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.

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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 20×20 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, letting others introduce new possibilities. If you want to use the concepts and measure of variety, you can easily set up situations in which the variety to be controlled is vastly greater than any variety you might ever have access to and so you cannot possibly control the situation, except restrictively. Stopping trying to find enough variety to control means accepting the vastly greater variety in the now out-of-control element while all those possibilities you would have excluded are no longer excluded, and, to take a cliché the world is your oyster.

Not restricting what you will consider to what you know already opens you up to experiencing the vast unknown; and in that you are likely to encounter what is to you the new[23].

3.2 Design as done

Research in design can be seen to fall into two categories (Gedenryd, 1998). The first and largest is that in which design is investigated through perspectives and methods imported from or associated with other subjects. For example, the history of design examines the outcome of designing through the perspectives and values of history; while this may give interesting insights, it can be argued that this research misses the central concerns of design, treating design as material to be subjected to investigation by and according to the aims and values of the imported discipline (history). The same can be said for design science, cultural studies and so on. Many researchers believe this is the only way to progress, implicitly suggesting that design is lacking a viable approach of its own and, therefore, needs to import one. These approaches bring their own insights but, I hold, recognise little value in design's own approaches[24]. There is also slight consideration of the appropriateness of the imported theory (Glanville, 2004a): but, of course, bringing in that which may not be obviously appropriate can lead (as in the argument about Ashby's Law) to benefits.

The second category is research that searches for the presence of a design approach in designing. I have argued in support of this position for nearly 30 years (starting with Glanville, 1980). I believe design is a way of acting which has great (and largely unrecognised) power and potential, and that researching this will tell us not only a lot about design, but will also give us insights into "different" ways of acting, and can cast a different light on other fields. Therefore, I will proceed in this paper by extending the earlier exploration of design as it is done, in a form of conversation.

3.2.1 Design as a conversation with the self (and with others). The idea that the central act in designing is a form of (Paskian) cybernetic conversation held with oneself has already been introduced.

It is a common experience that, having drawn something, we look at it later and see in it a different something that was not part of what we were thinking about as we drew it. This experience is at the heart of designing. There are two factors that are central:

(1) we look and then we draw; and

(2) we see something new, not previously intended.

The first is the basic mechanism that allows the circle which is the form of a design conversation. When I participate in the more familiar verbal conversation, speaking, I expect that my conversational partner will listen, and then, in turn, speak. My conversational partner, speaking, expects that I will listen, and then (completing the conversational circle) speak. For a conversation to take place, each participant must switch roles from being a listener to being a speaker (note how listening precedes speaking). It is not enough to speak, or to listen: what is at the heart of a conversation is the switch. This switch happens within each participant (I speak, I listen), but also between participants: I speak, my conversational partner listens; my conversational partner speaks, I listen. For a design conversation, substitute draw for speak, view for listen.

This is how, when I am my own conversational partner as is commonly the case in design, I can hold a conversation with myself: instead of the drawer/speaker and viewer/listener being identified with two different participants, we understand them as roles, which can be embodied in one participant (by role switching) and even, between groups. This is a basic quality Pask requires for participants in a conversation[25].

(The conversational model also allows the same process to operate between different individuals. It can, thus, also support the familiar social dimension of design – exactly as in the account of a conversation just given.)

The second comes from the first. A basic assumption of a conversation is that participants do not transmit or share meanings (this is one of the ways conversation theory is more powerful, and more accurately represents experience, than information theory). It is in this difference that novelty can be seen to arise: indeed, it cannot but arise. Thus, the aspect of the design process seen as conversation (novelty) can be understood not simply as an aim of the designer that some would count an irresponsible whim, but as unavoidable and necessary.

Why? Because if we construct our meanings differently, we cannot assume our individual understandings will be the same. Therefore, every time my conversational partner expresses back to me his/her understanding, I must assume it will be in some way different from mine[26]. Every utterance I make (whether spoken, gestured or drawn) will return from my conversational partner as different, and my test for understanding is, to put it tersely, whether I can adequately bring together what I hear with what I said. (This is one base of Krippendorff's (2006) *Semantic Turn*, although, surprisingly, he fails to recognise Pask's pioneering work.)

The difference between the two views comes from the distinctiveness not of the body embodying, but of the cognising entity: that is, the distinction in role between speaker and listener, drawer and viewer, regardless of whether they are taken to be in one or several physical bodies. It is the role that makes the difference, and it is the change between roles that allows the conversation with the self: for it matters not whether Pask's p-individuals are situated in one body or many, or even between members of a group of bodies.

To return to the argument about variety made in Sections 3.1 to 3.1.1.3, the conversation is one way in which the variety of the "repertoire" of the designer can be increased.

The process of the design conversation with the self opens another important possibility, that of accommodating more and more functions. This process is akin to Piaget's accommodation in the construction of constant objects and will be discussed below. The point, here, is that iteration of the circle of conversation allows, on each cycle, the addition of more functions and requirements to be accommodated into the design outcome. These can lead to failure, or they can lead to development. Their assimilation and accommodation does not always have to be perfect: the requirement is that they fit in well enough. This is, I have argued, a major part of how design handles what, in other fields, would be called complexity.

