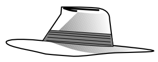
Appendix C

Some perspectives on complexity



Ray writes ...

In making sense of what is a burgeoning literature on complexity, I found it useful to formulate a typology of ways I experience the term complexity being used by different interest groups. I surprised myself somewhat by adopting this approach. In the past, I have been critical of the way typologies have been used. My negativity is triggered whenever I experience someone using a typology to argue 'this is how things are'. Another way of saying this is that they are reified: this happens when a concept is converted mentally into a real thing or fact. So, this typology is the product of my initial thoughts and later comments by a colleague, Pille Bunnell. However I take responsibility for the final version; you may or may not find it useful. In this typology I make an initial distinction in which there are four main groups. In some groups, I recognize other distinctions, which seem to me to be subsets of the major ones.

My main point is:

Complexity is a term that is contested by different interest groups. As yet we do not have the right language to speak about the range of concepts to which complexity is attributed. There appear to be, however, four main groupings:

1 Complexity is a property of something.
   - (a) Complexity refers to the condition of the universe, which is too rich and varied for us to understand in simple, common mechanistic or linear ways.
   - (b) Complex systems.
   - (c) Complex adaptive systems.
   - (d) Complex responsive processes.

2 Complexity is something we experience and thus what is complex will differ depending on who is experiencing – this is sometimes described as perceived complexity.

3 Complexity is an emerging discipline
   - (a) Complexity is a new science – or at least we are asked to accept that it is. Some claim this includes artificial intelligence, cognitive science, ecology, evolution, game theory, linguistics, social science, artificial life, computer science, economics, genetics, immunology, philosophy (e.g. LGMB, 1996, p.16; and Battram, 1998).
   - (b) Complexity theory (which among others includes organismic complexity, structural complexity, hierarchic complexity and dynamic complexity and so on).

4 Complexity, or complexity 'something' is used to describe a new way of thinking about the world (a trans-discipline, or meta-discipline) or a new paradigm.
   - (a) Complexity deals with the nature of emergence, innovation, learning and adaptation.

(b) Complexity is an organizing adjective and results in different metaphor clusters or is a source of analogy.

Because this is a course on managing complexity using a systems approach and not on complexity *per se*, I do not intend to explain all the terms and concepts in my typology and in this appendix. Also, my categories are not exclusive; for example, I suspect researchers developing complexity theory in relation to the management of organizations would reject the notion they were concerned with only metaphor (see below). My category 'complexity is something that is experienced' does not in itself preclude providing a scientific explanation for a phenomenon that is experienced. However this takes the discussion into deep epistemological water about doing science and distinctions between 'experiential science' (see Maturana and Varela, 1987) and 'discovery science' (see Schön, 1995). These matters are not my concern here.

The language of chaos and complexity has also entered the social sciences. The UK Economic and Social Research Council (ESRC), which funds research in the social sciences, commissioned in late 1998 a new research programme into complexity and dynamic processes. The appropriation of concepts from one field and incorporating them into another is common. 'Particular disciplines tend to adapt the new thinking to their own traditions, and then claim that their version is the pure one and that the others are merely metaphorical and unscientific uses of it' (Turner, 1997).

For the purposes of this document, it is sufficient for you to be aware of the broad distinctions I make in my typology. And be aware there is no great clarity in the way the term complexity is used, its meaning is contested by different interest groups some of whom are critical and some of whom are enthusiastic. As the course proceeds you will come across the term used in different ways that will be explained at the time. My interest here is with how complexity is being used as a term and how it is related to the concept of system.

The material that follows should be read as a type of annotated bibliography. It is intended as background and no more. It can be supplemented, for those interested, by other text sources or any one of the many websites that deal with this subject. My treatment here is by no means exhaustive in its coverage, nor would the interpretations given be agreed by all. My interpretations arise in two ways: first by my choice of material both in terms of source and then what to select and present from it; second in my interpretation of the subject matter. I have not included material already presented in the teaching text: for example, I do not include the category 'perceived complexity' here.

