Complexity Science: A 'Grey' Science for the 'Stuff in Between'

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ABSTRACT: *This paper explores the implications of the incompressibility of complex systems for the analysis and modelling of such systems. In particular, a provisional epistemology will be developed that attempts to remain faithful to the limitations derived from this aspect of complexity science. We will argue that such an investigation of complex systems highlights the relevance of paradigmatic pluralism or eclecticism, analytical creativity and boundary critique, and therefore has some affinity to sceptical postmodernism. Complexity science, like postmodernism, provides a clear warning as to the dangers of uncritically adopting any 'black and white' theoretical position. It encourages the deferral of paradigm selection and a healthy scepticism.*

Keywords: Complexity science, critical pluralism, postmodernism, epistemology

INTRODUCTION

It is becoming rather monotonous to continually read organisational related articles that tell us how the concept of (and the requirements for) the modern organisation is (are) changing, how it is more complex than ever, and how a paradigm shift is necessary in order to facilitate our continued analysis, and management, of such entities. We are told that we must distribute decision-making, encourage individual autonomy, and strive to innovate in the rapidly changing environment that characterises the apparent New World Order. The list is as far-reaching as it is impressive. These concepts coincide with a new, or at least emerging, description of organisations. This 'paradigm' appears, from particular presentations at least, to wholly reject the long held prevailing paradigm of the mechanistic, efficiency-driven, hierarchical, command and control organisation. (We would question the 'whollyness' of this position.)

Complexity science has emerged from the field of possible candidates as a prime contender for the top spot in the next era of management science. The number of management trade books on the subject has exploded with provocative titles such as *Leading at the Edge of Chaos* (Conner, 1998), *ReWiring the Corporate Brain* (Zohar, 1997), or *Adaptive Enterprise* (Haeckel, 1999) to name but a few. The majority of these writings seem to claim that the 'old' thinking is dead and needs to be (wholly) replaced with 'new' thinking, and that a new, all-embracing perspective, sometimes referred to as 'complexity thinking', is available that will solve all our apparent woes. Of course, much of this is the hype that accompanies any 'New Science', and we should know by now that the inevitable disappointment is also not far away.

AIMS OF PAPER

Despite the promise indicated by various authors within the field, complexity science has thus far failed to deliver tangible tools that might be utilised in the examination of complex systems. In an attempt to derive some *actionable knowledge* (Argyris, 1992) from the field the aim of this paper is to: (1) briefly familiarise the reader with the more popular aspects of complexity science, and then, (2) by focussing on the issue of incompressibility, provide a provisional outline epistemology that attempts to incorporate the lessons derived from computer-based observations of complex systems' behaviour and mathematical analysis of simple non-linear systems. It is difficult to provide a complete presentation within such a limited format and for the interested reader a much extended version of this paper is available (Richardson *et al*., 2000a,b).

THE THEORY OF COMPLEXITY SCIENCE

What is a Complex System?

The general message from the popular complexity science literature seems to be that, where we once focussed on the parts of a system and how they functioned, we must now focus on the interactions between these parts, and how these relationships determine the identity not only of the parts, but of the whole system. Of course, as everything is connected to everything else the notion of a distinct system as an entity becomes very blurred – where are the boundaries?

A complex (adaptive) system can be simply described as a system comprised of a large number of entities that display a high level of interactivity. The nature of this interactivity is mostly non-linear and contains manifest feedback loops. It is interesting to note that a result of this is that sometimes it can be very difficult to associate effect with cause – is the concept of the 'learning organisation', so popular in current management streams, oxymoronic? At the single-loop level at least there is cause for concern. Non-linear interconnectivity also places fundamental limitations on our abilities to validate models of complex systems.

There are a number of basic observations that have been made through the examination of such systems, primarily, through the use of computer simulation and the mathematics of non-linearity. The following sections will discuss the nature and implication of these observations in turn. For a more complete list refer to Cilliers, 1998.

