Managing Complex Organizations: Complexity Thinking and the Science and Art of Management

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Introduction

This article is an attempt to explore the implications of the emerging science of complexity for the management of organizations, especially financial managers. The general message that there is no one way to manage, and that management is as much an art as it is a science (which in itself is not a particularly original statement). In a sense complexity thinking is about limits, limits to what we can know about our organizations. And if there are limits to what we can know, then there are of course limits to what we can achieve in a pre-determined, planned way. Complexity thinking offers us a rigorous and scientific explanation as to why to some degree we are helpless, as well as provide some tools for thought that help us manage our inevitable shortcomings and limitations. In a way, accepting that we have limitations, and that we can never have complete control, is rather emancipating. Complexity thinking is about the middle ground between extremes, and so although managers are to a degree helpless and at the mercy of the 'system', it certainly does not follow that there are not many opportunities to affect organizational behavior in desirable, semi-planned, ways.

This article is intended for reading by financial managers, but of course its views and conclusions can be applied across a broad spectrum of management functions. But the problems of complexity and complication, are particularly felt by financial managers in the current environment, and managers in the corporate finance function more than most are likely to find this article useful.

What if organizations were merely complicated?

What if human organizations were *complicated* rather than *complex*? The simple answer to this question is that the possibility of an all-embracing Theory of Management would almost certainly exist. This would make management very easy indeed as there would be a book of theory (*The Management Bible* – it would probably challenge the current all-time bestseller in sales!) that would tell the practicing manager what to do in any given context. The means of achieving effective and efficient organizational management would no longer be a mystery. But what is it about the concept of 'complicated' that makes this scenario plausible? Why has the possibility of a final management theory not been realized yet, given the millions of man-hours and published pages devoted to the search? Why does approaching organizations as 'complex' rather than 'complicated' deny us of this possibility?

A very common (but incomplete) description of a complex system is that such systems are made up of a large number of nonlinearly[1] interacting parts. By this definition the modern computer would be a complex system. A modern computer is crammed full of transistors which all respond nonlinearly to their input(s). Despite this 'complexity' (sic) the average PC does not show signs of emergence or self-organization; it simply processes (in a linear fashion) the instruction list (i.e., a program) given to it by its programmer. Even the language in which it is programmed is rather uninteresting. Although there are many programming languages, they can all be translated into each other with relative ease. Technically this is to say that computer languages are *commensurable* with each other. A line of code in C# can be translated into Visual Basic very easily – the one line of C# code may require more lines of VB code to achieve the same functionality but it can be done. The universal language into which all such languages can be translated without loss is called 'logic' (more accurately, 'Boolean logic'). More often though, if a programmer wants to use a language very close to the universal language of computing, *assembly* is used as this at least contains concepts that are more readily used in writing programs (although the domain knowledge – microelectronics – needed to program in assembly is a major requirement). This is then translated into machine code (which is based on Boolean logic) - writing sophisticated programs directly in the language of the 0s and 1s of Boolean logic would be nigh on impossible for any human programmer. The computer cannot choose the way it interprets the program, it cannot rewrite the program (unless it is programmed to in a prescribed manner), and it cannot get fed up with running programs and pop to the pub for a swift pint! So, what is it about the modern computer that prevents it from being a complex system, but rather a complicated system?

The critical element is *feedback*. It is the existence of nonlinear feedback in complex systems that allows for *emergence*, *self-organization*, *adaptation*, *learning* and many other key concepts that have become synonymous with complexity thinking – and all the things that make management such a challenge. It is not just the existence of feedback loops that leads to complex behavior. These loops must themselves interact with each other. Once we have three or more *interacting* feedback loops (which may be made up from the interactions of many parts) accurately predicting the resulting behavior via standard analytical methods becomes problematic (at best) for most intents and purposes. In a relatively simple complex system containing, say, fifteen parts / components there can be hundreds of interacting feedback loops. In such instances the only way to get a feel for the resulting dynamics is through simulation, which is why the computer (despite its rather uninteresting dynamics) has become so important in the development of complexity thinking. We say that the prediction of overall system behavior from knowledge of its parts is *intractable*. Basically, *absolute knowledge about the parts that make up a system and their interactions provides us with very little understanding indeed regarding how that system will behave overall*. Often the only recourse we have is to sit back and watch. In a sense the term complex system refers to systems which, although we may have a deep appreciation of how they are put together (at the *microscopic* level), we may be completely ignorant of how the resulting *macroscopic* behavior comes about – i.e., complexity

[1] 'Nonlinearly' simply means that the parts are constructed in a way such that the output from one particular part is not necessarily proportionate to its input. The weather system is an oft cited example in which small additions of energy don't necessarily lead to small changes in the system's behavior.

is about limits to knowledge. Without this understanding of causality planning for particular outcomes is very difficult indeed. In the computer (which we will now class as a complicated system) causality is simple, i.e., low dimensional - few (interacting) feedback loops (although there are many millions of connections). In complex systems causality is networked, making it very difficult indeed, if not impossible, to untangle the contribution each causal path makes. It is hard enough to grasp the possibilities that flow from a small group of people let alone the mind-boggling possibilities that might be generated from a large multi-department organization. Maybe this is why a major part of management tends to be suppressing all these possibilities so that one individual might begin to comprehend what remains – departmentalization is an obvious example of a complexity reduction strategy.