Applied chaos theory – Cambell

This perspective is drawn from Cambell (1993). Like many other authors, his conception of complexity 'involves non-linearity' and because there are no general solutions to such equations 'each case [presumably of complexity] must be treated on its merits' (p.1). It also involves chance. As with many others he recognizes there is no agreed definition of complexity but argues that 'operational definitions are helpful' (p.2). Within his framework, Cambell recognizes certain basic characteristics that must be considered:

1 Purpose and function;

2 Size and configuration;

3 Structure, including composition and makeup.

He recognizes three categories of complexity:

1 Static complexity;
2 Embedded complexity;
3 Dynamic complexity, which includes dynamic processes.

For total complexity to exist all three factors should coexist but not at all times. With many other authors, he often conflates complex situations with complex systems. It is also unclear how he is conceptualizing systems; for example in, 'complexity can occur in natural and man-made systems, as well as in social structures', or 'the system is neither completely deterministic or completely random ...' (p.3–4). His acknowledged stance is that 'it is helpful to speak of systems without having to elaborate on all the details' (p.41); which I do not find particularly illuminating or helpful. He then goes on to define a system as any collection of entities surrounded by a wall!

Cambell states, 'As a rule, complexity occurs in dynamical systems, namely systems whose internal microscopic or external macroscopic motion is affected by one or more forces' (p.19). He further states 'not all complex systems are self-organizing, but all self-organizing systems are complex' (p.20). Intriguingly his conception for the study of complexity is not one of holism versus reductionism, nor holism or reductionism, but rather reductionism in the context of holism. This is similar to the idea I presented earlier of the systematic being embedded in the systemic.

Structural information processing – Streufert and Swezey

In this version of complexity theory the researchers are primarily concerned with the processes that 'generate the content of managerial and organizational functioning' (Streufert and Swezey, 1986, p.x and p.2). Their concern is with 'structure, with managerial information processing, and with the processing of organizational input into output', and 'structural information-processing is the central topic of a variety of theories known collectively as complexity theories'. The field of inquiry and action spelt out by these authors concerns the information processing that occurs between input and output. In systems terms this would be labelled as the transformation process.

The Streufert and Swezey book forms part of a series in organizational and occupational psychology; the authors are both from university behavioural science departments in North America. This particular intellectual tradition had its origins in concerns about the cognitive styles individuals employ when they process information. It is based on the earlier work of Kelly (1955) who proposed a psychology of personal constructs as a guide for psychotherapy and client-therapist interaction; however, he did not link his work to complexity, which was coined by later workers. Kelly's work has subsequently influenced many fields of research and practice. Streufert and Swezey's work exemplifies the dominant paradigm based on the information processing metaphor for human cognition. Rosch (1992, pp.84–106) recognizes this as the mainstream view in cognitive psychology but there are other paradigms as well that challenge this view. No doubt, others would now contest the claim that this particular tradition is all that constitutes complexity theory.

Applications in sociology

Turner (1997) argues the new sciences of complexity have equipped sociologists with 'a set of very powerful intellectual tools or concepts to think with'. He divides these tools into six categories:

1 *A new use of cause and prediction*. The traditional mode of science, which assumes a close dependence between scientific proof and predictions based on this knowledge, may have to be abandoned. This is because there would seem to be inherently unpredictable situations in themselves, and not just by virtue of the limitations of the observer. Turner (p.xiv) argues that if we are spared the labour of trying to predict such situations we can devote our efforts to trying to understand them in different ways – because unpredictable does not mean unintelligible or unable to be known – and that in the process, freedom recovers its meaning as a word. This theme relating to freedom will be picked up in Block 3.

2 *A richer understanding of feedback and iteration*. In human affairs it is 'beginning to look as if history and tradition are far more powerful determinants of how a society is organized than the economic and political forces that nineteenth century social theory reduced to social laws.' Feedback and iteration are seen to give rise to the laws of science as emergent properties of a recursive process.

3 *A revolution in the idea of time*. The idea is 'time will not go away', it is irreducible and irreversible, it can only go in one direction, unlike movement in space. This is why history is so important, including our own. Our life is lived in an ever-unfolding present, which is a product of our history. The past and future are merely different ways of living in the present.