There is, in this account, one mechanism that is at the centre of design. This mechanism implies that difference (and hence both the development of design, and the unavoidable potential of novelty) is inevitable; and that conversational partners can exist, equally, in one person or in a group. The circle of the design conversation can be used as a way of increasing "complexity" assimilating or accommodating ever more functions.

3.2.1.1 Trying, failing and re-starting. There are several further features of conversation that grow out of this account and which are also familiar in designing.

The first of these is the importance (and value) of failure. It is conceivable (and everyone reading will know the experience) that we cannot communicate in some conversation. There are times when we cannot complete the conversational circle. Under these circumstances, we have to give up. In Pask's terms, we agree to disagree, after which we can try to begin again. The same often holds in the central process of design. The conversation with the self may end up somewhere where the result is non-viable or even aesthetically unacceptable. It may also be that the particular conversational process cannot accommodate a particular enrichment of functions, with the result that the designer has to reject what has so far been developed and start again. Designers are all too familiar with this need!

It has been said of design that the most important ability of a designer is to throw away an old idea that is not working, and start again. This is a regular experience for the designer. In design, there is nothing negative about failure. In this sense, we have another analogy with cybernetics – possibly the first study to take error on board as a fact of life rather than something to bemoan and curse. Cybernetic systems exist because error is endemic.

3.2.1.1.1 Popper and Piaget. The activity that is design can be seen as proto-scientific. Taking Popper's (1963) characterisation of science as conjectures, tested thoroughly in an attempt (finally assumed to be successful) to refute them, we have a circular activity of improvement and enrichment which fits well to the characterisation, above, of the design conversation[27].

Furthermore, I have argued (Glanville, 2006b) the process Piaget describes in which we take experience, and, breaking it into parts, create (recurring) patterns and consistencies between them – leading us to consider that which recurs as constant or conserved – what we come to treat as an Object with an independent existence in a separate world, but which we learn about and know in experience. In this manner, Piaget (1955) tells us, we come to construct our realities. Of course, sometimes our constructions do not manage to sustain themselves and we have to reject them in favour of new assemblages of constructed patterns of repetition, which we take to be new Objects in our (re-constructed) reality. And sometimes we have to modify or expand a constant Object to accommodate new experiences. All these ways of behaving are strongly analogous to the way we work with the circle of the design conversation.

3.2.1.1.2 Conversation and objects: autonomy and eigen-values. The three other examples of second order cybernetic system that have been mentioned can be seen to represent a behaviour or characteristic of the central design conversation, the conversation with the self[28].

The first is the autonomy of the autopoietic system. An autopoietic system is one that in the first place generates, and then maintains itself within an environment. It was invented as an explanation of the process of living, by Humberto Maturana, and developed into its full form with Francisco Varela and Ricardo Uribe. It is the best known second order cybernetic system. While the authors of the notion of autopoiesis have never, to my knowledge, explored in detail how their systems come into being (it is a definitional point that they do so), they nevertheless create the conditions to create themselves, and they continue to generate themselves in their environments. We can say this is their purpose. But this is what designers do in the design process: they create the conditions in which the design outcome can come into being and continue to generate itself – that is, continuing the design act leads to an outcome that remains constant (at least in the designer's eye)[29], although detail may be enriched. In this respect, the process of designing can go on in principle forever, and, in essence, when we chose to stop designing is generally a personal and arbitrary decision[30]. What is important is that, when we have finished designing we have produced an outcome that maintains itself, as it were, independently of us (even if we still have influence) for no matter what we do it remains essentially unchanging, continuing to regenerate itself: in this manner it appears as an autonomous outcome, that is "organisationally closed". Thus, our designs are like our children, which grow to become their own persons.

The second is Von Foerster's eigen forms. Von Foerster is interested in certain types of process that, no matter where you start, always end up, and then continue to be, at the same place. Eigen functions that produce eigen objects are (mathematical) recursive functions that stabilise on particular values. Von Foerster developed them as a mathematical example that mimics the (cognitive) process which Piaget describes for the construction of his constant objects. Von Foerster's eigen forms give a rigourous mathematical demonstration of a process by which a system can operate on its own output, treating it as input, and arrive at a self-reproducing value. They model the process of coming into being, and continuing to be.

Von Foerster called the particular systems that behaved in this way eigen objects. Earlier, I had also used the word Object (but with an initial capital letter), to refer to supposed structures of inhabitants of universes of observation – in other words, structures which might support all the different views made by different observers, which, nevertheless, can be thought of as observations of the same object. Von Foerster referred to this work as a calculus for Piaget's notion of object constancy. The significant aspect of Objects is that, in order to become members of the universe of observation, they are argued to "observe themselves"[31] by taking two alternating roles: (self) observing and (self) observed, between which they are assumed to switch in a continuing circle. In this manner, they switch in the way that the designer in a design conversation does, and there is a strong analogy between the design conversation process and the process by which an Object continues to be in a universe of observation. A universe of observation is, of course, the universe of (radical) constructivism: the experience lies in the observing from which we may postulate and live by/in an external reality made up of objects. These experiences come from observation tagged onto what I call Objects.