(a) ***System memory/history*** (Cilliers, 1998, p.4) - *A complex system has memory/history captured at both the micro- (e.g. personal experiences, personal opinions, worldview) and macro-scopic (e.g. culture, ritual, value system) levels.* Therefore system history plays an important role in defining the state of the system as well as affecting system evolution.
(b) ***A diversity of behaviours*** (Allen, 1997) - *A rich diversity of qualitatively different operating regimes exist that the system might adopt*. This is a result of the non-linear nature of the relationships that describe the interactivity between the different system constituents.
(c) ***Chaos and self-organisation*** (Auyang, 1999) - *The system evolution is potentially incredibly sensitive to small disturbances (a phenomena popularly referred to as deterministic chaos) as well as being potentially incredibly insensitive to large disturbances (as a result of self-organisation or, alternatively, anti-chaos).* All possibilities in between also exist. Complex systems are often quite robust.
(d) ***The incompressibility of complex systems*** (Cilliers, 1998, p.4) - Complex systems are incompressible, i.e. it is impossible to have an account of a complex system that is less complex than the system itself without losing some of its aspects. Incompressibility is probably the single most important aspect of complex systems when considering the development of any analytical methodology, or epistemology, for coping with such systems. The following section will explore the ramifications of incompressibility in greater detail.

The Incompressibility of Complex Systems

As mentioned above, in a complex system everything is connected to everything else, whether directly or indirectly. The concept of 'boundary' is also problematic. Just because an obvious physical boundary is judged to exist doesn't mean that it should be immediately assumed that this is the correct boundary for analysis. And, just because particular boundary judgements were used in the past doesn't mean that they are appropriate again, even if the two situations appear to be the same. In fact, it is asserted that the boundaries analysts infer around a system are more a feature of our need for a bounded description rather than a feature of the system itself (Cilliers, 1998 p.4). Boundaries are often drawn where we want them, and this my not be the best for the job at hand. At a fundamental level, boundaries are inferred in order to allow us to begin to make sense of our surroundings. Hard enduring boundaries do not exist in nature; all perceived boundaries are transient given a sufficiently broad time frame. This does not mean that making the assumption that such boundaries exist is an unacceptable approximation in a wide variety of situations. An important aspect of analysis, which is beyond the scope of the current discussion, is how both implicit and explicit assumptions create, or force, the boundary for analysis. For now we will limit our discussion to the paradox of incompressibility versus our need for boundaries, or compressibility.

As already stated complex systems are *incompressible*. What this means is that if a model of a complex system was to be constructed that captured all the possible behaviours contained (both current and subsequent) by the system being represented then that model must be *at least as complex* as the system of interest. The reason for this is that there will always be something outside of the boundary (that is, the boundary inferred by the model) that would affect the system's behaviour in some way at some time.

Let us adopt a sceptical stance for a moment: because complex systems are sensitive to small changes, or, small errors in our assumptions, i.e. a small misplacement of the model boundaries, the model might be wholly inappropriate for the decision that it supposedly supports. The "something is better than nothing" phrase would

therefore be a wholly misleading guideline to bandy around the (operational) analytical community. ("Take nothing for granted" is possibly more suitable.) To model a complex system accurately, we would have to model life, the universe and everything. As analysts, we would have to take the first proposition of Wittgenstein's *Tractatus*, "The world is all that is the case," (Wittgenstein, 1921) completely literally. Acknowledging that there is only one complex system is useful since it forces the analyst to recognise the narrow scope and provisionality of their representations. Given that no hard enduring boundaries exist in reality, the use of the term "system" can be misleading as it suggests the existence of *completely* autonomous entities. Maybe we should rename complexity science as the 'science of partial complex systems'. This usage would make explicit the fact that when considering any problem we are in fact investigating a *part* of a complex system. As such, all the hypotheses and concerns raised by a 'science of partial complex systems' would be appropriate for all analyses, rather than just special cases.

Assuming the notion of incompressibility to be correct what does this mean for analysis?

Incompressibility essentially negates the possibility of the existence of a globally and permanently valid perspective, or paradigm. Furthermore, it means that there cannot be a perspective, paradigm, framework, etc., that can be used to wholly describe any sub-system embedded within *the* complex system. (Note that how we define any 'sub-system' will be dependent upon our perceptions and the use of our description rather than a permanent feature of the real world.) This observation may seem to deny the usefulness for analysis altogether. What it means, however, is not that we should not analyse, but that we should be strongly aware of, and blatantly open about, the provisionality of *any* perspective that might be utilised in underpinning an analysis of *any* problem – we must demonstrate considerable humility. Without this scientific "humility" we will continue to believe that our current understanding is true and defines all that is possible (and desirable).

The sceptical interpretation of the implications of incompressibility does not offer much in the way of advice, or *actionable knowledge* for analysts. It essentially argues for a 'paradigm-less' approach toward analysis in which categorisation of any sort must be avoided – a plainly impractical and absurd argument particularly given the category-based functioning of the human mind. Whether sceptics like it or not we rely heavily on categorisation to make sense of the world and to legitimate our decisions and resulting actions. The sceptical interpretation is best seen as a very important and profound health warning.