Another unexpected property of complex systems is that there exist stable abstractions, not expressible in terms of the constituent parts, that themselves bring about properties different from those displayed by the parts. More often than not emergence is portrayed as a process from which macroscopic properties 'emerge' from microscopic properties, i.e., the properties of the whole emerge from the properties of its parts. But this in an overly simplistic view of emergence. When recognizing the products of emergence, e.g., novel wholes, what is really happening is that we are abstracting (which essentially means information filtering, i.e., ignoring some information in favor of paying attention to some other information) away from the description in terms of parts and interactions, and proposing a new description in terms of entities or concepts quite different from the constituent parts we started with – regarding an organization as a collection of interacting departments rather than a collection of individual people is the same process. These new entities have novel properties in relation to the properties the constituent parts have, i.e., whole departments do not act just like individual people, and 'team-ness' is not the same as 'person-ness'. What is even more interesting is that these supposed abstractions can interact with the parts from which they emerged - a process known as *downward causation*. In sum, the expression "the whole is greater than the sum of its parts" is too simplistic.

In specially idealized complex systems such as in cellular automata (see the Wiki below) the parts are very simple indeed, and yet they still display a great deal of emergent phenomena and dynamical diversity. Complex systems which contain more intricate parts are often referred to as *complex adaptive systems* or CASs, in which the parts themselves are described as complex systems. The parts of CASs contain local memories and have a series of detailed responses to the same, as well as different, contexts / scenarios. They often have the ability to learn from their mistakes and generate new responses to familiar and novel contexts. Because of this localized decision-making / learning ability such parts are often referred to as (autonomous) agents. There is a profound relationship between simple complex systems (SCSs), i.e., complex systems comprised of simple parts, and CASs, i.e., complex systems comprised of intricate agents. The Game-of-Life, a particularly well-known SCS, shows how a CAS can be abstracted, or emerges, from a SCS! Intuition would tell us that a CAS is simply a more intricate SCS. The Game-of-Life demonstrates that our intuition is, as is often the case in complexity thinking, too simplistic. If you are unfamiliar with the Game-of-Life, 'invented' by John Conway, then I recommend starting with the Wiki at http://en.wikipedia.org/wiki/Conway's_Game_of_Life. The Game-of-Life, and other cellular automata-like systems, offer an entertaining way to learn a

great deal about complex systems dynamics and begin to develop a deep appreciation for the systems view of the world.

Complexity and incompressibility

Cilliers (2005) introduces the idea of incompressibility:

"*We have seen that there is no accurate (or rather, perfect) representation of the system which is simpler than the system itself. In building representations of open systems, we are forced to leave things out, and since the effects of these omissions are nonlinear, we cannot predict their magnitude*." (p. 13).

It is this concept of incompressibility that leads us away from a managerial monism – a definitive theory of management – to a managerial pluralism (assuming organizations are complex rather than merely complicated) – in which many theories co-exist each with their own unique strengths and weaknesses. Restating Cilliers, the best representation of a complex system is the system itself, and any representation of the system will be incomplete and, therefore, can lead to incomplete (or even just plain wrong) understanding. One must be careful in interpreting the importance of incompressibility. Just because a complex system is incompressible it does not follow that there are (incomplete) representations of the system that cannot be useful - incompressibility is not an excuse for not bothering. This is rather fortunate otherwise the only option available once we accept the impossibility of an ultimate theory is to have no theory at all – not a very satisfactory outcome (and contrary to what experience would tell us); I think I'd rather know something that is wrong rather than nothing at all. Knowing something and knowing how it is wrong is even better! Equally useful is knowing something that is wrong, but knowing why it is wrong.