Thus, it may be argued that the design conversation is not only built out of Pask conversations, but is reflected in major elements of at least three other prime second order cybernetic systems: Maturana, Varela and Uribe's autopoietic systems; von Foerster's eigen forms; and my own Objects.

3.2.2 Conversation as design. We might, after the accounts above of how design activity can be seen as a prime example of second order cybernetics, ask how this cybernetics can be seen as a design activity.

We can consider a conversation as being like wandering in the country; perhaps in a wood, maybe carrying a hamper for a picnic.

As we talk, we follow paths that, to someone else, will almost certainly seem arbitrary. Even talking around a topic we will move away in a manner that is both unpredictable and seemingly without purpose. We will end up somewhere, and will decide that this is a good place to stop.

Swap the word "walk" for the word "talk" and the word "topic" for the phrase "feature in the landscape" and the similarity is clear. The place where we end up is the place where we "decide to have our picnic". Arriving at this point, we can make sense of our journey: we can explain the trip and give it purpose. The word we use for this sort of walking is wandering: designing and conversation are both like wandering.

This is the process of design translated once more. We do not really know where we are going, when we design, but when we arrive we know that we have arrived, and can make sense of the progress. This is not to deny the importance of those aspects of design that we can treat as specifiable and which we can solve (in the traditional sense), but to recognise and allow the central act that makes (almost stumbles on) the new without quite knowing how or why, and can then explain this, by means of explaining the route taken, as a seemingly sensible (even logical) path. This account is, however, not a purposive problem solving activity. It is a post-rationalisation, an explanation after the event.

In our post-rationalised explanations, we often refer to the path we have trodden as a design: and thus we treat the outcome of a primary cybernetic event (a conversation) as design. What we do is to design an explanation that makes our activity seem purposive and logically directed: we use the word design in its meaning as intentional, as goal orientated, and therefore as cybernetic.

3.2.2.1 Arriving and stopping. And what are the criteria by which, after the event, we may explain the choices we make? Certainly neither truth nor utility, in any ordinary sense. Perhaps, the concept of beauty fits in here? If so, we have re-established the importance of beauty as a guiding criterion, in a world where we have come to prefer to measure utility. And we are judging the cybernetic act by criteria normally used for such acts.

How do we know we have arrived? Through a feeling of "all-rightness" a sense that this is "just right". This is an intuitive condition, an act of recognition and resolution rather than of a problem solved. We may be able to account for it after the event, but at the time, and to us and the involved deciders, it satisfies our intuition and our sense of OK-ness. This reminds us that designers do not seek the perfect solution, but one that is good enough. They do this not through lack of rigour, but by recognising that the area in which they work is ill-defined: and perfection, therefore, is unattainable. Design brings with it the concept of adequacy as a means of evaluation, rather than perfection.

This is a recognition and accommodation of the presence of error – that core aspect of cybernetics.

Nevertheless, there are outcomes that are so special and which work so well and so transcend inconvenience that we may indeed consider them perfect: such outcomes occur when by some magic the disparate elements and functions to be fitted together are somehow magnificently accommodated by the form that arises: when the designer is “on a roll”.

3.2.2.2 Shaping and forming: not designing an outcome. Perhaps, one of the most interesting differences between first and second order cybernetics lies in the manner in which they deal with purpose as internal or external. For a first order cybernetic system, purpose is associated with a goal external to the system: the system is then steered towards the goal, giving rise to the cybernetic metaphor of the helmsman for which the subject was named. The goal, seen as outside the system, gives motivation[32], but also allows the observer, again outside the system, to examine it in a “quasi-objective” manner. Thus, the external goal is associated with the external observer (the observer of) (Glanville, 1997a, b, 2004c).

When the observer is in the system, as in second order cybernetics, the goal that the observer sees the system moves towards must also be within the system.

The system with the observer in it has a different quality to the system as the observer of it observes it. We can, as observers of the system, talk of a stable system (as in the thermostat). When, however, we consider a system with an observer in it, and we are that observer, we may be perfectly stable from our point of view, while to an external observer of us we may appear to veer all over the place. Continuity of being, of maintaining our stability, lies within the system (in terms of Objects, and hence the self-conversation at the heart of design, in the switching between observer and observed within the circle that is the system). Viewed against some external goal by an external observer, all may appear different. We cannot, of course, see within the second order system from outside in the same way as we can from within. There is a problem with second order cybernetic systems, indicated earlier yet rarely recognised, that most descriptions of them are from a first order position. To create the second order description, the observers of need to enter in and become observers in. This is, in my experience, where the power of performance enters[33]. But it is also the power of the design conversation, where we, within, become (to the outsider) lost: what we do is incomprehensible and often beyond the scope of the best attempts at explanation. Think of what happens when you try to observe a conversation from outside, as opposed to being part of it.

