Autopoiesis: building a bridge between knowledge management and complexity

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Complexity science, as acknowledged by the publication of this book, has significant implications for the field of Knowledge Management (KM). The implications range from the philosophical (Cilliers, 2000a; 2000b) through to the practical including the possibility of new tools and techniques (Snowden, 1999; Kurtz and Snowden 2003). There is, however, a significant barrier to the application of ideas from complexity to the practical world of organizations and KM. This barrier has two related parts: (1) the lack of a consistent epistemology for considering knowledge, organizations and complex social phenomena and (2) confusion about the ascription of knowledge to logical levels - a manifestation of the micro-macro problem in social science (Coleman,1994, Goldspink & Kay 2004).

In this chapter we address both aspects of this barrier by building a bridge between complexity and knowledge management. In our view, this bridge exists in the form of Maturana and Varela's (1980) theory of autopoietic systems. Adopting it requires a move away from the reified view of knowledge that dominates most discussions of KM to one of knowledge which is deeply situated and contextualized. We will argue that social systems – including organizations – are complex systems of a particular class – they comprise human (biological, reflexive) agents. This has important implications for the range and type of behaviors we can expect from organizations, but it also has implications for how we theorize about them.

Perhaps because of its origins in the natural sciences, the epistemic implications of complexity applied to organizations have been appreciated by only a few researchers, Paul Cilliers prominent among them. The moment we wish to study or strategically

influence complex systems which are comprised of human agents we need to have a consistent framework for understanding what the defining characteristics of this class of complex systems is and what its implications are. That consistent framework, we argue, is supplied by the theory of autopoiesis. Not only does autopoietic theory provide a coherent and compatible epistemological basis for the study of complex social systems, it also provides a means through which to address the micro-macro divide and therefore the basis for a 'complex' view of KM.

This chapter will begin by briefly reviewing the way in which the barrier described above has been manifest in both the KM and complexity literatures. This will be followed by a brief description of the key concepts within autopoietic theory, as they relate to KM and Complexity. The chapter concludes with an exploration of the implications of a complex/autopoietic approach to KM.

Different Approaches to Knowledge Management

Over the more than fifteen years since the term Knowledge Management (KM) gained popular currency in organizations, considerable debate has ensued about how it may be conceptualized. Indeed, within organizational research, there would appear to be at least three broad streams of study relating to knowledge and its management (Sveiby,1994, von Krogh & Roos, 1996), with many sub-themes emerging under each as the field has developed. Considering each stream from the perspective of the epistemological assumptions it embraces, the first conceives of knowledge as an *object*. This stream is often associated with information science and information markets. von Krogh and Roos, (1996) refer to this stream as the 'Information Processing epistemology'. The key concern of this stream is with the codification of 'knowledge' into units of information that can be easily moved, sold or attributed value in some form.

The second stream of research views knowledge more as a process and is concerned with the behavioural aspects of organizational life and their effect on the retention and transfer of knowledge throughout the organization. von Krogh and Roos, (1996) referred to this as the 'Network Epistemology'. The key concern in this stream is with the different ways

of connecting people within the organization, with information systems often playing a central role as supposedly the most cost effective means by which this can be achieved. Epistemologically, as with the first stream, a reified view of knowledge is adopted. Partly due to this a further splintering of approaches has become evident:

- that of the individual, where knowledge is seen as the *property* of individual people, (i.e. Polanyi, 1958; 1967), ,and
- that of the organization, where the organization itself is viewed as *having* knowledge. (Walsh & Ungson, 1991;Weick & Roberts, 1993)

The sub-themes created by these distinctions have each spawned considerable literatures of their own, thus making a cohesive view of knowledge in organizations more difficult to discern. This confusion in relation to which level knowledge should be ascribed reflects a particular manifestation of the wider micro-to-macro problem (Goldspink & Kay, 2004). In this case it manifests in the debate about whether knowledge is wholly or predominantly a micro phenomena (i.e. associated with individuals), or a macro phenomena (associated with systems of individuals). This dichotomization is an inevitable consequence of conceiving of knowledge in a reified manner – i.e. as an object. Our aim should be, therefore, to frame knowledge in such a way that we can coherently conceive of the relationship between knowledge held by the constitutive elements of organizations (people) and the *emergent* capabilities that result from their interaction (i.e. organizational knowledge). As such we seek an understanding of the way in which knowledge and patterns of interaction mutually influence each other across logical levels of analysis.