Building on the work of Bilke and Sjunnesson (2001), Richardson (2005a) recently showed how Boolean networks (which are a type of SCS) could be reduced / compressed in such a way as to not change the qualitative character of the uncompressed system's phase space, i.e., the compressed system had the same functionality as the uncompressed system. If nothing was lost in the compression process, then Cilliers's claim of incompressibility would be incorrect. However, what was lost was a great deal of detail of how the different attractor basins (regions that describe qualitatively different system's behavior) are reached. Furthermore, the reduced systems are not as tolerant to external perturbations as their unreduced parents. This evidence would suggest that stable and accurate – although, paradoxically, imperfect – representations of complex systems do indeed exist. However, in reducing / compressing / abstracting a complex system certain potential significant details are lost. Different representations capture different aspects of the original system's behavior. We might say that, in the absence of a complete representation, the overall behavior of a system is *at least* the sum of the behaviors of all our simplified models of that system. Richardson (2005a) concludes that:

"*Complex systems may well be incompressible in an absolute sense, but many of them are at least quasi-reducible in a variety of ways. This fact indicates that the many commentators suggesting that reductionist methods are in some way anti-complexity - some even go so far as*

to suggest that traditional scientific methods have no role in facilitating the understanding complexity - are overstating their position. Often linear methods are assessed in much the same way. The more modest middle ground is that though complex systems may indeed be incompressible, most, if not all, methods are capable of shedding some light on certain aspects of their behavior. It is not that the incompressibility of complex systems prevents understanding, and that all methods that do not capture complexity to a complete extent are useless, but that we need to develop an awareness of how our methods limit our potential understanding of such systems."

In short, all this is saying is that we can indeed have knowledge of complex organizations, but that this knowledge is approximate and provisional. This may seem like common sense, but it is surprising how much organizational knowledge is acted upon *as if* it were perfectly correct.

The suggestion that there are multiple valid representations of the same complex system is not new. The complementary law (e.g., Weinberg, 1975) from general systems theory suggests that any two different perspectives (or models) about a system will reveal truths regarding that system that are neither entirely independent nor entirely compatible. More recently, this has been stated as: a complex system is a system that has two or more non-overlapping descriptions (Cohen, 2002). I would go as far as to include "potentially contradictory" suggesting that for complex systems (by which I really mean any part of reality I care to examine) *there exists an infinitude of equally valid, non-overlapping, potentially contradictory descriptions*. Maxwell in his analysis of a new conception of science asserts that:

"*Any scientific theory, however well it has been verified empirically, will always have infinitely many rival theories that fit the available evidence just as well but that make different predictions, in an arbitrary way, for yet unobserved phenomena*." (Maxwell, 2000).

The result of these observations is that to have any chance of even beginning to understand complex systems we must approach them from many directions - we must take a pluralistic stance. This pluralist position provides a theoretical foundation for the many techniques that have been developed for group decision making, bottom-up problem solving, distributed management; any method that stresses the need for synthesizing a wide variety of perspectives in an effort to better understand the problem at hand, and how we might collectively act to solve it.

Complexity and pluralism

The pluralism inherent in complexity thinking undermines the whole notion of a unified theory of complexity, i.e., theoretical monism. A simplistic view of unification would be similar to the example above of computer languages. Unification of this sort would suggest that if we work very hard indeed, eventually we will not only have at hand all the relevant laws of complexity, but that these different laws could be derived from *one* underlying principle. This is very much the basis of Theories of Everything (TOEs) in the physical sciences. Although there will exist a plurality of theories, they will all be coherent in that they can be expressed in terms of a more fundamental / general language (likely to be a form of mathematics) without any loss of detail.

We might refer to this as *commensurable pluralism*. However, if we assume that a complex systems perspective provides a more appropriate basis from which to understand our surroundings, then we must address the issue of incompressibility. Incompressibility leads to a different sort of pluralism altogether; a pluralism in which the different theories / representations are not all reducible to a fundamental language without loss of detail – even if we agree that a theory of individual psychology is more fundamental (i.e., lower-level) than a theory of team dynamics, *all* team dynamics will never be described in terms of individual psychology only. In such a pluralism the different representations are generally incommensurable with each other (i.e., not expressible in terms of each other), and rather than leading to a coherent TOE, a patchwork of theories results. Within such *incommensurable pluralism* there will be opportunities for limited translations, reductions and simplifications, but a TOE will never result. In this situation the importance of context also becomes apparent. Each approach in the patchwork will be valid only for a certain range of contexts, and so matching theory to context becomes ever so important. However, a feature of complex systems is that context recognition is not a trivial exercise as to define a context we must ignore some aspects of the situation of interest (as in the process of abstraction described above). Contexts which appear similar may actually be quite different, and so the process of matching theory to context is problematic at best, which again highlights the importance of approaching real world problems from many different directions. Furthermore, complex systems evolve (in a qualitative sense) and so fundamentally novel contexts emerge requiring new theoretical syntheses. If we assume that human organizations are best described as complex systems then this has quite profound implications for management science; implications that are at odds with traditionalist views.