A system, perfectly stable within, may appear erratic when viewed from without. That is the lesson of, for instance, ageing, of erratic behaviour, and of the design act.

3.2.2.3 Stopping and starting again. A further, also previously mentioned, feature of design is that of stopping and restarting. This characteristic is not particular or exclusive to activities known by the term design: for instance, it is inherent in much recent theory of science, such as Popper (1963) and (in a different manner) Kuhn (1970). It is familiar in many activities, of which conversation is the cybernetic example used above, as it is also familiar in the act of wandering that was used to illustrate the path of a conversation – and an act of design. But if this stop-reject-restart course of action is widely familiar, we might argue that this is an example of how design thinking is (unknowingly) in far more general use than in just those areas known as design.

Note, this is not, however, the same point as the point about non-designerly research into design.

This is, then, an argument for design as a primary way of thinking and acting, and from this we get notions such as management as a design activity (Collopy *et al.*, 2005). Indeed, several bodies have set themselves up to bring design thinking into "non-design" areas, for instance the Centre for Design at RMIT University, Melbourne. The observation in this section reflects a specialised application of the argument I made that the concepts Piaget argues for can best be understood as ways of designing (Glanville, 2006b).

3.2.3 Being out of control. Let us return briefly to that other cybernetic stream we have pursued: the concept of unmanageability; that is, the outcome already discussed of Ashby's Law of Requisite Variety. Unmanageability comes about when we try to control the uncontrollable.

In Section 3.1.1.4, the argument was made that being out of control does not have to be a bad thing: it can be seen as offering more options than we could, ourselves, imagine. Thus, it is a way of increasing our creativity because we have access to (for instance) ideas which would otherwise not have come to our minds[34].

It will be noticed that much of what has since been described in this paper in the form of the (design) conversation, can work only because we do not control. A conversation controlled by one participant is not a conversation. The point of conversation is that others bring what you do not. Restricting your response and the conversation to what you know is to destroy the conversation. It follows that design operates in a world in which Ashby's Law is not utilised. It is not that the Law is wrong: it is that this is a (second order) cybernetic activity to which the Law does not apply.

The same holds with the wandering metaphor. The point of wandering – its power – and the pleasure in it, is to follow your nose, to get lost, not to plan, to avoid the dominance of "efficiency"[35]. Both wandering and conversation gain their strength and effect because they epitomise systems to which Ashby's Law of Requisite Variety is not applied. They are acts in which we are out of control – our lives have become unmanageable.

3.2.4 Complexity. Complexity is often taken to be a major area of concern. Let me repeat a quote from Ashby used earlier. In the same paper in which he discusses the transcomputable, Ashby states:

> 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.

However, complexity is not a simple and unalterable property of phenomena. Consider what may be understood under the label "London": we can think of the amazingly complex organism made up of an almost unimaginable set of interrelated parts with a complexity measure that vastly exceeds Bremermann's transcomputability limit; or we can think of a very simple, unitary whole. The complexity we see in phenomena depends on what we want to see, our purpose, the context and so on.

Designers, by definition, are faced with situations generally seen to be of great complexity and ambiguity. But the circular process they go through leads to what may be seen, in the end, to be simple outcomes. Some (including some designers) may claim they are complex. But that complexity lies in what is embodied and contained in the outcome: the outcome itself is more often than not simple and, indeed, simplicity is a frequently used criterion of success. The Italian designer Bruno Munari is quoted on the walls of the Design Museum in London, thus:

> Progress means simplifying, not complicating.

Simplifying is not to be confused with over-simplification: what Munari points to (as does this paper) is a process by which complex requirements can be brought together within one, unified, unitary form. The complex requirements are dealt with (contained) within this form. Rather than try to specify every requirement and every relationship between these requirements, and then find an optimal solution, design starts more-or-less "aimlessly" and gradually constructs an "evolving" form[36] that not only changes, but in doing so accommodates the required functions also, often in a novel and surprising manner, where normal relations between functions are enriched or even replaced by new ones that are unexpected, different, and often very good! The accommodation of further requirements within the form, the assimilation of requirements by substantial shifts in that form (including rejection and restarting), and the conversational manner in which this is done (itself leading to developments in the form) all help designers to simplify the complicated (complex) in finding their final form through a recursive, circular action process.

Design brings to complexity an approach that is distinct from complexity science, which can lead to outcomes of great beauty and elegance. And if some functional requirements are less well satisfied than others, the result may be no worse than the complexity scientist achieves, and has the added value of bringing the beauty of the designed form (in this case, usually the form as physical, an object), and on occasion relationships that bring new pleasure and delight (Glanville, 2007b)[37].

