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Designing Complexity

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Abstract

This article considers the nature of complexity and design, as well as relationships between the two, and suggests that design may have much potential as an approach to improving human performance in situations seen as complex. It is developed against two backgrounds. The first is a world view that derives from second order cybernetics and radical constructivism. What is particular about this view is that it accepts that our understanding of the world is made by us, regardless of whether it originates in an external reality or not. Indeed, it regards the question of whether an external reality can ever be known by us as essentially undecidable, which is part of its power. In terms of complexity, this leads to the position that we chose the complexity we see in the world. The second is design. Design is a way of behaving that approaches complexity in a different way (and expecting a different type of outcome) than we have conventionally used. Designers work in a way (a conversation with the self via the medium of drawing) that allows them to deal with very complex, ill-defined and ambiguous situations that would probably be inaccessible using conventional approaches. The outcomes of design are generally novel but can never be argued to be the best solution. Design is necessarily a constructivist, second order cybernetic activity. It is suggested that, as second order cybernetics and radical constructivism give us new insights into the nature of complexity, design gives us a way of acting that comprehends these insights.

Designing Complexity

Background and benefits

Why should anyone involved in HPT read an academic paper that discusses complexity and design, written from a position that will probably appear unfamiliar, contrary and difficult? The answer, which may help the reader in some of the more abstract sections of this article, lies in what designers do. Designers handle, on a daily basis, what will be shown to be incalculably complex (and ambiguously defined) problems, bringing them to simple resolution: designers typically make one object that satisfies a myriad of often contradictory and ill-defined requirements. This ability, to change how they see what is represented as complex into the simple, is almost magical. This article introduces this way of acting, against a theoretical background that explains both the nature of the complexity and the activity that designers perform, using the languages of design, (radical) constructivism and (second order) cybernetics, second order being the term used to indicate that a subject is reflected back on itself, for instance, the cybernetic study of cybernetics, and the understanding of understanding.

This article comes, then, from two backgrounds that may not be familiar to most readers of PIQ: radical constructivism/cybernetics, and design as a profession based ub the activity of design (design-as-verb), and field of study.

The first is a world view that accepts that our understanding of the world is constructed by us, regardless of whether or not it originates in an external reality. It regards the question of whether an external reality can ever be known by us as essentially undecidable. In terms of complexity, this leads to the position that we chose the complexity we see in the world.

The second, design, used in the sense of design professionals, is a way of behaving that approaches complexity in a different manner, and expects a different type of outcome, than we have conventionally used in problem solving. Designers work in a way, which I characterise as a conversation with the self via the medium of drawing. This allows them to deal with complex, ill-defined and ambiguous situations, probably inaccessible using conventional approaches. The outcomes of design are generally novel, but cannot be argued to be "best" solutions. Design is necessarily a constructivist, second order cybernetic activity.

Several outcomes of the argument are developed and presented in the section later in the article on Valuation. These may be surprising and even seem irrelevant or undesirable. I hope this will not be so and ask the reader to at least suspend disbelief. Amongst the outcomes are:

a) an ability to cope with undecidable problems and questions that are apparently complex, and often ill-defined and ambiguous..

b) an ability to act without imposing inappropriate order, for instance, when any order is not possible/practicable.

c) a release from looking for the correct and unique outcome.

d) an understanding that a problem may be defined by the solution rather than, as we have learned to assume, the solution being defined by the problem.

e) the criterion (by which to assess outcomes) of adequacy rather than perfection.

f) consequently, the notion of leaving room for continuous improvement.

g) the acceptance and welcoming of opportunity over certainty.

It may help the reader to consider the meaning to him/her of these outcomes, and keep them in mind when reading the argument, for, while the article was solicited to bring these approaches into, and to argue the outcomes in, PIQ's arena, the accounts of them given here are not well contextualised and not fully argued

Finally, before entering into the article proper, I will delineate the shape of the argument developed in the article.

The next section, Setting the scene, argues the notion that seeing a situation or object as complex is a choice that is ours to make. Ways of approaching complexity introduces design, constructivism and second order cybernetics, suggesting they are closely related, and leads to a section on Cybernetics and Complexity, which introduces a traditional (first order) approach to complexity while preparing the ground for a discussion of two papers, by Gerald Weinberg and W Ross Ashby. These, in turn, discuss complexity from a traditional cybernetic position. Both show us limits to the familiar, scientific ways of handling complexity.

At this point, the article shifts focus with sections on second order cybernetics and constructivism, arguing the theoretical support for an alternative approach in which the observer is understood to be central to what is observed. This places second order cybernetics and constructivism at the heart of the position that the complexity we observe is a choice. There follow the three sections which hold the keys to the argument, in which Design is introduced and characterised, particularly as a type of conversation with the self, and it is argued that through this conversation designers have a way of approaching complexity. How they do this is explained.

The final two sections concern the benefits of the designerly way of handling complexity and the appropriateness of different criteria of assessment (Valuation); and a Conclusion.

A number of examples are placed in the text in boxes. However, it is, in the main, left to the reader to translate the insights in the article into action in HPT. This is the readers rather than this author's area of expertise .

A number of the references quoted have been chosen because they can be found collected in one source, George Klir's (1991) book "Facets of Systems Science." This book contains an excellent collection of papers. It may not be easy to obtain, but at least it's only one item!

Setting the scene

There is an old question which concerns whether the complexity we observe is in

the system being observed, or is in how we look at that system—i.e., in the observing. One way of thinking about this tells us the question cannot be resolved: it is akin to the question of what (and whether) a mind independent reality might be without our presence as observers. Our presence destroys the mind independent aspect, and our absence leaves us unable to observe and thus judge anything except as an act of faith. It is, thus, undecidable,; that is, we are free to chose whichever resolution we prefer. The question cannot be resolved without some sort of theological or metaphysical assumptions that inform epistemological positions, such as the unlikelihood of co-incidence.

This position, which goes back at least to the greatest of the sceptics, Pyrrho of Ellis, reflects an insight we have insistently brushed under the carpet as science has progressed along its triumphal route. This position has perhaps only recently re-entered our consciousness, as the limits of science have become more insistently apparent and more honestly discussed—on occasion through the discussion of complexity. In many respects, such a discussion makes science stronger.