The main criticism traditionalists have of the 'others' is that by refusing to focus management studies on a single perspective / theory, the potential political and influential clout of management academics has been vastly reduced. According to Pfeffer (1993):

"*Without a recommitment to a set of* fundamental *questions and without working through a set of* rules *to resolve theoretical disputes, the field of organization studies will remain ripe for a hostile takeover*." (emphasis added)

Donaldson (1995) built an entire book around this idea: *American Anti-Management Theories of Organization: A Critique of Paradigm Proliferation*. Donaldson's book is an indictment of existing management science which, he claims, has fragmented into competing paradigms. Donaldson argues that this profusion of perspectives is driven not by a genuine need to further the body of knowledge, but by a "push for novelty fuelled by individual career interests" typical of the academic environment[2]. He asserts that the resulting fragmentation of the field into mutually incompatible ideas has significantly weakened management science as

[2] Donaldson's argument may only account for why certain perspectives are more dominant than others, it does not explain why there is a "profusion of perspectives" in the first place. I would tend to think that if there was even a whiff of an ultimate theory of management then I doubt that the "individual career interests" of academics could prevent its development. Maybe the fact that after all the effort that has gone into trying to find this elusive organizational theory of everything (OTOE) we still only have a 'profusion' suggests that a 'profusion' is the optimal situation, and that an OTOE does not in fact exist (or that it is at least way beyond the grasp of mere mortals).

an intellectual enterprise worthy of attention and support – I think this is confusing the marketing of theory with the process of theory development (the last thing we want to do is compromise the standards by which theory is developed for the sake of marketing).

Donaldson's book calls for building a unified theory of organizations. Clearly this is at odds with what has been discussed above. In my view, paradigm proliferation is healthy for management science - not a disease that needs to be eradicated – status quos are never maintained and are rarely healthy in the long term. Fragmentation is inevitable, but what we must learn to do better is work with this fragmentation rather than force a 'commensurable unification' upon it. Efforts to this end are readily apparent with the current trend for cross-disciplinary and multi-disciplinary research. Such research will always be difficult and will not be overcome by pushing for a unifying framework which will do no more than paper over the cracks (and in so doing severely limit our opportunities to develop richer understanding).

Using complexity thinking

In this section I will briefly outline three approaches for how complexity thinking might support organizational management. These different approaches are derived from three different schools of thinking within the complexity movement. These three schools are not isolated from each other, but themselves form a complex system of interrelationships. Despite their interdependence I still find it useful to divide the complexity movement into these divisions. The three schools / themes / divisions that I identify and discuss are: the neo-reductionists, the 'metaphorticians', and the critical pluralists.

The neo-reductionist school

The first theme is strongly associated with the quest for TOE in physics mentioned above, i.e., an acontextual explanation for the existence of everything. This community seeks to uncover the general principles of complex systems, likened to the fundamental field equations of physics[3]. The search for such over-arching laws and principles was / is one of the central aims of the general systems movement. Any such Theory of Complexity, however, will be of limited value. In Richardson (2005b) I suggest that even if such a theory existed it would not provide an explanation of every 'thing' in terms that we would find useful. If indeed such fundamental principles do exist they will likely be so abstract as to render them practically useless in the everyday world of human experience - a decision-maker would need several PhDs in pure mathematics just to make the simplest of decisions. I do not want to sound too critical here as we just need to consider how much valuable science has come out of the quest for a TOE. It clearly has been a highly motivating and productive idea. We just need to have realistic expectations for this way of doing science. It is quite likely that we would start to see diminishing returns if society got too pre-occupied with this particular (reductionist) approach.

This complexity community makes considerable use of computer simulation in the form of bottom-up agent based modeling. The 'laws' such nonlinear studies yield provide a basis for a

[3] It is likely that these two research thrusts, if successful, will eventually converge if it is assumed assume that some kind of complex systems representation of the Universe as a whole is valid.

knowledge paradigm that is considerably broader than just bottom-up simulation, or any formal mathematical / computer-based approach for that matter.

The neo-reductionist school of complexity science is based on a seductive syllogism (Horgan, 1995):

Premise 1: There are simple sets of mathematical rules that when followed by a computer give rise to extremely complicated patterns.
Premise 2: The world also contains many extremely complicated patterns.
Conclusion: Simple rules underlie many extremely complicated phenomena in the world, and with the help of powerful computers, scientists can root those rules out.

Though this syllogism was definitively refuted in a paper by Oreskes, *et al*. (1994), in which the authors warned that "verification and validation of numerical models of natural systems is impossible," this position still dominates the neo-reductionist school of complexity in the social sciences. The recursive application of simple rules, is certainly not the only source of complex behavior, and should not be seen as the only legitimate way to study complexity in human organizations (or anywhere else for that matter).

Despite all the rhetoric about reshaping our worldview, taking us out of the age of mechanistic (linear) science into a brave new (complex) world, many complexity theorists of this variety have actually inherited many of the assumptions of their more traditional scientific predecessors by simply changing the focus from one sort of model to another, in very much the same way as some managers jump from one fad to another in the hope that the next one will be the ONE. There is no denying the power and interest surrounding the new models (e.g., agent-based simulation, genetic algorithms) proposed by the neo-reductionists, but it is still a focus on the model itself. Rather than using the linear models associated with classical reductionism, a different sort of model - nonlinear models - have become the focus. Supposedly, 'bad' models have been replaced with 'good' models. This is a strategy we see in a wide variety of fields, not just the sciences. Although I myself do not have a great appreciation of the history of art, it does seem to me that new artistic ways of expression are more often thought of as 'different' rather than 'better' or 'worse'. I think this is a healthier attitude towards different methods.