There is always a question of how to stop in such situations. Again, (second order) cybernetics gives us an answer. Von Foerster's eigen forms give us recursive, design-like processes which, at a certain point, reproduce themselves. The outcome of an iteration has the same value as the outcome of the previous (and the next) iteration: repeatedly carrying out the process on the output, leading to the generation of the same output (the value of one output is the same as the value of the following output). In design terms, the next iteration of the design conversation leads to no change in the form. When this occurs, the designer has reached a stable outcome, but not necessarily the "best": the criterion best has no relevance in this way of thinking. In practice, designers learn to know when to stop: they develop an intuition that recognises when they have reached a good enough place, just as the wanderer with the picnic hamper recognises when to stop, when (s)he has reached a point where there is no need to go further and (having "arrived") the wandering can be explained as if purposeful in a manner that makes sense of the journey to this place, because of the recognition of arrival: the arrival defines and gives purpose to the journey just as, so often in design, the "solution" defines the "problem".

3.3 Criteria and conditions: from cybernetics to design

In the above we have already indicated one condition that derives from this understanding of design and cybernetics: that the notion of "best" (in the sense of finding the optimal solution) is scarcely applicable and has little or no relevance in design. The appropriate criterion is not best, but good enough. A design should satisfy the specifiable requirements. It should lead to the creation of a special object or process that is new. The criterion of being best (or even being better) cannot be applied in any absolute manner because there is no strict scale and no basis for strict comparison, and because the so-called problem is, for many reasons already explored, undefinable. It may, of course, turn out that one design is judged better than another, perhaps because it is more in tune with popular taste, or because it is better marketed, but these are criteria of a different sort.

Notions such as optimisation, and other similar efficiency measures are scarcely appropriate to the outcomes of a design act: and the act, itself, is scarcely optimisable. What makes a designer effective is luck, guided by experience, intuition, talent and judgement. The fact that this will not appeal to those who follow a more mechanistic and realist approach does not mean these qualities should be excluded: indeed, it is the argument of this paper that they cannot be avoided and so should be welcomed.

Nor is the more practical outcome necessarily to be preferred to the less practical, for one outcome may be deemed preferable to another simply because of the novelty and/or beauty of its form, or for some other apparently arbitrary reason such as marketing success.

This is not to argue against functional adequacy, or sound fabrication: it is to say that the criteria by which we may value design outcomes are open, variable, chosen (optional), and not absolute. I can, of course, say that one knife, for instance, is better than another according to many criteria, but I cannot be insistent on the superiority of these criteria. Consider the success of knives with toothed, serrated edges: they never need sharpening, but they are never sharp. Against the functional criterion of sharpness, they fail. But against the criterion of staying as sharp as they were, they succeed. The resulting outcome of a design process is the outcome, and that is all.

A particularly attractive consequence of this is the responsibility the designer must accept for what (s)he has designed. The process of design is begun by the designer, the conversation is largely private, the designer drawing to him/herself. The outcome of the process is different in each case: design leads not to the best, but to a large variety of different outcomes, giving choice. The design process may be terminated when it reaches a self-reproducing (stable) state: but further judgements about it, and even about when to stop, are not judgements of absolute rightness or truth, but of honest recognition and beauty.

3.3.1 Ideals of behaviour brought from cybernetics and design (ethics). There are certain behavioural consequences of this way of working. These are seen in the environments in which designers practice. While designers may be almost paranoidly secretive about their ideas with outsiders, in a team they are remarkably open and generally willing to listen to comments and accept suggestions for improvements.

Consider the nature of the design conversation: for it to operate there has to be a listener (viewer). To listen requires an open mind and generosity. Without these, we cannot listen (as a creative act) and we do not participate. To design means to be able to see the possibilities not that we already have in mind, but that appear given to us by the other: to do this, we need an open mind (for a closed mind blinds us to (the value of) what the other says); and generosity (of heart) to welcome it as at least worth listening to, and potentially of more value to us than what we had thought of[38].

Together, with accepting responsibility (and acting responsibly) these are amongst those qualities we seem to hold as the most humanly and ethically desirable in ourselves. While we do admire, on occasion, the quality of ruthlessness, or we talk with either admiration or quiet resignation of competition, winning and the survival of the fittest (in which we profoundly misunderstand Darwin) and the lean, mean machine, it would nevertheless seem that we do admire people who are generous, open-minded and accept responsibility. Indeed, in today's world of approaching ecological disaster it is these qualities rather than those of selfish and self-centred competition that will save us, if we are to save ourselves. Design, in this account, is an way of acting that reflects and requires these more admired qualities; in contrast to that sort of problem solving which attempts to turn the world into an ever more efficient machine.

What does this offer us, from the side of design, for cybernetics? I have recently argued (Glanville, 2004b, 2005b) that cybernetics (at least, second order cybernetics) has ethical implications that exactly match those listed above: cybernetic systems work if we accept responsibility, and act generously, with an open mind[39].

This is hardly surprising, for the point of this paper has been to claim the central design act is an essentially second order cybernetic conversation: and it is the conversation in each that implies such decent qualities!