A third stream of research in knowledge management goes some way towards this. This stream identified by von Krogh and Roos, has received relatively little attention in the literature, and is termed the 'Self-referential epistemology'. This view is markedly different from the two perspectives described above and assumes that knowledge is a:

> "...private, history dependent process in each one of us. What knowledge is for you is only raw data for everybody else. Thus, you have always organizational

> knowledge with somebody, and the means to this is language." (von Krogh & Roos, 1996. p334)

In terms of bringing together complexity and knowledge management this third stream is significant for one simple reason: it moves the discussion of knowledge away from the reified perspectives common to the other streams of KM research to a perspective which is more aligned to the approach discussed by Cilliers (2000b).

Cognitive foundations of knowledge: the implications of complexity.

Knowledge begins with cognition and our cognitive capacity is inherent in our biology. Any theory of knowledge management and consequently any application of complexity needs, to be consistent with our understanding of the biology of cognition. If this is accepted then one of the first things we need to rethink is the widespread adoption within KM of the representationalist view of cognition. The idea that we capture understanding of the world in our brains – using some form of symbolic representation as with digital machines, is no longer defensible - we know our brains simply do not work this way. Continuing to use such a metaphor supports the continued idea that knowledge management can be associated with the capturing of salient representations about the real world and the idea that the more 'accurate' the representation the better the knowledge. This is inconsistent with what biology tells us about how we 'know' anything. Once this idea is rejected, with it falls the idea that human action is guided primarily by a rational weighing of facts about the real world and/or on the calculation of some 'utility' by each individual. This assumption is of course the foundation-stone of most management and organization theory.

Within KM, complexity theory is primarily argued to be relevant to understanding macro organizational dynamics. What we are arguing here is that the macro-level dynamics of organizations emerge from the activities of micro-level human agents. Complexity therefore has further relevance in that those human agents are themselves macro phenomena – emerging from the interaction of micro biological agents – cells. To build a bridge between complexity and KM, we ideally need a set if internally consistent theories

that allow us to traverse this cascade of micro-macro boundaries – from our molecular foundations to the highest order social phenomena. At the same time we need to reject the convenient way in which sociologists and organization theorists have avoided becoming entangled in the micro-macro problem by quarantining different levels of analysis. While convenient it means that we can never really explain the emergent nature of social phenomena – we can only provide incomplete descriptions. In this context, the field of complexity is providing us with the tools needed to move beyond this situation.

Our goal in this chapter is to set a model of organization which has the following attributes:

- It is conceptualized so as to capture the salient characteristics of human organizations yet sufficiently open to use it to reappraise a wide spectrum of individual and social behaviour.
- It avoids characterizing organizations in ways inconsistent with the insights currently available from biology and complexity, and;
- Supports the exploration of organizational properties – in particular the interrelationship between micro and micro levels – using methods intrinsically suited to the study of complex systems – such as computer simulation.

The foundations of the Bridge: A biologically grounded theory of how we come to know

While biology is continuing to expand our understanding of human cognition, there exists one body of work which serves to bring together much of what has been understood to date and – uncommonly - which does so in a manner that is consistent with complexity theory. This is the theory of autopoietic systems developed by the Chilean biologists Humberto Maturana and Francisco Varela (1980). Although it is not possible in this chapter to fully describe the theory, a brief outline of the core concepts within Autopoiesis is provided so that the subsequent discussions may be understood.

The theory was developed to provide explanations of the nature and characteristics of living systems (biological cells and meta-cellular organisms). The central idea is that living systems are characterized by their self-production; the components of the system producing the components of the system. The process requirements for self-production then constrain the way in which individuals can interact with and 'know' their environments.