The metaphorical school

Within the organizational science community, complexity has not only been seen as a route to a possible theory of organization, but also as a powerful metaphorical tool (see, for example, Lissack, 1997, 1999; Richardson, *et al*., 2005). According to this school, the complexity perspective, with its associated language, provides a powerful lens through which to 'see' organizations. Concepts such as *connectivity*, *edge-of-chaos*, *far-from-equilibrium*, *dissipative structures*, *emergence*, *epi-static coupling*, *co-evolving landscapes*, etc., facilitate organizational academics and practitioners in 'seeing' the complexity inherent in socio-technical organizations. The underlying belief is that the social world is intrinsically different from the natural world. As such, the theories of complexity, which have been developed primarily through the examination of natural systems, are not directly applicable to social systems (at least not to the

practical administration of such systems), though its language may trigger some relevant insights to the behavior of the social world which would facilitate some limited degree of control over the social world.

Using such a 'soft' approach to complexity to legitimate this metaphorical approach, other theories have been imported via the 'mechanism' metaphor into organization studies; a popular example being quantum mechanics (see McKelvey, 2001 for an example). While new lenses through which to view organizations can be very useful (see Morgan, 1986 for an excellent example of this) the complexity lens, and the 'anything goes' attitude that sometimes accompanies this perspective, has been abused somewhat. My concern is not with the use of metaphor *per se*, as I certainly accept that the role of metaphor in understanding is ubiquitous and essential. Indeed, in Richardson (2005b) it is argued that in an absolute sense all understanding can be nothing more (or less) than metaphorical in nature[4]. The concern is with its use in the absence of criticism - metaphors are being imported left, right and center with very little attention being paid as to the legitimacy of such importation – the organization as an organism being a popular current example. This may be regarded as a playful activity in academic circles, but if such playfulness is to be usefully applied in serious business then some rather more concrete grounding is necessary. As van Ghyczy (2003) warns, "Instead of being seduced by the similarities between business and another field, you need to look for places where the metaphor breaks down... [M]etaphors are often improperly used" (p. 87-88).

I refer to this school of complexity, which often uncritically imports ideas and perspectives via the mechanism of metaphor from a diverse range of disciplines, as the *metaphorical school*, and its adherents, *metaphorticians*. It is the school that perhaps represents the greatest source of creativity of the three schools classified here. But as we all know, creativity on its own is not sufficient for the design and implementation of successful managerial interventions.

The critical pluralist school

Neo-reductionism with its modernistic tendencies can be seen as one extreme of the complexity spectrum, whereas *metaphorism* with its atheoretical acritical relativistic tendencies can be seen as the opposing extreme. In my view the complexity perspective (when employed to underpin a philosophical outlook) both supports and undermines these two extremes. What is needed is a middle path.

The two previous schools of complexity promise either a neat package of coherent knowledge that can apparently be easily transferred into any context, or an incoherent mish mash of unrelated ideas and philosophies - both of which have an important role to play in understanding and manipulating complex systems. In my opinion, not only do these extremes

[4] Metaphor is the description of certain aspects of one thing in terms of certain aspects of another. If we consider the Universe to be one 'thing' then human knowledge is the partial representation of the Universe in terms of the 'things' that constitute human language. Language itself determines to a great extent what aspects of reality are promoted to the 'foreground' – i.e., what we pay attention to - and what aspects are demoted to the 'background' - i.e., what we ignore - in the same way that the fox metaphor - 'He is as cunning as a fox' - highlights a particular trait of an individual and compares it to the cunningness of the fox. At the same time traits like the fox's shyness are ignored. By describing knowledge as metaphor, the bias and limited nature of knowledge is explicitly acknowledged.

represent overly simplistic interpretations of the implications of complexity, they also contradict some of the basic observations already made within the neo-reductionist mold, i.e., there are seeds within the neo-reductionist view of complexity that if allowed to grow lead naturally to a broader view that encapsulates both the extremes already discussed as well as everything in between and beyond.