Just as we cannot, by definition, be certain about the status of any proposed reality that exists outside our sphere, and are therefore free to chose according to our needs and personal criteria whether or not to credit a mind independent reality, so it is, I believe, with complexity. Without the presence of an observer we cannot decide whether something we observe as being complex is, or is not complex in and of itself. We may infer, but such inference depends on a strong belief, to cite one key theme, that our descriptions do not either form or filter the experience that becomes our observations and our knowledge.

There is, however, a give away, which lies in the phrase “one way of thinking about this.” To state that there is an option is already to remove the oft mooted “observer independence” of what we choose to see, for choice is what we imply in saying “one way of looking,” and we make that choice.

In this article I take a position that until recently would have placed me beyond the pale.Nowadays, however, it is becoming more acceptable as we come to understand better the essential undecidability of the most basic positions we take. As we cease brushing the embarrassing arbitrariness of our decision under the carpet we come, instead, to recognise that it is precisely this undecidability, or choice, that gives ultimate value to human life. In turn, this meansthat, behind everything, we make choices and only we can be responsible for them. This is the type of fundamental choice that Viktor Frankl (2004) tells us, from his experience as a Jewish doctor in the Nazi concentration camps, is behind our human ability to survive in conditions that science determines are physically impossible. It is what keeps the characters of Samuel Beckett's extraordinary novels and plays so movingly human just as their faculties are, yet again, impossibly reduced.

The position I explore is that complexity lies not in what is observed, either as the system beyond/behind our observing, or in the act of observing itself, but in what we chose to do with the observations we make. That is, we chose to explore something as complex, and doing this expresses an intention. We have the choice.

As a simple (!) indication, consider the following: There is no problem in referring to the place London when saying I am thinking about London. In itself, London is, in my mind, an extremely simple concept that relates to an extremely simple object. It's just what I denote when I say "London." However, the moment I start investigating what I mean by this, I enquire what London is made up of and end up with something very complex. This complexity may or may not lie in the object I denote as London. There is no way of knowing this. But it certainly arises when I ask these questions, that is, as a result of my observing coupled with my intention. My intention leads me either to take other objects I know of and attach them to London, or to partition the whole (the London object), decomposing it into sub-objects (parts). Either way, I make the simple complex, that is, I can treat the simple concept denoted by "London" so that it becomes complex. Since the complexity may or may not be in the object, I have the choice of where I will locate it—in the object or in my observing. However, regardless of where it may originate, it is I who chose to appreciate London—as complex, or as simple.

I chose to locate the complexity in my observing. Why? Partly for the reasons given above, but also because it is simpler (!) this way (I follow Occam), and because in doing this I retain and recognise my inevitable responsibility for the choice I make.

Another reason that acts as an inspiration behind writing this article is that this is closely related to what designers do. Designers make wholes of parts; they chose to pursue the simple, and to make simple, in a manner to be explored later in this article. Designers master complexity, turning the complex into something simple. On the wall of the Design Museum in London you will find the following quote attributed to the Italian designer, Bruno Munari:

Progress means simplifying, not complicating

This is a restatement for the field of design of Occam's razor:

Essentia non sunt multiplicanda praeter necessitatem

Should a critic object that the world is made of parts that are agglomerated into wholes, as opposed to the view I have elected to take, then what designers do is to carry out this agglomeration through the act of design.

It does not require many parts before consequent possible outcomes become complex. Ashby and Wienberg, two scholars whose work will be presented below, suggest 5 (Ashby), or 10 (Wienberg) parts or variables are the limit of what humans can cope with at any one time. (The number accepted through psychology was first identified by Miller (1956) in his classic paper "The Magical Number Seven, Plus or Minus Two".) We need few variables to create almost incalculable interactive possibilities. We merely need a few parts that will interact, producing the sorts of combinatorials that lead us to impossibly large numbers. The converse of this is that handling complexity is, as Rosen (1977) points out, a matter of reduction, with all the "inaccuracies" that reduction involves.

Box A about but no later than here

Ways of approaching complexity

Recent studies in complexity often seem to be synonymous with the name of Stuart Kauffman and the Santa Fe Institute (founded in 1984). However, the subject has certainly been studied, as Prigogine (1985) reminds us, by many, since and probably preceding

Aristotle. The source of understanding or approach used in this article comes from cybernetics, or systems theory if you prefer, and is thus knowingly positioned outside the framework of the so-called complexity sciences. I chose to present this backcloth particularly because my main areas of research are cybernetics and design. This article is not intended as an attack, but as a different and distinct line of approach. Should complexity scientists insist what is presented here falls within their approach, I would reply that they have not understood it—even though some argue much of their work uses understandings developed in cybernetics (specially second order cybernetics, which will be introduced later), no matter that the cybernetics is somewhat misunderstood.

The reaminder of this article falls into two parts. In the first, two fairly traditional approaches to complexity, from cybernetics and systems theory, are explored. The first part ends with a contrasting analysis resulting from second order cybernetics (Foerster, 1979), often identified with Radical Constructivism (Glasersfeld, 1990).

This analysis thus provides a bridge to the second of these parts, in which the act of designing is treated as a way of handling complexity, integrating the parts referred to above into a whole, so that the whole becomes a simple embodiment of what was the complex of requirements, aspirations and aims. This section concludes with some reflections on the criteria by which we can judge our actions in the face of complexity.

Cybernetics (Systems Theory) and Complexity

From its earliest days, modern cybernetics has been involved with the complex. Of the two sources of modern cybernetics, both the Macy Group's mission statement, to study "…circular causal and feedback mechanisms in biological and social systems" (Pias, 2003) and Wiener's initial concern with predicting the behaviour of flying objects so that they might be shot down (as in Rosenblueth, Wiener, and Bigelow, 1943) confront the complex—and ways of treating the complex through interactions of the simple.

It is sensible, therefore, to consider treatments of complexity in cybernetics (systems theory), represented here through summaries of papers by Gerald Weinberg and W Ross Ashby. These papers present a view of complexity as a matter of scale as expressed through numerical combination, with Weinberg discussing the process of simplification and Ashby the limits of the computable,and hence of directly handleable complexity. The views they represent are complementary, the traditional view. Later in the article I will question this view.

