provided by Objects is that they must (be assumed to) observe themselves. The great advantage of this form is that Objects, being observed by others, will always reflect the individuality of those others. There are other advantages that come with the package, such as the generation (as opposed to the assumption) of a logic[18] (Glanville, 1975, 1999a).

*2.1.2.4.2 Conversation as the essential second order cybernetic paradigm.* To these systems we must add Pask's conversations. The word conversation was chosen by Pask (1975) because it is everyday, and refers to a common experience and form of communication. Conversation involves us listening and talking to each other, in an essentially circular form.

Pask analysed the basic mechanism of conversation to get a grip on the bare bones, the structure. This is in contrast to those who consider the meaning of elements in a conversation, or the emotional content and such like. Cybernetics is concerned with mechanism (the machine of Wiener's subtitle) and with structure/form: this allows enormous freedom in, for instance, emotional interpretation because the structure supports many such interpretations. The purpose of building such a structure, at least for some cyberneticians, is to permit and support such freedom.

Pask's conversational structures required at least two participants, the first of which presented some understanding (of some topic) to the second. The second took this presentation and built his/her own understanding of the first participant's understanding, presenting this understanding of an understanding in turn to the first participant. The first participant then makes an understanding of (the presentation of) the second participant's understanding of (the presentation of) the first participant's understanding, thus comparing his/her original understanding with the new understanding developed via the second participant's understanding. If these two understandings are close enough, the first participant can believe the second participant has made an understanding that is, at least operationally, similar to his/her original one. Of course, we may never claim the understandings of the two participants are the same. No meaning, no understanding is sent from one participant to the other: the meanings we acquire as we build understandings are ours alone. This is an enormous strength of the conversational model of communication[19].

Pask evolved his conversation theory in the context of learning. Pask may be considered the first to develop machines that learnt, and which took part in a shared learning environment with learners. His conversations were originally intended to permit learners to study the ordered topics of a subject in a manner, and developing understandings, that suited each learner. The conversations were held over the topics of vast "entailment mesh" of topics that constitute a subject, and also in the process of testing understandings developed by means of a thoroughly conversational process – teachback.

Conversation is the fourth essential circular cybernetic system that embodies the features of second order cybernetics. As Pask describes it, the conversation is the basic form of genuine interaction: and it is this which makes it so important, such a good model for design.

*2.1.3 The interesting conjunction.* In Section 2.1.1, I showed something of the conversational character of the process I maintain is at the centre of designing. This parallel is at the heart of the argument in this paper, that cybernetics and design are parallel activities.

It is the circularity of conversation that is at the heart of this parallel. The circular second order cybernetic systems mentioned in Sections 2.1.2.4 and 2.1.2.4.1 also have something to show us about design. In particular, von Foerster's Eigen-Forms and my Objects provide strong theoretical support for aspects of the central design process, enriching the support provided by Pask's conversations.

But earlier, first order cybernetics still has something to contribute. I do not refer to the old parallel that helped sustain the design methods movement, but to the working of Ashby's Law of Requisite Variety. I shall start the in depth examination of the parallels between cybernetics and design with what this law can tell us about creativity.

## 3. Body of argument

### *3.1 Cybernetics, design and determinism*

Cybernetics was born at about the time that design became recognised as a way of acting, yet seen to be somehow lacking. This lead, in architecture, to the development of design science and attempts to show that design could be carried out in a completely rational and logical manner – that is, scientifically. This is not the place to explore how this was attempted or the source of what I believe is its inevitable failure. Cybernetics was seen as a major weapon in the arsenal used in the attempt to produce a rational design process, within a determinist framework. This was not surprising, for cybernetics was correctly understood to be concerned with mechanism. What has changed in cybernetics since those days is how that mechanism is seen (Wiener's metaphor of the animal as the machine has in some respects reversed in second order cybernetics so that the machine is often seen through the metaphor of the animal).

There is, however, one first order cybernetics example of an understanding of design that continues to have great relevance and power, and that is Ashby's Law (of Requisite Variety).

*3.1.1 Variety and design*. As recounted, variety is a measure devised by W Ross Ashby to help us understand the (cybernetic) controllability of a system, and Ashby's Law of Requisite Variety states the conditions necessary for effective cybernetic control: that the controlling system has at least as much variety as the system to be controlled.

(For a second order system, in which, which element is recognised as the controller and which the controlled is essentially arbitrary, each controlling the other, the variety clearly can only be the same. Second order cybernetics originated at the end of Ashby's career and was not formulated before he died, so he never had the need to reconsider his Law.)

In this part of the paper we will examine how Ashby's Law can illuminate the activity of design.

*3.1.1.1 Animal and machine*. Cybernetics, especially in its original version, dealt with definable examples which it determined, modelled and then controlled (in the cybernetic sense). It was concerned with clear-cut states. Being able to define states and their causal relationships is one way of describing classical physics (especially mechanics), and abstracting it to this level is one reason cybernetics is (like maths) both a subject and a meta-subject at the one time. This assumption is essentially the assumption in Louis Sullivan's dictum, sloganised by the modern movement in design as "Form follows function" and was one reason design methods and first order cybernetics were such natural bed fellows: for both wished (to quote Wiener's subtitle) to use the machine as the metaphor for the animal.