Local vs. non-local knowledge

Incompressibility leads neatly into the debate over whether non-locally valid descriptions of systems, i.e. descriptions that are valid over a broad range of different contexts, are possible or whether we must accept the critical context-dependence of any description. As with many of the lessons that might be derived from complexity science, there is no black and white answer but a range of possibilities, which in itself indicates that context is of critical importance. Any black or white answer would have to be to some extent context-independent which, by definition, is the complete opposite to the view that knowledge is context-dependent. Using the concepts of the phase portrait and the attractor basin (see Richardson *et al*., 2000a,b for a detailed explication of these concepts) metaphorically helps us understand this dilemma. Let us assume that we have developed a model that we have strong confidence in, as it appears to account for much of the system's (or, partial complex system's) currently observed behaviour. The question arises as to whether we can now take this model and make predictions about the future operation of the system. The answer is that if the qualitative nature of the assumptions that describe the new context remain the same then the model will be useful, i.e. if we remain in the same attractor basin within 'assumption space' then the knowledge derived from such a model can be translated and transferred into the new context. Qualitative changes in context prevent such a translation from occurring. So, at first consideration it seems that knowledge is strongly context-dependent but this dependence does not necessarily wholly devalue this knowledge in light of a new context. Playing the sceptic again, the recognition that a new context is qualitatively similar to another is strongly subjective, and so some feature, however small, might be overlooked. This would mean that the two contexts are incommensurable. There is considerable background 'noise' in making such a judgement and according to the phase picture the impact of this noise depends upon whether a separatrix has been crossed.

The essential lessons from this discussion on incompressibility are diffused over a spectrum. At worst knowledge is so incredibly context-specific that the search for understanding valid in other contexts is utterly futile. And, that attempts to make use of such knowledge in different contexts would be completely irresponsible, leading to wholly inappropriate advice and action. At best, knowledge based upon a particular context is indeed valid for a bounded range of other contexts, but this validity should never be taken for granted as the boundary describing this sub-set of contexts is rarely plainly apparent. The quest for frameworks that attempt to describe the many contexts of organisational management, say, is not futile, but any frameworks developed should be regarded with a healthy scepticism when it comes to making use of them in specific circumstances. As an example to characterise 'wholes' within the complexity field itself consider the following example.

The London School of Economics has a 'complexity project' that is developing a complexity lexicon that they are encouraging the use of when considering complexity. This is a worthy aim, but it must be remembered that there are an infinite number of ways to talk about complexity, and that the words used have different associations when used in different contexts – the transference of meaning is strongly context-dependent. The meanings of words should not be defined and enforced at the global level but should be allowed to be negotiated at the local level. The prescribed lexicon will undoubtedly provide a sound starting point, but we should be overtly aware of how language, which is based in a particular perspective, limits our 'vision'. On the other hand, and in support of such quests for context-independent frameworks, we must also acknowledge how language enables us to 'see' – we have to start somewhere. Again, to some this awareness may seem to be a trivial matter, but we believe it to be of crucial importance, assuming that the world is complex and that the need for 'quasi-paradigmless', or multi-perspective thinking follows naturally from this. In many ways complexity science provides insights concerning analysis that might be seen as nothing more than common sense. The need for an awareness of the provisionality of all understanding may seem obvious but as a community this and others issues seem to have been forced into the background. Maybe it's because we feel so much securer with the prevailing Modernist view of Absoluteness and Truth – it's so much neater.

COMPLEXITY THINKING AS EPISTEMOLOGY

The aim of this paper is not to question the basic observations made concerning 'the complex system', but to understand how the implications of these observations affect analyst's abilities to discovers 'truths' (with a small 't') concerning such systems. Elsewhere (Richardson, *et al*. 2000b) we have also suggested, in attempting to follow through these implications, that chunking the field of operational analysis in distinct 'paradigms' is misleading, our insinuation being that complexity thinking leads to a break from traditional paradigm-based thinking, and the necessary destruction, or least 'fuzzification', of the boundaries that allow us to recognise a paradigm as a paradigm. As a result, attempts to rigidly define the boundaries of the complexity paradigm are, we argue, contradictory to the fundamental complexity message. This does not mean that attempts to do so are not valuable, but it does mean that the boundaries should be seen as provisional and definitely local. We must each play the sceptic until such a time that we need to "fake" being "affirmative" so that action can be legitimated and initiated. But, in so doing, and in recognition also of the fact that the system evolves, we need to review and possibly change the analytical boundaries.