Gerald Weinberg's "The Simplification of Science and the Science of Simplification"

> *Newton's genius was … his ability to simplify, idealize, and streamline the world so that it became, in some measure, tractable to the brains of perfectly ordinary men.* (Weinberg, 1972, p. 505).

We might attempt a proper definition of complexity reflecting the position we wish to take: for instance, complexity exists when a physical system has more than a handful of variables, as Weinberg shows with such clarity in his paper. However, it will be more helpful for us to consider, as Weinberg also does, how we might account for how complexity comes about.

Weinberg gives a clear example of how complexity is mastered by filtering our description of the world, while also pointing to the problem of complexity multiplication—the computing law of squares. His example is Newtonian mechanics, which he puts forward as the ideal of western science over the last 300 years. He explains how Newton managed to reduce and then simplify assumptions, arriving at a triumphal summary consisting of just one equation. As examples of Newton's simplifications Weinberg citesthe use of a point to represent a mass, and the model's base in our, peculiarly simple and aligned, solar system (the planets all rotate in the same plane). He remarks that if Newton had considered all the potential variables, for instance all the bodies that might impinge on our solar system, such a comets, dust clouds, asteroids and things further afield, he would have been dealing with maybe, to take an arbitrary big number, 100,000 bodies, and therefore about $10^{30,000}$ possible relationships which he would have needed to express in equations—clearly an unmanageable number of equations even for today's computers.

Newton actually dealt with a fraction this number—Weinberg suggests 10— leading to approximately 1,000 relationships. Even this number is too large for us to handle, so Newton introduced another, inspired simplification, that you need only consider 2-body arrangements, arrangements with, for instance, 3 bodies can be recomposed into 3, 2-body arrangements, each determined by the same basic equation, Newton's Law of Gravitation. As Weinberg reminds us, "We have assumed, as one always assumes in mechanics, that only certain kinds of interactions are important" (p. 503). But shortly after he remarks, "If we have a problem for which Newton's mechanics did not work, it would never make its way into the mechanics textbook" (p. 503).

Weinberg is showing us how the "ideal" of science is, in fact, a vast and brilliant collectively composed simplification. He shows us, as did many others around the time he wrote this paper, that science has dealt with such simple systems, but that there is neither need nor reason to limit it in this manner any more. The understanding of complexity, including the use of computers, will mean we can deal with matters involving more than 5 or 10 bodies and their possible relationships.

W Ross Ashby's "Introductory Remarks at Panel Discussion"

> *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.*
> (Ashby, 1964, p. 510)

Like Weinberg, Ashby looks to combinatorial mathematics to give an entrée to complexity. But his purpose is different. While Weinberg shows how Newton simplified his way of looking at the situation to produce his mechanics, Ashby is concerned with a different simplification, what we might call the fallacy of computation. He wants to warn us against a particular form of technological optimism: the belief that, as a result of the amazing increases in computing power, if we haven't the computing power to deal with a problem now, we will be able to deal with it soon. He comments that we talk of astronomical numbers without understanding what "astronomical" means, and examines such numbers.

His argument takes two paths. In one, he follows Hans J Bremermann, who (Ashby reports) calculated the computing capacity of matter: "Even if we take single atomic states as markers (i.e. 'digits') for computation, the known physical laws make it impossible for any computer made out of matter to process more than about 10^{47} bits per gram per second. Let such a computer be as big as the earth and go on for all geological time, it is physically incapable of processing more than about 10^{73} bits" (1964, p. 508) (These numbers are not to be taken literally and absolutely: they are intended to demonstrate a ball-park sense of scale.)

The other path is his own. He shows that the product of the number of atoms in the known universe and the life span of the universe since the earth solidified (in micro seconds) is less than 10^{100}. That is, the total number of atomic events that can have happened in our universe (surely an astronomical number) is around 10^{100}. Thus, he claims, *"Everything material stops at 10^{100}"* (1964, p. 508).

Ashby then discusses the number of states a simple device for displaying visual patterns might take. A matrix of 20 by 20 lights, and assuming that they are either on or off, can display 2^{400} (that is, 10^{120}) pictures. This is significantly larger than the total number of atomic events. Thus, even such a simple device as this light matrix will generate a significantly larger number of states than the truly astronomical number of atomic events in our universe, which defines where everything material stops.

Ashby indicated to us already in 1964 the ludicrousness of assuming that computing power is limitless. As a result, he states, *"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"* (p. 509).

Ashby offers two responses to his finding. Either to prove that the type of size 510calculations he is using are nonsensical (they are, of course, only intended to indicate a sense of scale), or *"If this view is right, systems theory must become based on methods of simplification, and will be founded, essentially, on the science of simplification"* (p. 510).

Whereas Weinberg showed simplification as, until recently, the only approach to the complexity of the universe, Ashby (whose paper precedes Weinberg's by 8 years!) shows us it takes very little to reach beyond the size of the material, and we still necessarily depend on simplification in all but the simplest of cases. Computers may help, but they are not the solution they are often presented as.

Second order cybernetics

Weinberg stresses the importance of the simplifications used in order to master complexity, lauding Newton's genius. But, most tellingly, he fails to point to the greatest assumption of all, that complexity exists in nature, in "the world out there," in a mind independent reality, rather than as a consequence of how we chose to investigate and understand, or build descriptions. While the assertion that "the general systems theorist understands … because it is his chosen task to understand the simplifying assumptions of a science—those assumptions which delimit its field of application and amplify its power of prediction" (Ashby, 1964, p.) is a generous one, it is (as Weinberg demonstrates in his own paper) hard to apply with consistency and rigour!

Ashby's world is similar. The greatest mechanist of cybernetics, his view is of a magnificent celestial machine, existing for us to try, with our inadequate resources, to understand.

It was an unspoken assumption of early modern cybernetics, in keeping with the science of that time, that the investigating scientist registered the actual—the stuff of reality—without impinging upon it. The act of observation did not affect what was observed. In the case of the "weaker" sciences, this was seen as a rarely achieved ideal. This assumption was so habitual and unquestioned that it became invisible. It is, in effect, the undecidablity of the question of the existence of a reality independent of us, as observers.