Within autopoietic theory, an individual's behaviour is determined by particular states of nervous system activity (Maturana & Varela 1980), this activity is defined by the concept of operational closure, which presupposes that in all cases nervous system activity results from and leads to further nervous system activity in a closed cycle (Maturana & Varela 1980). Possible and actual changes in state of the nervous system are therefore defined by the nervous system's structure and not external forces. External or environmental forces may act as triggers for change but it is the nervous system's structure that dictates which forces can be a trigger (Mingers 1991). Therefore changes to the structure of one person's nervous system, and consequently their behaviour, will be unique to that person. The environmental perturbations that act as a change trigger in one person will not necessarily trigger a change in another, or if they do, the change that is triggered may take a different form and/or have different implications for the viability of that person in his/her environment, given his/her history.

Although the nervous system is operationally closed it is plastic, its structure changes over time and it is this quality that allows for changes in behaviour and subsequently

what we describe as learning (Mingers 1991). Therefore as the nervous systems structure changes, so too will the potential range of behaviours that its structural-determinacy makes possible. The term used for this history of structural change is *ontogeny* (Maturana & Varela 1992).

Where there is a history of recurrent interaction between two individuals, a structural congruence can develop – they become structurally coupled. We have argued (Goldspink & Kay 2003; 2004) that structural coupling is the mechanism by which all social structures emerge including what we refer to as organizations. Thus structural coupling constitutes the building block for organizational knowledge.

This description of autopoietic theory should only be considered as a cursory introduction to some of the major concepts. The significance of these ideas, however, becomes apparent when they are applied to the notions of cognition, knowledge and organizations, as they define the process by which the individual comes to know of their environment and orient themselves within it.

Implications for understanding cognition.

Varela, Thompson & Rosch (1992), have developed a theory of cognition consistent with the autopoietic nature of living systems. They state that cognition takes place whenever an organism behaves in a manner consistent with its maintenance and without loss of identity, that is, without loss of any of its defining characteristics. This theory challenges the most commonly accepted view of human cognition – that of cognitivism or representationalism. Specifically they state:

> The central intuition behind cognitivism is that intelligence—human intelligence included—so resembles computation in its essential characteristics that cognition can actually be defined as computations of ***symbolic*** representations (Varela, Thompson & Rosch 1992, p. 40) [our emphasis].

Thus representations are defined teleologically - they are intentional, and are "about something for the system" (Varela et al, 1992, p. 44). Cognitivism constructs a duality: the environment is experienced as a facticity and acted upon directly, but is also conceived and symbolically represented in the mind. Mind and behaviour are linked as hypothesis and experiment. This way of understanding human cognition is being increasingly criticised from within biology and other disciplines such as artificial intelligence (AI) and by complexity theorists (Cilliers 1998; Cilliers 2000; Stacey 2001).

Both AI and complexity theories have given greater impetus to *connectionist* theories of cognition (Cilliers 1998). Here emergent structure or pattern arises from massively interconnected webs of active agents. Applied to the brain, Varela Thompson & Rosch point out:

> The brain is thus a highly cooperative system: the dense interconnections amongst its components entail that eventually everything going on will be a function of what all the other components are doing (1992, p. 94).

It is important to note that no symbols are invoked or required by this theory. Meaning is embodied in fine–grained structures and patterns distinguished throughout the network. Symbolic approaches require a direct mapping—symbol to symbolised: implying

availability of a tangible referent, or at least a referent that can be mapped with minimal ambiguity. Connectionist approaches can derive pattern and meaning by mapping a referent situation in many different (and context dependent) ways. Meaning in connectionist models is embodied by the overall state of the system in its context. It is implicit in the overall 'performance in some domain'. Needless to say, if knowledge is not embedded in symbols 'it' cannot be stored in a database.

Varela et al note that:

> …an important and pervasive shift is beginning to take place in cognitive science under the very influence of its own research. This shift requires that we move away from the idea of the world as independent and extrinsic to the idea of a world as inseparable from the structure of [mental] processes of self modification. This change in stance does not express a mere philosophical preference; it reflects the necessity of understanding cognitive systems not on the basis of their input and output relationships but by their *operational closure* (1992, p. 139).