One of the first consequences that arise from the complexity assumption is that as we ourselves are less complex than the Universe (The Complex System), as well as many of the systems we'd like to control / affect, there is no way for us to possibly experience 'reality' in any complete sense (Cilliers, 1998: 4; see also the comments above regarding incompressibility). We are forced to view 'reality' through categorical frameworks that allow us to 'fudge' our way through life. The critical pluralist school of complexity focuses more on what we cannot explain, rather than what can be explained - it is a concern with limits, and how we take those limits into account when trying to understand the world around us. As such, it leads to a particular *attitude* towards models, rather than the privileging of one sort of model over all others. And, rather than using complexity to justify an 'anything goes' relativism, it highlights the importance of critical reflection in grounding our models / representations / perspectives in an evolving reality. The keywords of this school might be *pluralism*, *open-mindedness* and *humility*. Any perspective whatsoever has the potential to shed light on complexity (even if it turns out to be wrong, otherwise how would one know that it was wrong?), but at the same time, not every perspective is equally valid in any given context (try fixing your car with prayer rather than with a good mechanic). Complexity 'thinking' is the art of maintaining the tension between pretending we know something and knowing we know nothing for sure.

The three schools and management

Now that we have identified and discussed the three schools of complexity, how does each one contribute to the management of human organizations? The first one, neo-reductionism, is the easiest as it simply adds a new collection of analytical tools to the decision-makers tool set. These tools will probably impact the fields of management science and operations research the most, providing some very powerful tools to facilitate the decision-making process surrounding larger strategic questions. Indeed such models are ideal for exploring that class of question where individual behavior matters only as a contribution to group behavior. They will probably not contribute to rather more mundane day-to-day management activities - it is unlikely that the development of an agent-based model will help much in deciding if to promote someone or not, or whether to change the supplier for the hallway coffee machine (techniques such a causal mapping and multi-criteria decision analysis are 'complexity' tools better matched to such 'micro' questions). There are certain types of problems that can benefit from nonlinear analytical models and some problems that will not. This school of complexity seems to be the most visible at present, and is probably to easiest of the three to apply. Given the immense computational resources needed to utilize the neo-reductionist's tools, there is also a certain level of glamour and excitement associated with this sort of complexity application; this seems to have captured the imagination of the management world, even though the problems it can usefully be brought to bear on are limited.

The metaphorical school of complexity can certainly play a part in the day-to-day activities of management. Given that our personal worldviews determine to a large extent what we 'see' and how we 'manage' what we 'see', replacing / enhancing that worldview with a perspective that is rather more sensitive to the complexities that are inherent in daily experience, can have a profound effect. Richardson *et al*. (2005), for example, considers project management through the lens of complexity-inspired metaphors. It is difficult to fully appreciate the influence the widespread usage of complexity-inspired metaphors will have, but I would like to think that many of the shortcomings of the dominant command and control metaphor (which, unfortunately, has become rather more than a metaphor) will be mitigated. Of course, replacing one worldview with another creates as many new problems as it solves. It'll be interesting to see what these new problems will be. (Although, seeing management as a problem solving process is itself a feature of the command and control attitude).

The metaphorical school does not only legitimate the use of complexity-inspired metaphors though; it is often used to justify a fully blown pluralism in which anything goes. We have to be careful that our wish to explore all possibilities does not lead to chaos (and I don't mean this in the mathematical sense). Quoting van Ghyczy (2003) again, "It's tempting to draw business lessons from other disciplines - warfare, biology, music. But most managers do it badly" (p.87). I would also add the many academics also do this badly.

The critical pluralist school of complexity also has implications for all aspects of management, although it is possibly one of the hardest to 'teach'. It encourages not only management, but all participant members of an organization, to approach everything they do in a critical way and to maintain some (ontological) distance from their ideas, i.e., to not take our ideas of organization too seriously - use our ideas to guide, or initiate, our thinking about organizations, not to determine our thinking. Complexity 'thinking' is a particular attitude towards our ideas of the world and the world itself, not a particular tool / method, or even a particular language. The last school is rather more philosophical than the first two and is also the hardest to describe in any complete sense. To close the article I'd like to discuss briefly why I believe philosophy is important for organizational managers (and every sophisticated thinker for that matter). I hope it is already clear that I believe complexity science itself suggests the central importance of a philosophical attitude when considering the world we experience.

Why philosophy?

Managers seem reluctant to study philosophy. They're not alone. This is not particularly surprising given that many books on the subject are often devoid of any practical recommendations. However, when I talk about a philosophical attitude I'm not saying that we all need to go out and invest considerable time in penetrating obscure texts. Philosophy is a study of what underlies choice. In both management and research choices abound. Researchers have to choose which methodology they are to employ in understanding a particular aspect (which of course also has to be chosen) of management; the boundaries of the research study need to be chosen (which is strongly dependent upon research methodology), etc. Managers have to continually decide which information is required to make a particular

decision; how to interpret that information for the purposes at hand, and even choose what the actual purpose might be, as well as what the issue is that needs to be decided upon (although, often this is done very much unconsciously without much attention to the actual framework within which they have been 'taught' to operate).