But this assumption was odd for a subject concerned with circularity, where the whole purpose of the controlling element is to change the behaviour of that which is controlled. It is easier to understand when we remember how we have hidden the question and its associated uncertainty as, and in, what is an unacknowledged belief.

Why is it an odd assumption? Because the assumptions it makes about the nature of the observer that observes the system, and the observer within the system, are different. The attitude to the observer is thus inconsistent, the inconsistency remaining unnoticed until pointed out by Margaret Mead (1968), a founding member of the Macy Group, in a paper entitled "The Cybernetics of Cybernetics."

The inconsistency was resolved through the development in the period 1968–1975 of second order cybernetics, which is the cybernetics of cybernetics, or cybernetic understandings applied in/to cybernetic study (Glanville, 2002b). If the concern of the subject is to examine what happens in systems in which the observer or controller is active, then we might expect that these systems would be examined by a similarly cybernetic observer. Thus, this new type of cybernetics arose, in which the observer of the system is understood to be part of the system under observation; the observer is in the system and **we are examining not the observed system, as in earlier modern cybernetics, but the system including the observer, that is, the observing system** (Foerster, 1974).

This second order cybernetic way of looking changes things. Within this framework we can no longer talk of the reality that exists independent of us, for our act of observing ties us into the system, making the observer(s), integral. Second order cybernetics, therefore, formalises the question of a mind independent reality. As suggested in Setting the scene, the question is explicitly held to be undecideable; we have no way of telling whether such a reality exists independently of us. This is how second order cybernetics is closely connected to Radical Constructivism. It is notable the figures commonly recognised as founding each (Foerster and Glasersfeld respectively) were close friends, each a welcome leader in the other's field.

Construction

Radical Constructivism is a term proposed by Glasersfeld (1987) to describe a form of constructivism that, returning to its roots, takes the question of the reality of a postulated mind independent reality seriously, like second order cybernetics. It neither brushes the question under the carpet nor hedges it by talking of observer limitations. Radical Constructivism is concerned with the sorts of questions Piaget (e.g., 1955), and others, asked about how we come to construct our understanding of the world, and what that understanding tells us.

What implications can we draw from this position, when we try to deal with complexity—which, Ashby tells us, is at the root of the cybernetician's/systems theorist's concern? This position does not deny there might be complexity in any mind independent reality that we may postulate, any more than it denies the possible existence of that mind independent reality itself. It insists that to say that a mind independent reality, and the complexity in it, exist is an interpretation, an assertion, a postulate, a belief subject to our choice and intention: which cannot, therefore, be indubitably demonstrated or proven. This point is critical. The assertion may be convenient, but it can only be taken as true, insofar as we chose to treat the convenient as true. In choosing to see something as constituted of complexity, it is we who chose that complexity—the interpretation that leads to us deciding complexity is present in our interpretation. In any system where we claim complexity, we contribute to the complexity we claim.

Why, then, do we chose the complex when we could chose the simple? Any answer is bound to be speculative, especially the answer I suggest, which is that we are accustomed to expecting the complex. It is a habit that is certainly associated with the success of science. The approach of science is to look at the world as complicated: complication comes from the method science uses (see the section on Wienberg, above). Science breaks wholes down into apparently "simple" and independent parts, which leads to complexity arising from this breaking down. We see those simple parts, and consider the complexity that results from our choice in seeing as inherent and natural, whereas it originates in our choice. Our belief in the authority of science overwhelms other ways of seeing.

But there are other approaches. Consider the insights of Buddhism, which teaches us to value the uniqueness (rather than the connectedness) of each moment, epitomised in the Zen story of the monk, chased over a cliff by a tiger and hanging onto a vine above waves breaking over rocks, who sees a wild strawberry and eats it: how delicious! Science gives us a quality in life by means of a type of control that promotes the material and minimises the recognition given experience. Other ways of valuing use different criteria, for instance,fully enjoying our experience, that lead to less concern for scientific control and the material.

I do not advocate giving up the benefits of science for a Zen strawberry. I do advocate that we realise that there is more than one way of looking at the world, and that we act on this. We have a choice. It is important to try to make a point clearly here. I claim that we contribute to the complexity we describe, and that we chose to understand the world or parts of the world as complex. Even speaking of parts of the world immediately begins to generate complexity. I do not talk of complexity in any mind independent reality that may or may not exist because I cannot access that world. So I do not deny the possibility of the existence of complexity independently of me—any more than I deny there may be an external reality: I merely deny the possibility of knowing about this, as opposed to believing in it. To repeat myself, the world may or may not be complex, but that is not my concern. My concern can only be with what I may know, or, more precisely, what I may understand about how I can understand my understandings. In that knowing I am always present. Nor am I saying that the choice is always easy to see: we may spend our lives trying to invent it. But difficulty in making a choice does not deny that there is a choice to be made.

Box B about here

Nevertheless, we do have a shorthand by which we, knowing that it is we who make the knowledge, form it in such a manner that we locate it in some object by treating it as a property of that object, or of that object's relationships with the objects we describe as its sub-parts. In our culture, we tend to behave as if this choice, and this description, were not a choice and description, but an actuality; we confuse the map with the territory (Korzybski, 1933). Our shorthand becomes entombed, an implicit epistemology.

I leave out the short but oh-so-significant phrase, "as if."

And I forget I have a choice in how I understand the experience I live in.

Design

Designers form one group of people who deal explicitly with complexity on a regular basis; handling complexity is what they specialise in. As remarked, design is a word often used, nowadays, in a manner that largely ignores how those who practise the original design disciplines act. In contrast, my use comes from design and my practise as a designer and design educator. Designers have handled complexity professionally for thousands of years. Because they are not scientists, and work in a manner generally considered at odds with scientific working, what they do is often dismissed or, at best, scarcely considered.