4 *An anthology of recognizable structures and shapes*. Examples range from fractals to 'Bucky balls', the recently discovered new icosahedron form of carbon named after the architect Buckminster Fuller. Fuller began building habitable domes in 1948 that had a structural integrity sustained by the overall network of tensile stresses in the building. Later, Stafford Beer (1994b), drew on the structure and properties of icosahedrons (20 faces + 12 vertices = 30 edges + 2) to design a collaborative process to formulate a system of interest among individuals who have different perspectives. He called this syntegration.

5 *The idea of the attractor as a way of dissolving old dualisms*. Turner expresses this as not being afraid of irrational numbers, such as pi, with their non-recurring decimals. He argues these stymied the attempts by Greek scholars to eliminate indefinite thinking that did not accord with their attempts at understanding order and harmony. Turner goes on to say 'the strange attractor ... the fractal form embedded in any non-linear feedback process, is the graphic and undeniable evidence of the life and freedom embodied in physical reality'. (This latter quote shows clearly that he is using fractal as a metaphor and not according to its defined meaning).

6 *The technique of (non-linear dynamic) modelling*. Instead of creating a hypothesis, testing it on the experimental and observational facts until a counter-example shows its flaw and then trying another, we can now create a facsimile of reality by successive tweakings of the variables and the connections among them. We can run this on the computer as long as we like, check that its behaviour continues to resemble that of

> the reality and then read off what those parameters are. This procedure reverses the top-down, theory-to-phenomena approach of classical science.

Turner, an Oxford graduate, is a professor of arts and humanities at the University of Texas at Dallas. The material I have drawn on comes from the foreword to a multi-authored volume, with contributors having backgrounds in physics, cognition, nursing, medicine, maths and computer science as well as sociology.

The chaoplexity perspective?

After writing his mammoth book *Out of Control*, which, it is claimed on the cover, 'shatters more paradigms per page than any other text this decade', Kevin Kelly (1994) lists some of the questions that remained with him after doing the research for his book. Several relate to complexity. He wrote:

> And what is 'complexity' anyway? I looked forward to the two 1992 science books identically titled *Complexity*, one by Mitch Waldrop and one by Roger Lewin, because I was hoping one or the other would provide me with a practical measurement of complexity. But both authors wrote books on the subject without hazarding a guess at a useable definition. How do we know one thing or process is more complex than another? Is a cucumber more complex than a Cadillac? Is a meadow more complex than a mammal brain? Is a zebra more complex than a national economy? I am aware of three or four mathematical definitions for complexity, none of them broadly useful in answering the type of questions I have just asked. We are so ignorant of complexity that we haven't yet asked the right question about what it is.

I might ask whether Kelly himself is asking the right questions. However, as with John Horgan (1996), there are a range of commentators and scientists who adopt this perspective. Horgan's perspective is summed up in the concluding lines of his chapter on this subject:

> So far, chaoplexologists have created some potent metaphors: the butterfly effect, fractals, artificial life, the edge of chaos, self-organized criticality. But they have not told us anything about the world that is both concrete and truly surprising, either in a negative or a positive sense. They have slightly extended the borders of knowledge in certain areas and they have delineated the boundaries of knowledge elsewhere ... Computer simulations represent a kind of meta-reality within which we can play with and even – to a limited degree – test scientific theories, but they are not reality itself (although many aficionados have lost sight of that distinction).

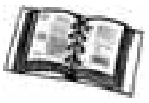
Relativism and subjectivity

John Horgan (1996), in his chapter on chaoplexity, appears to arrive at the conclusion that 'complexity can mean anything you want it to', or is 'in the eye of the beholder'.

This appears to be problematic for him. I experience Horgan as wanting to nail things down with precise definitions, and in the act of doing this, revealing his wish to see complexity as a property that all could agree exists in a given situation, machine and so on. Because of this, I experience him, and many others, as wanting to hold on to a particular scientific explanation of complexity and to avoid the stigma of being labelled as relativist or subjective at all costs. (Relativism is the label given to a theory not relying on a criterion of truth independent and outside of itself. Subjective often means knowledge particular to the individual; it is contrasted with so-called objective knowledge.) This is an epistemological debate to which systems thinking provides some alternatives as will be demonstrated as the course progresses.