*3.1.1.2 The undefinable*. Ashby, himself, pointed to one of the main problems of problem definition that are significant in design. In his "Remarks at a Panel" Ashby (1964) explains that there is a limit to the computing capacity of even the most powerful conceivable systems. These derive from the finite size and life of the universe as we understand it. Beyond this limit we reach the transcomputable. Because the (literally) astronomically vast universe is nevertheless finite, there is a limit to what may (theoretically) have been computed in it. Ashby shows that this limit can very quickly be exceeded. Even relatively simple problems such as computing, exhaustively, the possible states of a light matrix of $20 \times 20$ light bulbs exceeds the computability limit Ashby derives, using both his own argument, and the argument developed by Hans J. Bremermann. These arguments tell us that problems very rapidly become transcomputable. Design almost always faces a situation where it has so many interrelated variables (assuming this concept is appropriate to design) that the problems it deals with are essentially transcomputable.

But it is questionable whether the concept of a variable (and thus a measurable unit) is relevant in design. In Section 1, I explained that designers are interested in the new: the new is, by definition, not something that is inherent in the existing (so it cannot, in the original sense of the word, be predicted and thus does not depend on a notion such as "variable")[20]. It may be seen as connected, and even rational, after the event, but before the event it can only be thought of as what, in chaos theory, would be a sort of discontinuity. The new is, by definition, outside the predictable (at least until it is created, when it may be accounted for).

Furthermore, as any designer will attest, for all but the very simplest jobs (and perhaps even for them) it is extraordinarily difficult to specify precisely what is needed or wanted, and within whatever specification can be produced there will be conflicts and inconsistencies. I have explored this aspect in a recent paper on design and complexity (Glanville, 2007b) and will not take it further here except to draw to the reader's attention the lack of experience most of us have in specifying – except in the crudest terms – what we want of a house (to use an architectural example). How do we describe the experience we seek? Do we, in specifying a WC, also take into account that this is the one room (in most houses) where privacy is guaranteed, so that it may serve, for instance, the function of a retreat? Or how do we get light into a kitchen from east, south and west (so that it is sunny all day, in the northern hemisphere) when the kitchen has to fit in with other rooms that also demand light and view – the kitchen being the most used room in a house?

These factors render it impossible to expect to adequately and accurately define a design problem.

*3.1.1.3 Definability and variety*. Ashby's arguments about limits and transcomputability were introduced at the start of the previous section. Ashby's Law of Requisite Variety states that, for any system to be controlled, or, to use one of the two other cybernetic synonyms, managed (the other is regulated)[21] the variety (number of states) in the controller must exceed the variety in the system to be controlled. But if the variety of the controlled system is transcomputable, it is in principle inconceivable that we can compute enough states to be able to control it. This happens in principle, as has been reported, in surprisingly simple systems. Thus, the aspiration to model, to control (without restricting) the performance of many systems is unrealistic. This is profoundly shocking to most of us, and takes some getting used to.

Of course, this does not stop us trying, but we use strategies that belie the problem. Ashby also states (in the same paper) "The systems theorist may thus be defined as a man, with resources not possibly exceeding $10^{100}$, who faces problems and processes that go vastly beyond this size" – an explicit recognition of the difficulty. The tactics we use to alleviate this essential problem lie in how we define the context in which we chose the states according to some (often unspoken) notion of relevance or appropriateness; or by transforming what we do to the notion of control so it becomes control-as-restricting. Both of these strategies work, but one intentionally restricts, while the other also finds a way of redefining variety so that it becomes manageable. As Ashby tells us in this quote:

> Systems theory ... will be founded, essentially, on the science of simplification ... The systems theorist of the future, I suggest, must be an expert in how to simplify.

*3.1.1.4 Being out of control, unmanageability, and creativity*. It is therefore possible to describe design problems as essentially unmanageable, in the two senses that:

(1) variables may not be relevant; and

(2) even if they are, such variables are often incomplete, contradictory and define problems that exceed the transcomputable.

In general, when we use the word unmanageable, we indicate a negative. But here it is positive. This is why, a common idea of how we should be in our world is to be in control – that is, to manage. We use this "control" language extensively. It is useful to be in control! Drivers who are not in control, for instance, may be an enormous danger[22]. But being in control means defining, in some sense, the range of what will be considered, that is, the range of the possible. In effect, when I am in control I restrict the world to what I can imagine or permit: I define possible and desirable states; I impose my order. But, doing this, I necessarily restrict: not in the sense of the limiting control practised by, for instance, dictators; but in the sense that I support a predetermination of what-is and what-might-be, and aim towards specified – and therefore predetermined – goals.

Let me give an example of the way this sort of control restricts. If I go to a restaurant with a group of friends, and it is always I who chooses the restaurant, we will only go to restaurants that I choose; and choosing the restaurants reflects my taste and knowledge (or, perhaps better, ignorance), which can be seen as a limitation, a sort of filter that reflects only what I already know. If, however, I let others choose the restaurant, I will often go to a restaurant I did not know, thus finding new (to me) restaurants. I can regard these introductions as gifts from my friends, increasing the range of my experience, knowledge and choosables, even if I decide a particular, new-to-me restaurant is bad. (Often, of course, I find great new delights.)

My contention is that the restaurant situation provides a good illustration of the operation of the Law of Requisite Variety. The great benefit of not having enough variety to control a system is that, if I give up trying to control rather than being annoyed that I cannot, I can discover many possibilities I would have excluded if I had insisted on being in control. These possibilities are unexpected, outside my frame of reference, in a word, novel. This is akin to giving up control of the choice of restaurant,