However, the world of complexity in which designers work may be more challenging than the areas in which complexity scientists work. This can be understood when we compare what designers do to how we consider complexity in the idealised view of science. What the complexity scientists chose to consider derives, in large part, from the combinatorial explosion that comes about when even a relatively small number of parts are allowed to relate and combine together. Discussion of this forms a large part of Ashby's cited paper. Finding viable parts, usually called variables, is a central activity in science, where complexity is understood to arise through the decomposition of wholes into parts which interact. Wienberg (cited earlier) shows us that the ideal model of science, mechanics, works because individual parts are isolated and there is no relationship between the parts. In science we spend a lot of time trying to establish this isolation. Complexity occurs when the parts are not isolated, and/or when the number of parts is relatively large.

Designers, as complexity scientists, deal with many parts, often deriving from functions or requirements, most of which are associated with very rich data. However, they face a different sort of problem which generates yet more complexity: a lack of clarity in many of these parts. In defining the functions or requirements to be satisfied, we can almost always introduce or omit a function or requirement. To add to these difficulties, two further aspects in how designers work make their taskcomplex. First, they are not looking to reproduce what is, but to create something new.

Second, they are usually dealing with the ill-defined.

Designers create, from a situation presented as complex, something simple: a unique, new whole, through the making of which they handle and reduce complexity. They may be thought of as making the hidden choice: initially seeing the situation in which they operate as complex, and acting to see it as simple.

Let us explore the two aspects of the complexity designers face. The first—creating the new, the anticipated novelty—is that it is precisely the identity of what will constitute the new which cannot be specified, although conditions surrounding it may be. If what the new is to be can be specified, the resulting outcome will not be new. To satisfy the novelty condition, the unique and novel identity of the outcome must be a surprise. That which constitutes the new in the design outcome may well appear to be—and can be described as if—the outcome of a logical process, but only after the event. In this respect, the novelty that designers look for is not unlike the endeavour in a PhD study, where the student is expected to make a novel and unique contribution to knowledge, becoming the world's only expert in this area and thus precluding any possibility of a supervisor who is already an expert in the precise area of study.

Box C about here

The second is the matter of definition. While some design problems are "easier" than others (a design task may seem clearly and simply defined), there is usually a difficulty defining what the problem is. Often, those creating the definition may have little or no experience in this activity, which may generate a conflict, when the definition explicitly requires one thing while actually intending another. Requirements may also be in conflict, and many cannot be clearly stated. Indeed, the expected novelty is part of this problem, for it cannot be defined (see above). Or there may be uncertainty concerning what the definition should comprise. Further, one reason for employing a designer is to benefit from his or her imagination, which often includes an ability to reconstruct/reframe the problem so that its character changes, often becoming "simpler."

In these respects, the circumstances in which design is practised are messy. That is another aspect of its complexity. The call of the Modern Movement in Architecture, that "Form Follows Function" (originally commanded in 1896 by the American inventor of the skyscraper, Louis Sullivan) was hopelessly optimistic. The definition of the requirements, that is, the statement of functions, is full of these difficulties. Form follows function led to approaches to design such as the Design Methods movement which have been largely abandoned today as being wildly unrealistic, based on a profoundly misinformed view. These approaches seem to mirror many in HPT—which, if the argument in this article is taken to hold, may give the HPT practitioner pause.

Put another way, design deals with situations we see as enormously complex, making them simple in their resolution—these situations may be so complex that it is inconceivable that, according to Ashby's argument, they may ever be dealt with by the central concept that Sullivan invokes in his functionalism: mechanism.

Design Facing Complexity

Earlier in this article, I claimed Design as the quintessentially radical constructivist activity; designers construct new worlds, and their actions are always intended to change the world, not to maintain it as it is. Elsewhere I have argued more fully that forms of radical constructivism are synonymous with second order cybernetics (Glanville, 2006). Not surprisingly, therefore, I also argue that design and second order cybernetics are closely connected (Glanville, 1n press b).

Given the particularities of the situation and conditions of enhanced complexity in which designers work, it is not surprising that they handle complexity in their own peculiar and yet successful way, distinct from the approach complexity scientists takes. To demonstrate what designers do and don't do, I shall first explore an attempt to make design more scientific that peaked around 1965–70, relating it to the two earlier papers introducing cybernetic views of complexity.

Sullivan's call for form to follow function implies design is a simple causal activity. Set up the variables, functions, parts, etc. clearly and the ideal and optimal form will result. Sullivan's call drove the aesthetic of the modern movement in architecture and design and the belief that, if the functions were properly set up, the resulting form would be unique, unambiguous and anideal fit to the functions in the sense that the requirements of each would be well satisfied. Thus, the outcome of the design process would be scientific and removed from the subjective. This aspiration was caught in such aphorisms as Le Corbusier's *"the house is a machine for living."*

The design methods movement that peaked around 1965–70 and which still holds sway in some areas attempted to realise this aspiration as a formal method. This approach scarcely considered that there might be possibly structural ambiguities and ill-defined requirements, that some functions might contradict others, or that there might be any uncertainty over what constituted a function, demonstrating how the adoption of a theory can cause us to fail to recognise important factors which may render that theory inappropriate or plain wrong. The approach also ran into the problem of complexity in Ashby's manner: the combinatorics might easily lead beyond the limits to the material. The approach needed, therefore, simplification, and the simplification in a sense undermined the definitional quality of the dictum. In effect the call became modified to form should follow function, but only in so far as we can simplify the function so that it's manageable.

Design as it is done

One of the problems with the position described above that follows from Sullivan's dictum is that it is not about how design is done (descriptive), but about how some people claim it should be done (prescriptive). By exploring aspects of how designers do design, we can expect to see how designers tackle complexity, rather than pursuing ideas about how they ought to do it.

Box D about here

The way in which designers design may be considered either as a sort of craft approach developed and stabilised by the activity of the unformed collective of designers over millennia, or as a way of thinking which humans practise and exist through and/or within (the position I hold). We will consider a process that almost all designers, and almost all studies of design, recognise as central to the activity of designing (Gedenryd, 1998).

Central to the process of design is the drawing, sketch, or doodle. These are often made without much purpose. The important thing about them is that the drawer, having drawn, looks at them, and then modifies or redraws. This simple, iterative, recursive, reflective and clearly cybernetic act is at the centre of the design process—it is the mechanism of the designer's magic. And, insofar as it involves the observer within a circular process, it is a second order cybernetic act. Furthermore, in so far as it is a way of making an understanding of a yet to be constructed object, it is constructivist, as well as concerned with construction.