From my perspective those who wish only to have a scientific explanation of complexity, in the manner of Horgan, deny the unique cognitive histories we each have as human beings. None of us share a common experiential world, all we have at our disposal is our ability to communicate about our worlds of experience and, sometimes, a history of living in a common culture over a period of time. The common culture allows us to appreciate the apparent paradox between our individual and unique cognitive histories and our experience that collectively we do not experience the world in relativistic or subjective ways.

A hierarchy of complexity



T551

Kenneth Boulding (1956), one of the founders of General Systems Theory, proposed a typology of complexity based on the concept of hierarchy. Francois (1997) says any classification, like Boulding's, can be questioned but after nearly 40 years it has not been contradicted by any subsequent experimental or theoretical development. The levels he recognized are shown with examples in Table C1.

Checkland (1993) points out this schema is not based on empirical evidence, so as with any schema all we can ask is: Is it convincing and does it help? He claims it is a source of insight because it provides a way of appreciating the history of management science as a discipline, therefore it is of help. Checkland considers Taylorist (or Fordist), scientific management in engineering workshops as examples of level 2 systems; the development of cybernetics with its focus on feedback and control emphasized level 3, and the attempts in the 1970s and 1980s to bring in behavioural science to treat management problems were aimed at levels 7 and 8. Together they span much of the history of management science.

Perhaps more important in this context is Checkland's observations in response to the question: 'Is it convincing?' He says yes it is, but is concerned at the unanimity regarding the ranking in the hierarchy and says: 'we still have no definition of the nature of the scale of system complexity ... hence we still cannot argue intelligently about the relative size of the gaps between levels ... we have no adequate account of systemic complexity.' Some may argue it is this gap the new sciences of complexity are attempting to fill.

Table C1 An informal intuitive hierarchy of complexity

Level	Characteristics	Examples (concrete or abstract)	Relevant disciplines
structures, frameworks	static	crystal structures, bridges	description, verbal or pictorial, in any discipline
clock-works	predetermined motion (may exhibit equilibrium)	clocks, machines, the solar system	physics, classical natural sciences
control mechanisms	closed-loop control	thermostats, homeostasis mechanisms in organisms	control theory, cybernetics
lower organisms	organized whole with functional parts, 'blue-printed' growth, reproduction	plants	botany
animals	a brain to guide total behaviour, ability to learn	birds and beasts	zoology
man	self-consciousness	knowledge of knowledge	symbolic language
socio-cultural systems	roles, communication, transmission of values	families, the boy scouts, drinking clubs, nations	history, sociology, anthropology, behavioural science
transcendental systems	inescapable unknowables	the idea of God	?

(Checkland 1993, following Boulding 1956)

Complexity as heterogeneity

Godfrey-Smith (1996), concerned with cognition and the place of mind in nature understands complexity as heterogeneity.

> Complexity is changeability, variability. Something is simple when it is all the same. In this sense, complexity is not the same thing as order, and is in fact opposed to order. Heterogeneity is disorder in the sense of uncertainty ... If complexity is understood as heterogeneity or variability, then both an organism and an environment can be said to be complex or simple in the same sense. An environment with a large number of states that come and go over time is a complex environment.

This has implications for systems thinking because it raises the valid perspective that different forms of complexity can be associated with a system and its environment. Remember that specifying a system is shorthand for specifying a system in an environment.

Because Godfrey-Smith is concerned with organisms and mind, he conceptualizes these as systems and goes on to distinguish between internal – within the organism as system – and external – in the environment – complexity. From his perspective, there are many different types of heterogeneity and there is no single measure of complexity. It is not clear to me whether heterogeneity is similar in conception to the variety of Ashby (see below).

Godfrey-Smith also distinguishes between first-order and higher order properties of complexity using the following example.