They go on to argue that connectionist approaches, while an advance on cognitivism are not consistent with an approach which views biological agents as operationally closed (i.e. as autopoietic) in that "… the results of its processes are those processes themselves" (1992, p. 139). They assert:

> Such systems do not operate by representation. Instead of *representing* an independent world, they *enact* a world as a domain of distinctions that is inseparable from the structure embodied by the cognitive system (1992, p. 140).

It is this theory of cognition that is reached by following the implications of the autopoietic view of living systems. There is no objective independent view of a world which can be captured in symbols which have widely shared meaning and which can be captured, stored and managed. Knowledge is 'in the system'. Cognition as 'enaction' implies an intertwining of experience and conceptualisation which results from the structural coupling of an autonomous organism and its environment. Here environment recedes from determinant of knowledge to constraint. Intelligence moves from problem solving capacity to flexibility to enter into and engage with a shared world. It is intrinsically and necessarily social and contextual.

The advantage of linking the theory of autopoiesis and complexity is that it provides a consistent framework that links both the constitutive (micro) and emergent (macro) dimensions of social organization in a manner consistent with what we understand about the defining character of humans as biological and reflexive linguistic agents.

Autopoiesis provides a model of how social phenomena emerge from the complex (and non-linear) interplay between the heterogeneous (in having unique ontogenies) agents (people) which make it up. From this perspective, organizations or social systems can be seen as a specific class of complex systems and it is autopoiesis which clarifies the distinguishing characteristics of this class, in particular the linguistic/reflexive character of social agents.

The nature and role of Knowledge in Organizations

Maturana and Varela have provided a biological grounding point for a complex systems understanding of knowledge in organizations. In this understanding, knowledge is defined as a process of bringing forth 'a' world. That world is the lived experience of the

individual as he/she responds to his/her environment. Within this conceptualization, the notions of 'doing', 'being' and 'knowing' are all bound into the single notion of knowledge and all are subject to structure-determined processes of change. The range of behaviors available will depend on the individual's history of interaction with others – his/her ontogeny. As the nervous system's structure changes in response to the environment, so too will the potential range of behaviors that its structural-determinacy makes possible. As an observer we might call someone 'more knowledgeable' if, after observing them, we notice that they generate a wider range of behaviors or are more successful at satisficing the constraints they confront in that environment. Over time a human being may extend the behavioral repertoire he/she can generate and this we call learning – the gaining of knowledge. Knowledge may therefore be considered as the range of actual and potential behaviors that an individual may generate to respond to and remain viable within any given environment. This is however a judgment made by an observer and is a comment on that observer's assessment of the quality of the responses the subject generates. The observer is noticing a macro (emergent) pattern and ascribing to it certain qualities. This brings us to how we may understand the relationship between individual learning (as described above) and an organizations capacity to survive in its environment.

We have so far considered the pathway by which order is generated bottom up – from micro to macro in a way that reconciles it with biological constraints and describes the particular mechanisms that operate with biological agents – humans. But what of the top-down, macro and micro processes, how can these be resolved within this framework? Within autopoietic theory this top-down process is explained through the dynamics of the

individual's relationship with their environment. The ontogeny of each individual, while unique to that individual, is also a product of its interactions with others – it is a co-evolved structure which is the product of structural coupling. Each agent is constrained to interact in a limited way - not by the other agents in a direct causal sense but by virtue of its structural determinancy. The individual adjusts their behavioural repertoire as a function of their interactions with those other agents (its nervous system is now geared to produce a learned limited subset of responses). In this sense the collective aspect of knowledge is 'in' each agent – it is reflected in the constraints embedded in its nervous system. What we have described so far could be applied to any social animal. There is however another pathway between macro and micro that is unique to humans[1].

The capacity in humans for reflexive self-awareness is central to this. Maturana and Varela attribute this capacity to the development of a critical level of plasticity in the nervous system. It is associated with the capacity to 'coordinate the coordination of action' in and through language. A human agent may become an observer of self and of others and the observations he/she makes play a role in the social process.