The mechanism in this process, that allows the generation of the unforeseeable (the new), is its conversational nature. That is, each drawing iteration can be seen as analogous to a statement uttered and then, as it is viewed, listened to (Glanville, in press a). The process can be virtually instantaneous and continuous, but can also occur over long periods and with considerable time gaps. The drawer (utterer) and the viewer (listener) can be, and usually are, the same physical person. The switch in the role is enough to allow what was drawn to be understood by the viewer as different from what, if anything, the drawer had in mind when drawing. Thus, each iteration potentially gives rise to, in the person of the designer, a further understanding. The process does not depend on there being only one person fulfilling both roles. Others can, and, in practise, do join in; design frequently involves team work. It is likely the reader will recognise this activity for it does not belong only to those designated as designers, but also to many who are organising and presenting ideas, being generally creative. We use it in a limited way every time we revise something. For instance, writing this article involved me in several iterations, first in beginning to find something to write about, then in developing and finally refining the text, that have lead to an outcome that is substantially different to the first sketches—and my initial expectations. The inclusion of the editor and referees in the process has further expanded the conversational circle and contribution, leading to a single, final outcome.

It is through the shift in understanding, the reconsideration of the drawn marks made as the role changes, that the process acquires its power. From a meaningless and purposeless drawing a form can develop. This form can be refined and can also be rejected; the designer can go back to earlier stages, start again, or allow others in, in order to design a new form, or confirm one already made. Thus, this process allows the making of something from an initial, amorphous, ill-defined nothing.

This description is, of course, an idealisation, an over-generalisation, a simplification. The tabula rasa, the blank sheet of paper that it has been presented as being drawn on, and the purposelessness proposed as typical, are not absolute requirements and may never quite be how things are. The description above has been used precisely because it is a simplification and, at the same time, it allows an apparently wider range of freedom of action. There are normally restrictions and constraints, which sometimes are accepted as advantageous. Nevertheless, this process, even if it is hedged in, provides a way of generating something (a form) from nothing, by making a mindless mark. And that's magic!

What distinguishes designers from other creative groups is the applied nature of what they do. They satisfy external needs: the form that results from the design process is not arbitrary in the sense that it accommodates many functions. External needs are one source of the complexity facing designers, and how it matches the complexity scientists attempt to deal with, which is a more recognisable complexity. But the design processes also deal with complexity, arising out of vagueness, ambiguity and lack of definition.

The designer deals with complexity in parallel with, and through the same central process used to make form, adding in and incorporating the required functions. Thus the developing form gradually incorporates and meets more and more of the functional requirements, the form changing to accommodate them. Sometimes, further requirements cannot be accommodated, requiring either a change in brief (not always damaging and negative) or a radical change in the form—meaning that the designer goes back towards his/her roots, starting the conversational process again. This may happen several times, and is recognised in the design world in the three key concepts:

that the first idea is almost always wrong;

that the role of many ideas is to move you on and then be discarded;

and a major design skill is to be able to re-start.

This process involves improvisation rather than problem solving. By not pre-defining what in HPT terms might be thought of as the problem space—an action that in design is more-or-less impossible without (as has been argued) severe distortion, openness is left to allow new solution types and spaces, and the accommodation of many complex requirements, in a positive manner. It may be that a little of this openness might bring its own rewards in

HPT.

The conversational process is well equipped to deal with what might be thought of as a constant process of enrichment, a process of accretion that allows the designer to integrate more and more requirements within the form being developed. On occasion this process goes extraordinarily well and the designer finds that, somehow, everything fits almost as if pre-ordained, and that the design in progress and in process accommodates the previously unconsidered perfectly and without difficulty. When this happens, the designer may be said to be "on a roll" and there is an extraordinary feeling that everything will fit, without effort or difficulty—an approach to perfection.

One aspect of this that is rarely mentioned is the confidence that becomes so fortified when the designer is on a roll, allowing one to act in this manner—to design. This confidence allows the designer to believe that problems not dealt with yet will be successfully dealt with when they time is right. This has been referred to by Stephen Gage (personal communication) as style. This notion of style is completely detached from the notion of style/fashion, or even style as defining historical design periods, being more related to notions such as learning style. Designers develop a personal style that gives them confidence to believe they will be able to sort out the problems they are not concentrating on at a particular moment, later. From the skill that supports this belief stems the personal style that can be recognised in the processes and objects they design. However, this style is more personally fundamental, a sort of life-skill that humans develop so that they do not have to deal with all aspects of a complex situation at once. It's what allows designers to believe there will be a successful eventual outcome of their design conversations with themselves, even while they absorb more and more functional requirements into these design conversations.

Box E about, but no later than here

Valuation

We might study complexity because it is interesting in its own right, or because of the relationship between complexity and simplicity, or for any of another myriad reasons. But no matter why we study it, we may ask why it is a problem. **Complexity becomes a problem when we cannot handle it. In effect, this happens when we wish to do something with it, especially when we wish to act in a situation where we chose to understand that complexity reigns**. This occurs when we describe complexity as embodied in a problem, or in the context/environment in which a problem is to be handled. We have considered two approaches to handling complexity, the traditional and design, concentrating on and exemplifying design, implicitly contrasted to the traditional.

The processes of the traditional approach, culminating in complexity science, may be thought of through the notion that form follows function—originally a statement of an aesthetic in architectural design. This implies that we can aspire, by developing precise definitions of variables and their values, to combine them to the single, unique and perfect answer to some problem set that was indeed complex, leading to problem definitions of unimaginable, even astronomic, complexity. In terms of design, this method was presumed to lead to a unique and logical design outcome. But it has not succeeded, except when the problem has been definable in very restricted terms.

In contrast, design as practised provides a different approach, much more in keeping with the claim at the outset that complexity is a matter of the observer's choice. Rather than define variables at the outset, accepting many are essentially undefinable, it works incrementally and somewhat arbitrarily, accepting that "traditional" precision is neither appropriate nor possible.