3.4 Epistemology

Design is, I have argued (Glanville, 2006a) the quintessential constructive activity. Designers, by definition, construct (new) realities. Epistemologically, this places design in a sensitive position. Clearly, there is an aspect to design (in how it has been discussed here) that is close to philosophical solipsism/idealism, as opposed to realism. But the position argued is not idealist. Constructivism proposes a philosophical position that accepts the essential undecidability of questions of the nature of the world when we posit that we are removed from (our experience of) such a world. In effect, it denies that we can remove ourselves from our own acts of observing, and thus it questions what we can know of a world from which the observer is excluded. It is not idealist, it is not realist, it asserts we cannot resolve the difference between these two polarities and must chose, therefore, either one or the other (as we wish, to suit our purposes and convenience, and not necessarily with any great consistency); or we may chose to "sit on the fence" and refuse to decide. In the extreme, some few will chose not to sit on the fence, but to make sure the fence is maintained and valued for what it is.

Designers work within a constructivist framework (Glanville, 2006b). This is clear in the literal sense that they construct (or, in the physical world, cause to be constructed) new artefacts, outcomes of the design process. The assumption of the desirability (and inevitability) of novelty in itself presupposed the notion of construction. But at a less literal level, designers also work within a similarly constructivist framework. To understand this we need to return to the primary act at the heart of designing, the conversation with the self.

A conversation is a mechanism to contain a constructivist act. No meanings are passed, rather, they are made by the participants. They are constructed, and the presence of the constructors is always acknowledged. Each participant makes his/her own understanding of what they believe their conversational partner means, and re-state them to that partner. Each compares their own understandings before and after conversational interchanges, to confirm adequate similarity in these personally held understandings. The conversation (as developed by Pask) is a basic second order cybernetic activity: the conversationalist is always involved, is always in the conversation, rather than, as a traditional observer would be, talking about it[40]. So conversation, as expressed in Pask's conversation theory, is both a quintessentially second order activity, and a constructivist one.

But it is also at the heart of design. If the heart of design can be understood as cybernetic and constructivist, design is, itself, a constructivist activity – in terms of its philosophical position.

The epistemology appropriate to the act of design is constructivist and the analysis is second order cybernetic. In fact, design is perhaps the most universal and widespread of all second order cybernetic activities. And it is one of the oldest: in terms of both human development (Piaget) and of the history of known, conscious human activities.

3.4.1 Knowledge of and knowledge for. There is one final epistemological aspect, which concerns the type of knowledge that both design and second order cybernetics work with and construct (Glanville, 2005a, 2007a).

The word Design, as we have discussed it, is intended as a verb; it is an activity, leading to an outcome which (in other contexts) is also called design – in this case used in the form of a noun. In this paper, I have generally tried to avoid the use of the word as a noun.

The sort of knowledge that science gives us, through the observer of the system, is knowledge of the system. This sort of knowledge helps us understand, in a very particular way, what is[41]. This is passive, neutral, leading to no action on and creating no change in the world – as good science should. An important aim in disengaging the observer is to leave the world neutral and untouched. The concern is to produce knowledge of the world, as we find it.

But the purpose of designers is to change the world. They are concerned with action on the world that is intended to change it – to create the new. They are not observers of the world, but observers in the world, and hence actors. Designers need knowledge for acting. And, in a sense, the process at the heart of design, generating those actions, can be said to generate this knowledge for acting on the world as we make it.

These – knowledge of and knowledge for – are very different sorts of knowledge, reflecting differences in understandings of knowledge (and intelligence) that stem back to at least Aristotle, which have been built on in recent studies by, for instance, Polyani (1967 – tacit knowledge) and Schön (1983 – reflective knowledge)[42].

There is a rarely questioned orthodoxy, that if we understand better, we can act better. This is taken as self-evident, yet seems untested and may be flawed. For instance, being able to predict the heat loss of a proposed building does not much help a designer. Unless the designer is very lucky, all (s)he learns is that (s)he has got it wrong. Knowledge of has traditionally been converted to knowledge for by means of a sort of transfer knowledge that is the special area of technology. Technology, consisting in large part of what we refer to as engineering, converts knowledge of into knowledge for.

However, designers look for a direct knowledge for. Often, knowledge of simply gets in the way. Second order cybernetics is the field that constructs knowledge for action in the sense that it is always concerned, not so much with knowledge, as with knowing, with knowledge that is generated by and concerned with action and the actor: with observer-involved knowledge for.

4. Conclusions

4.1 The interesting conjunction

In writing this paper I have had two intentions. The first has been to show that there is an interesting conjunction between the two subjects, cybernetics and design. To argue this point I have characterised the understanding I have of each field, and introduced a number of qualities which are central to each and can be seen to be similar. In this way, the sympathy and empathy of each subject to the other, and their mutual relevance, was introduced.

4.2 Conversational circularity: the analogy between cybernetics and design

The second intention was to demonstrate a strict analogy between cybernetics and design. In the case of cybernetics, circularity is present from the first attempts to characterise the subject of the Macy Conferences, and the general interest in that circularity in cybernetics, to the point where it is understood to be the key characteristic of the subject. We can go so far as to insist that cybernetics studies circular systems and their consequences, even taking this as a definition, should we want.