From the perspective of the researcher Hughes (1990: 11) suggests that philosophy underpins the whole selection process because:

"*... every research tool or procedure is inextricably embedded in commitments to particular versions of the world and to knowing the world. To use an attitude scale, to take the role of a participant observer, to select a random sample, to measure rate of population growth, and so on, is to be involved in conceptions of the world which allow these instruments to be used for the purposes conceived. No technique or method of investigation (and this is true of the natural sciences as it is of the social) is self-validating: its effectiveness, that is its very status as a research instrument making the world tractable to investigation, is, from a philosophical point of view, ultimately dependent on epistemological justifications. Whether they may be treated as such or not, research instruments and methods cannot be divorced from theory; as research tools they operate only within a given set of assumptions about the nature of society, the nature of human beings, the relationship between the two and how they may be known*."

When managers choose to adopt a particular perspective, or set of procedures, or what issue to focus upon, these choices are philosophically equivalent to the researcher's selection of a particular methodology. Both sets of choices are underpinned by particular views of how the world we observe is constructed, and how it should respond to our actions upon it. More often than not we are unaware of the commitments that our choices imply. It is not a question we are often taught to ask. It is not a question we have evolved to be too concerned with either. Of course, researchers often spend some time on these concerns, because many of them have been taught to. However, many managers, as well as most of us at large, are very rarely concerned with the underlying assumptions upon which our choices made. If we were, we would be rather surprised as to the absurdity of some of our most cherished beliefs.

Philosophers often refer to the dominant worldview (or philosophy) of the average layperson as *naïve realism*. The 'naïve' part is possibly a poorly chosen label as it would seem to indicate that all of us who are not philosophers are a little daft, in that we have been so poorly misguided into ever believing that realism could possibly be a sensible way to view our surroundings. I think, given that much of our sensory and decision making equipment has evolved in a way that naturally leads to a kind of realism, perhaps we can be forgiven for not knowing any better. Maybe common sense realism is a more positive way of distinguishing a layperson's realism from a philosopher's realism.

Realism is based on a what-you-see-is-what-you-get (or WYSIWYG for those fluent in computer jargon) worldview, i.e., that our senses tell us accurately what the world is comprised of and how those parts interact - what-you-sense-is-what-there-is (WYSIWTI), if you like. The first implication of realism is that the way in which we 'see' the world is quite independent of what our senses, and our beliefs, guide us to 'see'. This is quite contrary to the quote given above which suggests that our senses and beliefs profoundly affect what we 'see'. If our senses are truly unbiased (as naïve realism suggests) then understanding the world around us simply

becomes a process of map making. For this reason realism is often referred to as *representationalism*.

A second implication of realism is to regard causality as a first order process, i.e., if a change in object A results in a change in object B we have a tendency to assume that such a correlation refers to some causal mechanism - 'A caused B to ...' So not only do the objects A and B exist as such, they also affect each other directly. The 'existence' of A and B would be seem to be a trivial matter especially when considering objects such as cars and computers, but what about concepts like 'consumer confidence' or 'social capital'. Furthermore, given WYSIWTI, the possibility that it is an unseen object C that affected A and B (or mediated the affect), or that two unrelated objects C and D affected A and B directly, or that the change in B resulting from a change in A was no more than a coincidence (and therefore not causal even if there was some correlation) are all scenarios that are omitted from a simplistically realist perspective. The natural sciences have developed tools to allow us to 'see' objects that remain 'unseen' with the naked eye, but even here any explanations offered must necessarily be based on what has been detected.

Quite often realism is associated with 'linearity', but this would be a mistake. The advent of the computer has allowed us to 'model' scenarios in which complicated loops of interaction can be represented and explored, a trick which the human mind seems woefully inept at doing. The main consequence of realism that concerns me here is that it leads to an overconfidence in what we have represented and analyzed as being exactly how the real world works. Quite clearly this is not a view devoid of merit. If it was then our ability to successfully achieve anything would be very much lower than it actually is. Clearly, to a useful degree, realism produces rather good results.

Given the successes of modern science, it is not surprising that realist viewpoints dominate Western thought - it is a natural way to view things, and such impressive machines as computers have been built that surely prove the power of realist thinking. Relating this back to philosophy, the success of modern science is arguably the reason that philosophy has fallen by the wayside. If science leads to correct knowledge all the time, then what is the point of questioning its underlying assumptions; surely the way in which modern science and the realists view the world is how the world *is*? Each new management fad promises to provide the ultimate answers to the hard questions troubling practicing managers, which again encourages philosophical ignorance. Why bother thinking too hard if there is a framework 'out there' claiming to do the thinking for us?