> Consider two different types of behaviourally variable organism. One is smart in the sense that it can track the state of the world and react to changes in its environment with appropriate behavioural adjustments. But the set of rules or conditionals – if the world is in S1, then do B1 – which determine which behaviour is produced in each situation, is fixed. This organism is behaviourally complex when compared to an organism which does the same thing in every situation, which performs the same action come what may. The organism which adjusts its behaviour to circumstances, but does so in a rigidly, pre-programmed way, has a first-order property of complexity in its behaviour. Such an organism is inflexible in contrast to an organism which is able to modify its behavioural profile in the light of experience, an organism which modifies what behaviour it is that is produced in the presence of a given environmental condition.
>
> The second type of organism is able to change the set of conditionals [elsewhere these might be described as goals] that determine what it does in a given situation. This is learning: the learning organism can learn that it is not good to produce B1 when the world is in S1, and better to produce B2 instead. This is a second-order property of complexity. There is also third-order plasticity, the ability to change the learning rules which are used to determine the list of conditionals ... and so on. [Those familiar with the work of Donald Schön may recognize these categories as single, double and triple loop learning.]

While the language is that of cognitive biology, it is relevant to my conception of the ideal systems practitioner, and a number of the first, second and third order distinctions will recur throughout the T306 course. In this sense I am concerned with what Godfrey-Smith describes as functional complexity – the range of possible behaviours our cognitive capacities will allow. As with this author, my interest is in being able to do lots of different things in different conditions, to expand our behavioural repertoire. For me difference, or diversity, is associated with creativity and our evolutionary possibilities, both in our day-to-day engagements, much as a pair of dancers improvising together, and over the long term in our living together (amongst whom I include other species).

Godfrey Smith distinguishes functional complexity, described above, from structural complexity, which he describes as what the system is made up of, e.g. how many different parts there are and how these are connected and interact. This aspect of complexity is also relevant to a systems practitioner. Finally, it is worth noting that the author adopts a realist stance to complexity by arguing ‘complexity properties are real features of environments that exist independently of organisms’, and ‘if an organism is to construct or transform the complexity in its environment it must do this by physical intervention in it’.

Complexity as variety

Variety is considered to be the condition for complexity by Francois (1997). This 'variety' is the word used by Ross Ashby in formulating his law of requisite variety, often phrased as 'only variety can destroy [absorb] variety' (Ashby, 1956, p.207).

Ashby's law, while general, establishes in a mathematical form that a system's regulation is efficient only if it relies on a control system as complex as the system itself. Control systems must have a variety equivalent to the variety of the system itself. Within this framework complexity is the property of a system of being able to adopt a large number of states or behaviours (Espejo et al, 1996). This leads, in the field of management cybernetics, to the notion of variety engineering.

Kelly (1994, p.590) observes 'there seems to be a "requisite variety" – a minimum complexity or diversity of parts – for such processes as self-organization, evolution, learning and life'. But he is concerned to know 'what is variety?' and 'when enough variety is enough?' He suggests there is not a good measure for variety. Given the existence of management cybernetics, it is somewhat surprising these questions remain with him. Complexity as variety is a topic that will be taken up again in Block 3.

Taking analogies from complexity science and applying them to in organizations

This is an evolving field as typified by the work of Ralph Stacey and colleagues. In his early work on the subject Stacey's perspective on complexity is claimed to be building on the study of non-linear feedback networks or complex adaptive systems. This is also described as the science of complexity by Ralph Stacey (1996).

Stacey saw the science of complexity as providing a 'new frame of reference' to break out of the trap of thinking of successful organizations as 'systems tending to states of stable equilibrium adaptation to their market, societal, and political environments'. They are 'disturbed from such states, or from a consistent journey to such a state, by disturbances in the environment' (Stacey, n.d.). Within this [old] framework, continuing success is seen as identifying changes as soon as possible and aligning the organization to fit them by taking control action. This argument resonates with the early work of Donald Schön in his book *Beyond the Stable State* (1971).

Stacey (n.d.) regards a complex adaptive system as a system that:

- Consists of a large number of agents interrelated in a non-linear way; in a way the action of one agent can provoke more than one response from other agents.
- Interacts with other complex adaptive systems and together they constitute the environment to which each must respond.
- Acquires information about the systems constituting its environment and information about the consequences of its own interaction with those systems, meaning complex adaptive systems employ feedback.
- Identifies regularities in the feedback information it acquires and condenses those regularities into a schema or model, in effect selecting one of a number of competing models that might explain the regularities.