There is a considerable difference in aspiration for the outcome in each approach. The traditional seeks the ideal, one and only possible and acceptable solution. The solution is seen as an automatic consequence of the problem. The problem thus defines the solution, which is often talked about through the intersection of problem spaces. Define the problem properly and the unique and correct solution will appear.

Thus, the traditional approach is associated with two notions: that the problem defines the solution, and that the aim is the perfect—a unique and correct outcome.

This is in line with traditional scientific thinking about the notion and working of the Laws of Nature, that, if well-defined, they will properly and adequately lead to all that is appropriate to their area of application, and that we can aim to know the objective truth about what is to be known (i.e., the mind independent reality, out there).

In contrast, what I have called the design approach cannot aspire to perfection or to unique correctness. This is exactly its strength. It does not try to impose an inappropriate order on areas of activity where such order is unachievable. Nor does it assume that the outcome, the solution, is defined by the problem; it can't be, since the problem can't be defined. In fact, it is the solution that defines the problem. This can often be seen when designers produce something that is unprecedented, but wonderful. We create the new not only in terms of the outcome, object, or process, but also in terms of the functions and combinations of functions. This was beautifully expressed in a Times obituary for the British architect, Dennys Lasdun, where Lasdun was said to have said, *"Our job is to give the client not what he wanted, but what he never knew he wanted till he saw it."*

In design, the criterion is adequacy, not perfection. **We aim for the good-enough, an aspiration that is perhaps both more human and more appropriate than the endless chasing of the perfect**, then bizarrely followed by attempts to improve on it. In design, we accept that the solution defines the problem and that we look for the good enough.

This is a way of understanding that depends on opportunity rather than certainty, openness rather than closedness, the infinite and undecideable rather than the finite and decided.

> There are other benefits to aiming for adequacy rather than perfection. Firstly, there is always room for improvement and improvement is to be expected, that is there is always room for further human action. Nothing is final, there is always a further chance—and we remain challenged. Secondly, **the approach emphasises our responsibility for our actions (including our observations), and our freedom to make those actions and observations** .
>
> Thirdly, it recognises and depends on very human qualities, such as choice, curiosity, challenge, individuality. Finally, it makes delight an acceptable criterion. It makes it

more than acceptable. It makes it essential.

By all these means, designers gain mastery over often inconceivable complexity.

Box F about but no later than here

Conclusion

Complexity is seen as a choice, insofar as we chose, as observers, to see what we observe as complex—or not. Complexity is not, thus, a property of things, or a fact in a mind independent reality, but exists in observations and the choices made by the observers that make these observations.

Designers have a way of working that allows them to handle complexity generated in both the combinatorics of variables familiar in complexity science and actually explicated in cybernetics some time before complexity science was brought into being, as well as complexity deriving from difficulties related to defining such variables, which may arise because the very concept “variable” is not appropriate. The process placed at the heart of design is circular, constructivist and described by the characterisations of second order cybernetics. I claim , in line with current thinking in constructivism and second order cybernetics, that complexity is an observer’s choice rather than given by a mind independent reality.

This position gives us a power to handle complexity quite different in quality to the power science offers us. Science offers us a way of breaking wholes into parts (itself an action that creates potential for complexity), and then of handling the complexity generated by the potential relationships of those parts by acts of simplification through filtering and omission. A constructivist, second order cybernetic position, offers us the opportunity to recognise complexity not as existing de facto in nature, but as arising from our way of looking, and, therefore, the possibility of reducing such complexity without necessarily simplifying, as is the way of science. One means it offers is design. What designers do is to bring a vast set of complex and usually ill-defined parts into a single, unique form—a whole. The way they do this denies the perfect outcome, replacing that with a notion of good enough. The result is to open up a world of imagination in which solutions proposed may define the problems to be solved in such a manner that radically different, unanticipated possibilities are considered.

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Box A.

We tend to talk of how we see the world as if it were determined by what we see, which we take to be driven from a real world we take to exist independently of us, somehow sending us messages through our senses (a mind independent reality).

However, what we see as for instance an organisation is precisely that: what we see as an organisation. The same holds for units of that organisation, for its processes and for human performance within that organisation. Seeing the pattern we recognise is something humans do; it is we who see this pattern.

Very often a new manager will completely re-cast an organisation, sometimes in such a way that it acquires a completely new purpose or identity. This indicates that the organisation is not a fixed entity that exists independent of us, but in our seeing of it, which we have control over ; in other words, we can chose how to understand it and what we understand will, thus, depend on just that: our understanding. An early management guru, Reg Revans, insisted that managers should always be brought in from outside the area of operation of a company, so that they were not trapped in the standard or agreed way of understanding. They thus had better chances of effectively re-casting the organisations they were to manage. HPT, in its interest in, for instance, Front End Analysis and other forms of tight prescription, may lead to this manner of trapping.

The same holds for the organisational devices we use, the tools. There is nothing sacred about for instance the organisational flow chart, an arbitrary but useful device allowing us to understand in a particular way. So the tools we invent, and then chose to use, determine how we will construct the organisation we look at.

Box D.

"Form Follows Function" might almost be a description of how we believe the world as described in science works. It implies an automatic outcome, and, insofar as it inspired the Design Methods movement of the mid 1950s to the late 1960s, provided the basis for the scientisation of design, indicating that design as done is messy and inadequate. Attempts to scientise design have failed in both what they attempt and the adequacy of the outcomes of their methods, suggesting that the attempt to scientise is inappropriate.

If this is so for design, it may also hold for other areas. As an example, I go so far as to argue that science is a form of design and not vice versa (Glanville, 1999).

One disadvantage of the mechanical process implicit in form follows function is it is only as good as the description on which it's based—the variables, their connections, their value ranges, even the notion that such a way of looking is helpful and appropriate. As they say: *garbage in, garbage out.*

Consider the structuralist approach to knowledge that depends on a notion of completeness resulting from the assumption of a taxonomy, where holes may be found and then filled. There is nothing to show either a particular taxonomy, or any taxonomy in general, relates to knowledge. Further, it assumes that somehow knowledge can exist independent of knowers and knowing. I would argue that human experience of knowledge, distinct from belief, is that it is not stable. What we know changes. Old truths become new lies. The use of knower centred approaches, such as Pask's conversational learning and representation of knowables (Pask, 1975; Pask, Kallikourdis, & Scott, 1975) allows what we know to change, insisting on the essential presence and contribution of the knower.