Two of the big questions for philosophers are what objects *exist* and how can we *know* about those objects. Jargon-wise, the study of what exists is referred to as *ontology* and the study of how we come to know these objects of existence (the study of knowledge) is referred to as *epistemology*. These two areas of interest have been enthusiastically investigated for at least 2500 years, until very recently that is. The Newtonian view of the Universe leads to an 'exquisitely intricate timepiece' model, i.e., the Universe is a really big machine. As a big machine it can be taken apart, its parts can be studied in isolation, and knowledge of the whole can be accurately gleaned by summing together the knowledge of its component parts. In popular views of modern science, there is something referred to as the scientific method which guides us in the study of these parts. So ontologically the Universe is a big machine, and

epistemologically we have the scientific method to give us knowledge of the Universe's parts and eventually the Universe as a whole.

What is often missed from popular views of modern science is that science does not always work very well, and that there is no such well-defined process called the scientific method. This may come as a surprise to the many opponents and critics of modern science, but most decent scientists are well aware of their chosen occupation's shortcomings. Questions of ontology and epistemology really haven't been answered to complete satisfaction, thus there is still very much a role for philosophy.

The famous physicist Louis de Broglie once said "May it not be universally true that the concepts produced by the human mind, when formulated in a slightly vague form, are roughly valid for reality, but that, when extreme precision is aimed at, they become ideal forms whose real content tends to vanish away?" (quoted in Cory, 1942). This suggests that we should use scientific understanding (not knowledge) to guide our decisions, not determine them as such understanding is only correct in a loose sense. This is true of all understanding once we accept the limitations of the realist worldview. Rather than regarding our knowledge as faithful maps of reality we must see it as a potentially useful, but not necessarily so, caricature of reality, or as a metaphor. This follows from the fluid and complex nature of systemic boundaries as seen from the complexity perspective. Causality is complex, intricate, multi-ordered, and intractable. All this suggests a renewed concern with ontology and epistemology and therefore with philosophy. What is ironic is that, though it has taken a revolution in science (spurred by a technological revolution which resulted from the dogmatic application of realist thinking for the past 400 years) to bring complexity to the fore, philosophers have been concerned with complexity for hundreds if not thousands of years.

Some concluding thoughts

The aim of this article was not to provide a general introduction to complexity science, but to consider the various ways in which it might inform managerial action in a general sense. There are various tools that have derived from complexity science that might be used in the analysis of certain managerial problems. However, it is the implications of complexity thinking for the 'managerial attitude' that I have focused on here as I believe the shift from a linear simplistic attitude to a nonlinear complex attitude is significantly more challenging than a simple switch from one framework / tool to another as is more common in our faddish modern world.

The concept of incompressibility discussed above would suggest that attempting to capture the complex systems-derived implications for organizational management in some short conclusions would at best be a limiting exercise, and at worst rather irresponsible. However, in the hope that you have read the preceding pages and not just jumped to the conclusions, I will attempt to do just that with the knowledge that you will appreciate that this is a problematic exercise to say the least. The laws of complex organizational management, therefore, might be listed as follows:

1. **Just because it looks like a nail, it doesn't mean you need a hammer**: A complex systems view acknowledges that context recognition is problematic, and as such deciding what to do is not a simple exercise of repeating what you did the last time you were in the same situation. The chances are the situation is quite different.

2. **Decisions made by the many are often better than those made by a few**: A precursor to any decision has to be a thorough consideration (critique) from multiple perspectives (pluralism). This might be the application of a variety of different models, or simply just asking more than one person for their opinion. Such an approach quite naturally leads to creative thinking, and enables the development of a richer understanding on a context of interest before a decision is made. Beware, however, as "too many cooks may spoil the broth";
3. **Expect to be wrong (or at least not completely right)**: There are limits to how pluralistic and critical our decision making processes can be. But even with all the time and resources in the world (and a commitment to do the 'right' thing), decisions can only be made based on our best current understanding, and that understanding will always be incomplete. Everything is connected to everything else. We can't consider everything so we construct artificial boundaries to help us make a decision – without those boundaries we are helpless, with them our responses are limited (but at least we have some responses!);
4. **Flip-flopping is OK**: Contrary to certain US politicians, being prepared and confident enough to change one's mind when it becomes clear that one's model is proving ineffective (and even counterproductive) is actually a virtue, not a sin. The complex organization evolves in unforeseeable ways and as such we must be prepared to "move with the times". The simple act of making a decision (based on past experience) can change how the future unfolds. Don't make the mistake of escalating one's commitment in the face of mounting contrary evidence. Dogmatism is rarely an effective strategy.

These bullets may be common sense to the experienced manager (endowed with an innate understanding of human networks). What is particularly interesting about complexity science is that it provides a scientific way of making these points. Good science has the tendency to change what common sense is over time, and I am excited at the prospect of an emerging systemic common sense. The complex systems view really is a profoundly different way of understanding the world from what we in the West (primarily) have become accustomed to. The modest hope is that the systemic task of managing will be no less challenging, but may be a little less frustrating (oh, and that our companies' obligations change to stakeholders rather than stockholders, but that may be asking far too much!).

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