One of the implications of this view is that 'knowledge' relates to an observed capacity to remain viable in an environment. It is an ex-post attribution by an observer and as such it plays no role in any organizational process unless:

- the observer is a participant in the process (i.e. is one of the agents of the network which is giving rise to the observed pattern) or;

[1] It may apply to other organisms which have evolved a capacity for self-awareness such as some apes and cetaceans and possibly elephants but the evidence is not yet clear on this, perhaps due to our inability to create a common language with them.

- if the observer was external, he/she becomes a part of that system by communicating his/her observations such that those being observed respond by changing their behavior.

Note that this mechanism highlights a distinctive feature of human complex systems – an evolved capacity to distinguish self from other and to be reflexive – i.e. observe macro pattern and respond to it thereby changing the micro-process and potentially, at the same time, contributing to a change in that macro pattern.

Of course every human agent that makes up an organization is an observer. The distinctions and attributions made by each will be based on their unique ontogeny. However, as this ontogeny is a product of a shared process (resulting from their structural coupling with others) it is both a product of and the means for maintenance and generation of organizational knowledge. Note also that none of the distinctions made by an agent can be seen, a priori, to have a privileged position – none represent a 'true' knowledge. Different distinctions made by different participant/observers will have different implications for the trajectory of the organization and its viability in any environment. Those implications are, however, dependent on the time and place of their occurrence and the state of the system as a whole at that time – they cannot be anticipated in advance.

As each agent has a unique ontogeny, the macro observation that each makes will itself be unique (this is to say that the macro pattern will look different and have different meaning from the reference point of different agents) and hence will also have different behavioural implications. In this sense the pattern is instantiated uniquely in each and every agent and yet is also a product of this process. It is the difference (at the micro

level) which gives rise to the commonality (at the macro level) because the difference at the micro level is itself a product of the history of arriving at the commonality at the macro level. Looked at another way, knowledge 'bootstraps' from ignorance as agents act in a common environment and enter into recurrent interaction as they seek to remain viable in that environment.

What does this imply about the constitutive nature of an 'organization' and what the literature refers to as organizational knowledge? The first observation that needs to be made is that knowledge, existing in patterns of distinctions, requires a distinguishing entity, i.e. a living system. As distinctions themselves, 'organizations' are not entities in a distinguishing sense (Kay, 2001). Indeed this point is emphasized in the ongoing debates within the literature on autopoietic theory regarding the ontological nature of organizations. In our view, to consider organizations as knowledgeable in themselves constitutes an inappropriate reification which denies the basis for their *emergence* in and through the structural coupling of the humans which give rise to them. Organizations are distinctions not distinguishers. This is to say organizations cannot 'have' knowledge.

That organizations can be distinguished by an observer to have changed their patterns, exhibiting variation, selection and retention processes (Aldrich, 1999) in a purposeful way is to confuse outcome with process. Complexity theory can aid the development of our understanding of the process by which these changes occur. However, it can only do this if we are mindful of what the general principles of complex systems translate to within biological and, more specifically, human systems.

The reflexive and recursive nature of this process, as we have seen above, requires a clear epistemology accounting. Without this accounting it is easy to become confused and to see knowledge as a cause rather than the endpoint of a process.

Conclusion

Complexity has been demonstrated here to have profound implications for our thinking about knowledge and organizations and hence Knowledge Management. When applied to the domain of social action, complexity implies the need to adopt a radically different view of the origins of and nature of knowledge. This is because when we consider that organizations are complex systems of a particular class – ones comprised of human (biological reflexive) agents, we are drawn to a very different understanding of the origins of social structure and hence the nature of organizations as well as the nature of cognition. As well as causing us to rethink the implications of complexity for knowledge at an individual level this approach requires us to question what we understand about the constitutive nature of an 'organization'. We are compelled to consider the organization as a distinction made by an observer. As a distinction (and not a thing), it cannot itself make distinctions and so cannot 'have' knowledge.

Here we have presented a view of knowledge where what the observer identifies as 'knowledge' is an attribution based on the observation of coordinated behaviors at some level of the organization. Knowledge does not cause anything – it is not a basis for, nor

the origin of coordinated behaviour, it is an attribution that denotes (for the observer) the presence of some attribute in the quality of interaction being observed.

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