In the previous section the implications of incompressibility upon analysis were explicated. In this section, we offer a high-level conceptual approach to analysis that acknowledges the difficulties previously discussed.

Given that no one perspective can capture the inherent intricacies of complex systems, the analysis of complex systems requires us to consider a number of perspectives. The underlying premise for this is that by exploring a number of perspectives a richer appreciation of the 'state of affairs' or 'problematic situation' of interest will be developed, resulting in more informed decision-making. In considering a variety of perspectives, a negotiation between these perspectives is encouraged that drives the exploration process. The merits and deficiencies of each perspective would be examined in light of both the supporting and contradictory evidence offered by the other perspectives. This evidence may be in the form of individuals' experiences, the numerical output of a particular computer model, etc. As the different perspectives are played against and with each other new perspectives emerge that are, at least, an eclectic mixture of the parts of the constituent perspectives that seem most relevant to state of affairs under consideration. This intra- and inter-perspective exploration, or boundary critique, will identify other perspectives that might be worthy of inclusion, further fuelling the exploration process. After a number of exploration cycles a number of perspectives that are deemed acceptable are left. This endpoint might come about in a number of ways: the creativity, fuelled by the differences between the various perspectives or a variety of creative thinking exercises, may die out; the perspectives might naturally converge in a way that satisfies the basic needs of each perspective; or, a particular perspective becomes dominant and forces an end to the exploration process. Remember that in using the term perspective we are not distinguishing between formal and informal models, and so the perspective of the person that controls the budgetary strings also vies for a position in this inter-perspective exploration. The end point of an analysis then becomes the point at which a perspective, which may have emerged during the analysis or was present at he beginning, becomes overwhelmingly dominant.

In short, a principle requirement of a complexity-based epistemology is the exploration of perspectives. It may be useful to associate the terms *weak* and *strong* exploration, where weak refers to intra-perspective exploration and strong refers to inter-perspective exploration. Weak exploration encourages the critical examination of a particular perspective, which is undoubtedly driven by its differences with other perspectives. Strong exploration encourages the sucking in of all available perspectives in the considered development or synthesis of a situation-specific perspective. These two types of exploration are not orthogonal, and cannot operate in isolation of each other. The greater the number of perspectives available, the more in depth the scrutiny of each individual perspective will be. The deeper or broader the scrutiny, the higher the possibilities

are of recognising the value, or not, of other perspectives. Essentially, complexity-based analysis is a move from the contemporary authoritarian or imperialist (Flood, 1989) style, in which a dominant perspective bounds the analysis, to a more democratic style that acknowledges the 'rights' and value of a range of perspectives, whether they be formal modelling methods or informal and subjective personal viewpoints. The decision as to what perspective to use is also deferred until after the exploration process. Whilst scepticism plays a central role in the exploration process, it plays a lesser role during implementation, at least initially. In order to confidently implement a decision, we must learn to fake affirmatism (something that comes quite naturally to most people), but always be aware that conditions will change that might require substantial rethinking of the implementation design itself.

The basic concept of strong and weak exploration is all well and good, but analysts would be frozen by the plethora of possibilities that such paradigmatic freedom offers – the familiar *paralysis by analysis*. How would such an approach be operationalised? It is clear that the analyst must, in addition to other activities, be concerned with the management of the variety of perspectives; an activity that falls under the umbrella term of *facilitation.* What other frameworks, however limiting, might support such a perspective-based negotiation?

Operationalisations of a Complexity-Based Epistemology

Thus far the paper has discussed the epistemological implications of assuming that the world is best described as a complex system. Exploration both within and without different perspectives is encouraged, supporting the need for criticism, creativity, and pluralism. From a sceptical point of view, any attempt to operationalise such a complexity-based epistemology, via a well-defined framework, would be in contradiction to the underlying tenets. From a pragmatic point of view, however, we must accept that frameworks are essential in providing at least a focus or starting point to analysis. What we must be strongly aware of is that the theoretical insights offered by any framework should not be used to *determine* our explorations, but considered as an offering of *direction*, or simply as a source of creativity to fuel the exploration process.