- Acts in relation to the systems that are its environment on the basis of the schema it has developed.
- Observes the responses its actions provoke, as well as the consequences of those responses and uses the information to revise its schema, meaning it employs feedback to learn or adapt; this is rather complex as it involves adjusting both the behaviour and the schema driving the behaviour.

An important notion is that system and environment co-evolve; it is not a case of a system adapting to its environment. This has implications for practice, which are taken up in the course text.

In subsequent work (e.g. Stacey, Griffin and Shaw 2000), characterized by a lack of scholarly engagement with the systems literature, Stacey and colleagues, change the emphasis of their concerns to what they call 'complex responsive processes'. They do so in part as a reaction to many complexity theorists talking of 'complex systems as objective realities that scientists can stand outside of and model' (p.ix). They prefer instead to define a 'participative perspective', something which is also a concern of authors in this course (e.g. Block 4).

Increasingly many management and leadership trainers and practitioners argue for a perspective informed by 'complexity science'. An example is a series of articles published in the British Medical Journal in relation to managing and leading in the UK National Health Service (NHS) (Plsek and Wilson, 2001; Fraser and Greenhalgh, 2001; Wilson and Holt, 2001; Plsek and Greenhalgh, 2001). The main argument they make is that most thinking in organizations is still conditioned by an understanding of organizations as machines, which 'lets us down badly when no part of the equation is constant, independent or predictable' (Plsek and Greenhalgh, 2001, p. 625). They argue that new metaphors from the science of complex adaptive systems can help deal with issues in situations like the NHS. Chapman (2002) draws on this material to explore why governments must learn to think differently to avoid 'system failure', particularly in processes of public sector reform. What most of these authors do not develop is a notion of what skills are needed to use these metaphors in purposeful action for managing change. T306 is designed to help you develop these skills.

Chaos theory and strange attractors

Weather systems are regarded as chaotic systems. They behave in a non-linear way because weather patterns that emerge are highly sensitive to initial starting conditions. This is popularly known as the butterfly effect, a description coined by the meteorologist Edward Lorenze. The description is 'a means to convey the extreme sensitivity of the systems that emerge; the idea that a butterfly flapping its wings over the Amazon could lead to a hurricane on the other side of the world.' However, not all non-linear behaviour results from sensitivity to initial starting conditions, nor does such sensitivity always lead to non-linear behaviour.

Chaos theory, fully described by Gleick (1987), was taken up avidly by the media and management consultants and academics in the 1980s. It is a widely held view that 'it was disappointing' in its results (LGMB, 1996; and Battram, 1998). It is now considered by some as a subset of complexity theory.

In its *Complexicon*, a lexicon of complexity prepared for managers, the Local Government Management Board (LGMB, 1996; Battram, 1998), describes three sorts of 'attractor' associated with complexity and chaos theory. These are point, closed loop and strange attractors.

The term 'attractor' has been used – mainly for physical phenomena such as water flow, or a pendulum – to describe things in motion being pulled toward a definitive point or region during its cycles or periods. It is as if certain things in motion (I would prefer not to call them systems) have no degrees of freedom in their choice of movement. The position a pendulum swings back to when it comes to 'rest' is described as a point attractor. Electrical circuits and economic cycles are considered to oscillate and demonstrate periodic fluctuation (i.e. the cage in which the phenomena occur is slightly larger). The point these return to is called a closed loop attractor. The pattern that results from a non-linear chaotic system is characterized by a line infinitely long, never repeating itself, never crossing itself, never following the same path but drawn in limited space and continuing indefinitely. The pattern that results is called a strange attractor (Meri, 1995).

Meri, (1995) recognizes four types of human behaviour that he relates to understandings from chaos theory and the different forms of attractors:

- Repeating former behaviour in the same way, e.g. industrial repetitive tasks;
- Varying behaviour slightly and predictably, e.g. a man shaving his face;
- Adapting new behaviours that intermix linearity and non-linearity, e.g. immigrating to a new country;
- Chaotic behaviour leading to a new, more complex mode, e.g. social chaos as in Russia in the 1990s.

Personally, I find it difficult to think of how I might embody these concepts in my systems practice, or what might be gained from doing so. On the other hand, I do experience them as powerful explanations of certain phenomena.