One such circular (cybernetic) system around which the argument was developed is Pask's conversation; and the workings of the Paskian conversation were explored in this paper.

In the case of design, the central act of designers is claimed to be a form of conversation that takes place largely with the self, via paper and pencil[43]. This central act is argued to be circular, and the workings of this circularity are explored – in part as a way of introducing novelty. (There are many other aspects to design, but they are taken to be secondary.)

Further, examples of circular systems are explored for their presence in design, and qualities of design are sought in cybernetics. The implications of these further parallels are explored in, for instance, understandings of ethical considerations.

The crucial analogy of this paper is drawn around the centrality to each subject of circularity, in the guise of a conversation (usually held with the self). The central analogy between cybernetics and design is argued to exist in circularity as embodied in a conversation.

Notes

1. Architects tend to believe they do not belong in the same category as designers. From my point of view (and even though I was educated as an architect and teach architecture), architects design like all other designers, and in this paper I use the verb design for the activity of all designers, including architects.
2. Systems theory and cybernetics are closely related. As François (2006) says: "Cybernetics is obviously the dynamic complement of systemmics."
3. The Oxford Conference in the mid-1950s derailed architectural education for some decades by imposing an inappropriate and clumsy pseudo scientism on the teaching of the subject.

4. See Mead's (1968) paper, Cybernetics of cybernetics.
5. It is difficult to appreciate just how revolutionary feedback, circularity, purpose and intention were in science in 1943.
6. Karl Mueller has recently published a study in which he shows that the developments von Foerster made in second order cybernetics amount to a radical and revolutionary research programme (Mueller, 2007).
7. For a critical exposition of von Glasersfeld's work, see the recent festschrift edited by Glanville and Riegler (2007).
8. I owe my dawning understanding of the importance and workings of actors to my long association with Gerard de Zeeuw. For a critical exposition of certain central themes in de Zeeuw's work, see the festschrift edited by myself (Glanville, 2002).
9. It is, indeed, stranger that even now, when there seems to be a reawakening of an interest amongst designers and artists in cybernetics, that they are still looking at the older version of cybernetics which is far less relevant to their concerns than second order cybernetics – as we will find out over the course of this paper.
10. There are other personal connections, two of whom participate in this volume. Paul Pangaro comes from drama and studied with Pask, sharing with Pask an appreciation of the importance of drama. He now teaches design. The architect Stephen Gage worked with Pask both as a student (I recently saw Pask's diary for 1967 – the year I met him – which was full of appointments with Gage) and later as a teacher and practitioner. He even contemplated studying with Pask for a PhD.
11. My original design education was in architecture (and musical composition), and I have taught design, mainly in architecture, all my professional life. When reading an overview of approaches to design, it is often important to keep in mind the design discipline that the author comes from. There are differences in, for instance, beliefs about optimum outcomes that vary from very ill-defined areas such as architecture, to more proscribed areas such as industrial design. This paper is no place to explore this, but it is mentioned in Krippendorff (2007), in this issue. Regardless of these differences, the activity of holding a conversation with oneself is central to all.
12. The earliest, and still arguably the best, definition of architecture was by the Roman architect and writer, Vitruvius, who called for "firmnesse, comodotie and delight" (in the translation by Sir Henry Wootton): in today's terms, being well-built, functional and delightful.
13. I have argued that Pask's study of conversation epitomises truly interactive systems (Glanville 1997b, 2005c). Interactive systems may include those systems in which the observer acts. I have also argued that those entities that persist through the action of self observing, which I call Objects, provide a form for inhabitants of a universe, the entry to which is through observation and being observed (Glanville, 1975).
14. This is the use made by the architect Inigo Jones in his annotations of Palladio's Five Books.
15. The difficulty of intentionality is specially associated with social sciences. While it is not difficult to consider systems made of so-called inert matter as intention-free, it is much harder to avoid intention when we examine animate systems, such as people. The "Hawthorne Effect" in which the subjects in a study change their expectations in line with changes in experimental conditions (what is considered an acceptable light level in a factory increases as the light level of a work place is increased) has been well known since the 1930s.
16. See Conway and Siegelman's (2004) biography of Wiener, *Dark Hero of the Information Age*.