The moment you include the human knower, redefinition becomes not only possible, but likely, with results that lead to novel understandings that change how we see the possibilities within which we can act, generally to the good.

Box E.

Sketching, the central activity of designers, is not exclusive to design. Or, at least, something that works like sketching is not exclusive to design.

Sketching is very much a "suck it and see" activity—a "what if?" process. The "what if?" question gives it its currency and effectiveness. And it is also, and importantly, through the question "what if?" that it gains openness, including openness to redefinition of the situation in which we act.

Sketching allows us to try things out and to discard them according to criteria we take responsibility for. The process is recursive, so it can be repeated while we add more "what ifs?".

This approach can be used with resources as well as ideas; new combinations of the tools we have designed (see box in Setting the scene) can be composed or edited to produce courses of action that may move far from what a pre-determined system would allow, often giving an outcome better than traditional methods in which we might analyse, for instance, human performance based on a determined set of factors, prescribing change in terms of a predetermined goal.

One example is the "discovery" of float glass. Until the 1950s, making flat sheets of glass was difficult: sheet glass was imperfect, plate glass expensive. Pouring liquid glass onto a liquid instead of a solid bed allowed the highest quality of glass without the processes of grinding and polishing associated with plate glass. The "what ifs?" included "what if?" the bed is not solid, and "what if?" we do without grinding and polishing? The inspiration for this approach apparently came from watching oil float in a smooth layer on top of washing up water, before adding detergent.

Box B.

Heinz von Foerster gives a telling example. He observes that when some material is judged to be indecent or pornographic, it is we who make the judgment. Thus, the indecency is with us, and not in the material so judged. Pornography lies in the eye of the beholder, just as for a long time we have said “Beauty lies in the eye of the beholder.”

This notion is very powerful. For instance, if we apply it to the quality “intelligence” we find that intelligence is not a property of the individual, but is attributed by an observer to that individual as a result of his or her behaviour. (This is the position behind the so called Turing, 1950, Test of intelligence.) Taking this one step further, we will understand that the behaviour we consider happens between us and the individual in question. Thus, intelligence is not seen as a testable property of an individual, but a joint and shared quality that we recognise in the other but which originates in the response to or interaction between us. This allows us to consider intelligence in a different and perhaps much more creative manner, and it allows us to talk, as we do colloquially, of intelligence in animals and objects such as computers (see Glanville, 2001).

We can extend this understanding: it does not apply just to intelligence, but to all behavioural systems. But all we can use to judge others is our experience of their behaviour in response to us. This position is the second-order cybernetic one of the included observer.

We may lose some ease of measurement, but we gain a more sophisticated understanding. Consider, for instance, the design of a training program. The purpose is to create a change in trainee competence. As the trainees’ competence changes so their ability to act with the training program changes, as does their understanding of the material they are offered. What matters is the way the two, the trainee and the program, fit together, like a shoe and a foot, supporting and developing each other, and that is what we can meaningfully attempt measure, not the changing performance of the individuals.

“Indecency is in the eye of the beholder” turns out to be a very positive statement!

Box F.

The Dutch social scientist and theorist, Gerard de Zeeuw, makes interesting arguments about improvement in society.

One very important point he makes is that humans are given value by challenges. If we solve people's problems and fail to leave them with new ones, we take away from them something that is very important. Humans don't want to be free of challenges; they want to be free of tiresome problems. De Zeeuw consequently argues that it is our job, when improving social situations, not so much to solve the problem, but to design the next one. The point is to provide continuous improvement. The part of this which is radical is providing the continuous.

It is therefore undesirable, as well as often impossible, to solve problems for all time. Our experience of the failure of our attempts should teach us this, but we often turn a blind eye. De Zeeuw's position helps us not to turn the blind eye and so not to seek the perfect solution that history shows us evades us, and which is, when we look at characterisations of it (for instance, Thomas More's, 2001, Utopia), undesirable, but to accept that perfect solutions are often impossible and usually undesirable.

De Zeeuw's work is generally written in the manner of scenes from an ongoing movie, rather than backward looking position papers. This is consistent with his position of continuous improvement. The best source for a distillation of the sense of his work is not in his own publications, but in an article in a festschrift for him (see Glanville, 2002a).

The name of de Zeeuw's peculiarly Dutch special field is Andragology.

Box C.

The expression, "Thinking outside the box," tells us that we can easily get trapped within the frameworks we set up to define problem definitions and hence to generate mechanically derived solutions (the box of the inappropriate). Part of our difficulty lies in the no longer recognised assumptions or presuppositions we work with. These presuppositions often reflect choices made in the face of undecidable questions, where the option to chose has been forgotten and we become trapped in the consequences of the choice that was made and which we have acceded to—without us ever realising what we have done.

The assumption that we can properly define problems depends on our confidence that we have an absolutely unquestionable understanding that is structured in a completely clear-cut manner. If this is not so, and it is a very strong assertion, then any proposed course of action argued from this base is itself questionable. While, pragmatically, many such proposals may appear to work, the difficulty lies both with the ones that don't, and those courses of action that are excluded precisely by the way the field of action is set up.

An example of being caught in the box of the inappropriate can be found in the PhD Thesis of Graham Barnes (2002). Barnes explored the way that the psycho-therapy championed by Eric Berne and known as "Transactional Analysis" had stopped being a theory that was built on observations and had become, instead, a theory that formed and determined its observations, and hence its psychopathology, and again hence its therapy without any consideration as to whether the therapy worked. The therapy was demanded by the theory and hence must be right. The outcome was that schizophrenics were treated in a manner that is inconceivably unhuman, homosexuals were denied their homosexuality and hence their souls, and recovering alcoholics were sent out to kill themselves by drinking.

The Design act may not lead to certainties, but it does lead to an openness and a type of testing that is generally considered admirable. It seems unlikely that, if Berne had seen his theory building as designing the good enough rather than determining the perfect and true, his theories would have been blindly allowed to lead to such increase of human misery.

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