A number of well thought out attempts have been made in the development of 'meta-frameworks' that recognise the problematic nature of analysis, offering guidelines as to how to manage the exploration process. These meta-methodologies have not been developed within the 'official' complex systems research community, but within the management science community; more specifically, the operational research community. Examples of these developments include: (1) the *system of systems methodologies* (Jackson, 1987), (2) *total systems intervention* (Flood & Jackson, 1991, and Flood, 1995), *creative design of methods* (Midgley 1990), and *critical appreciation* (Gregory 1992). In order to legitimate the various methodologies a variety of philosophies are drawn upon, such as Habermas's early work on knowledge-constitutive interests as well as his later work on *truth* statements, *rightness* statements and *individuals' subjectivity*, Foucault's theory of power, etc. For a good survey of the different methodologies and their associated philosophical underpinnings see Midgley, 1997.

On examining these different approaches the reader may notice that generally each subsequent methodology attempts to make more explicit the role of ongoing critical reflection, and the categorisation process – partly driven by the ongoing critique of the different methodologies. In an extended version of this paper (Richardson *et al*., 2000b), in acknowledging the coercive forces (from regulative, normative, and mimetic pressures) acting to shape the form of any intervention, we discuss the culture in which any analysis is performed. We believe that if the analytical culture was to acknowledge the central role critical thinking plays, then there would be little need to explicitly design-in the activity. Afterall, hasn't examination of the underlying assumptions of any perspective always been associated with 'good' analysis? If anything should be taken for granted it is the centrality of critical reflection, or boundary exploration and critique, to all forms of analysis. It is perhaps a poor reflection on the current analytical culture that critical thinking as an activity has to be made explicit.

SUMMARY AND CONCLUSIONS

A Modernist Argument for Affirmative Postmodernism?

By assuming the world to be a complex system, complexity science offers an alternative perspective that supports the need for criticism, creativity and pluralism through the notion of strong and weak exploration. It can be interpreted in such a way as to highlight the dangers of *any* categorisation, via the concept of chaos, but also (by it's acceptance of the need for categorisation to 'see' in the absence of a complete representation of everything) via incompressibility. By illustrating the inherently problematic nature of boundary selection, complexity science warns of the risks of employing off-the-shelf perspectives, and the need to partake in an intra- and inter-paradigmatic negotiation to facilitate the development of context-specific representations of perceived reality. In a way, dare we suggest it, complexity science provides a modernist argument for affirmative postmodernism. Boundaries are constructed for convenience. Quasi-paradigmless thinking should prevail until we are forced to take a position, i.e., fake positivism and invoke an imperialist stance.

All contexts are unique. If they were not, then past experience would always be sufficient when confronting any situation. This uniqueness means that attempts to associate existing understanding with particular contexts is problematic. This would imply that the recognition of contexts is a black and white exercise. Complexity science suggests that all are contexts should be considered 'grey'. As such, new perspectives must be tailored to 'fit' the new context (definition of which is problematic in itself) through the synthesis of a variety of formal and informal paradigms (used in it's broadest sense) via strong and weak exploration. Furthermore, complexity science (or 'the science of partial complex systems') warns us of attempts to systematise the exploration process, but at the same, acknowledges such a requirement. A healthy scepticism must prevail to prevent from slipping into potentially 'bad' habits.

Taking Responsibility

One more point before we conclude. Complexity science raises some ethical concerns that refer to the inevitability of choices that cannot be backed up scientifically or objectively (Cilliers, 2000). Why associate these concerns with ethics? Firstly, because the nature of the system or organization in question is determined by the collection of choices made in it. There are, of course, choices to be made on all scales, major ones, as well as all the seemingly insignificant small ones made all the time – and remember that the scale of the effect is not necessarily related to the scale of the cause. In a way, the history of the organization is nothing else but the collection of all these decisions. Secondly, since there appears to be no final objective or calculable ground for our decisions, we cannot shift the responsibility for the decision onto something else – "don't blame me, the genetic algorithm said we should sell!" We *know* that all our choices to some extent incorporate a step in the dark, and therefore we cannot but be responsible for them. This may have a pessimistic ring to it, but that need not be the case. An awareness of the contingency and provisionality of things is far better than a false sense of security.

In conclusion, we find that complexity science offers an alternative way of legitimizing the current interest in boundary critique, creativity, and pluralism. Furthermore, in acknowledging the partiality and provisionality of any attempt to describe a particular 'problematic situation', complexity science also raises concerns for how we recognise ethical behaviour.

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