17. The term "observe" is used in its scientific sense, rather than to more pictorial visual sense of the everyday.
18. It is not claimed that Objects exist in any physical sense, but that they can act as an explanation, a structure that permits.
19. A traditional view is that, to take part in a conversation, we need coded (and hence meaningful) communication. I argue the opposite. We can have no code that we share and interpret without a conversation, by which we can establish that we will set up a code. Thus, for me, conversation is the essential communicational mechanism.
20. This is also why it does not emerge, at lest in any historical sense of the word.
21. A reminder: the cybernetic notion of control is distinct from the popular notion. In popular use, control is often connected with restriction. Cybernetic control is enabling: it helps us towards some aim. Another way of saying this is that cybernetic control is concerned with effectiveness, as in Stafford Beer's definition of cybernetics as effective management.
22. Contrast this to drivers in, for instance, Egypt, who appear to be completely out of control but are actually very much in control: the control is, however, localised in each driver, rather than in a large system.
23. This is one way to increase creative potential. It is not the only way! (Glanville, 1994, 2000).
24. See the 1956 Oxford Conference on Architectural Education.
25. Pask calls such participants p-individuals: p is for psychological (and not, as many have suggested, Pask). In Pask's account, they are embodied in m-individuals (m is for mechanical).
26. Unless the tendency of language to make uniform flattens out difference. This is why repeating back the statement of the other cannot indicate an understanding, in a conversation, but only an ability to imitate sounds.
27. Keep in mind, however, that science is deductive whereas one intention of design is to be inductive, transcending deduction.
28. The concept of constancy, here, refers to maintaining an identity. It is a tricky concept and will not try to further elaborate here.
29. For references, see Section 2.1.2.4.1.
30. I am not yet certain, myself, whether the progress by which the autopoietic system generates itself in a manner similar to the progress of the design process.
31. The term "observe" is again used in the scientific, rather than the visual sense.
32. In a sense, purpose in a cybernetic system can be thought of as arising from the attempt to unite system and goal.
33. I refer to the power of, for instance, the lecture-as-theatre. Theatrical events (which, by definition, are performed events) have a presence and ability to both convince and involve the audience. The power of performance in the context of explaining second order cybernetics is that the observer (audience member) is no longer left only to appreciate, intellectually, the explanation, but is sucked into the experience of the explanation: they become part of a second order cybernetic system. The immediate effect is often of knowing something powerful has happened but not being sure what it was.
34. The concept of creativity being used here is associated with novelty. How the novel may be made is important. The position taken here may seem to those who believe in the romantic depiction of the troubled creative genius to be too easy, but will be recognised by others as close to the way many people recognised (by their peers) as creative account for the way their novel ideas come into being.

35. Contrarily, the outcome of this wandering (designing) activity often transcends what we could have imagined without wandering, in a manner that leads to improvements in "efficiency" while also promoting qualities such as delight.
36. Form, used in design, is strongly associated with shape. Although not completely divorced from mathematical and philosophical usage, it is the shapely quality that is generally referred to in this paper.
37. There are, however, some who believe that complexity science may be the theoretical arm of design.
38. I am using the conventional, realist short-hand, in this example.
39. These qualities are not the only ones I argue for, but are the most relevant here.
40. A fuller account of conversation theory would include a discussion of the concurrent levels of a conversation: the contextual level of the substrate, and the critical level of the meta-conversation, including an explanation of how the conversation can switch levels so that, for instance, it may ascend to the meta-conversational level. At that point, the meta-conversational level becomes the level of the conversation (we talk about how we talk about conversation, for instance), with a new (meta-)meta-level above this. And so on, recursively and in either direction. See Glanville (1997b), a summary of Pask's work (especially conversation theory), with extensive references to his work.
41. I am using the conventional, realist short-hand in this description.
42. There is a whole body of work on design knowledge. The work of the two cited scholars is often considered essential. This paper is not the place to explore design knowledge in detail.
43. Of course, nowadays paper and pencil are not always used. Here the phrase is used as a token for all media in which a sketching type of activity takes place. The change of media may, however, lead to significant changes in how we sketch and what outcome we may expect, possibly modifying the design act, in consequence.

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About the author

Ranulph Glanville studied a diploma in architecture at the Architectural Association School, London (working in the area of experimental electro-acoustic music), followed by cybernetics (his PhD, which tackles the question of what structure might sustain the belief that we all see differently yet believe we see the same thing, was examined by Heinz von Foerster, his supervisor was Gordon Pask) and then human learning (PhD, dealing with how we understand architectural space, examined by Gerard de Zeeuw, supervisor Laurie Thomas). He has published extensively in all four fields. He has taught in universities around the world. Although he took early retirement from a full time post in the UK he currently holds posts at UCL, London, UK, where he is a Professor of Architecture and Cybernetics, Sint Lucas Brussels and Gent, where he is Professor of Architectural Research, and Professor and senior visiting Research Fellow at the Royal Melbourne Institute of Technology University, Melbourne, Australia. He travels the world advising universities as a professor of odd jobs. He has consulted in a variety of areas from a mental health hospital to a bank and from universities to the creation of CAD systems for designers. He has approximately 300 publications to his name. In June 2006 he was awarded a DSc, recognising his research in cybernetics and design. He is married to the Dutch physiotherapist, Aartje Hulstein, and his son Severi works with digital media in Helsinki. His hobby is whichever of his interests he is not currently doing. He lives in Southsea, UK, and relaxes in the upper cabin of jumbo jets. Ranulph Glanville can be contacted at: ranulph@glanville.co.uk