Chaos Theory and Information Systems

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Abstract

The application of chaos theory has recently spread from the physical and biological sciences to organisational theory. This paper explores the relevance of chaos theory to information systems research. Chaos theory focuses on the behaviour of dynamic systems that are inherently unstable. They do not manifest fixed, predictable behaviour, rather their behaviour is non-linear and aperiodic.It is suggested that chaos theory has application in information systems where the effects of an information system within an organisation are often unpredictable and unintentional. Four themes are derived from a discussion of chaos theory: the importance of emergent behaviour, the influence of an essentially arational body of knowledge on decision-making and information systems development, the significance of choice and selection and the significance of chaos theory for the prediction of the effects of information systems. Chaos theory provides a means of extending our descriptions of information systems and sensitising practitioners to some of the problems in information systems.

INTRODUCTION

Information systems are generated as artefacts of human organisations. They constitute traces, impressions, imprints of a living, dynamic organisation, captured at a specific point in time and space and recorded as electrical signals in a computer system. They are representations of how human actors, inside and outside the organisation, believe the organisation works, the processes as they see them, the data they believe describes the organisation and its interests.

The information system is attempt by actors within the organisation to concretise concepts, tacit understandings and social process, to provide an objective description of the organisation, to algorithmically compress the elements of the organisation into a form in which the maximal informational content is communicated through the shortest possible description (Chia, 1998). The generation of an information system is an exercise in isolating a description of the organisation that is reduced, made simple and controllable. It is an exercise in creating stability, applying individual control and indicating intentionality. The very idea of modelling indicates a reductionist approach in which the elements of an organisation are simplified and rendered context-independent. The organisational process and dynamics are cast as a problem to which an information system provides the solution. They render the organisation explainable and manageable. They provide an apparently objective view of the organisation which a manager can control as if he or she were outside the situation, objectively observing and controlling (Introna, 1997).

For structured, repeatable processes within organisations information systems work effectively. These processes - the issuing of a telephone bill, the printing of paycheques, the updating of bank accounts - can work effectively, providing the administrative efficiency and stability that enables the organisation to survive and pay attention to more strategic issues. In these case the problem is easily generalisable, involving simple puzzles that can be isolated from their context and solved (Griffin et al, 1998). However, even for these problems the development of the information system is fraught with danger. The complexity of organisational networks and the difficulty in persuading different actors, groups and personalities to agree on the generalised solution can result in the failure to deliver systems to deal with seemingly straightforward problems. Here the complexity of the interacting processes, the multiplicity of business demands and political agendas, and the technological difficulties can render the development of a viable information system difficult or

impossible. Consider the problems of the London Ambulance System, the failure of Taurus, or the complexity of delivering systems to support the opening of the market in utility companies such as gas and electricity.

Such factory systems frequently fail to met user requirements. Organisational requirements drift from those modelled in the systems, enhancement and maintenance are inevitable. Dissatisfaction with the delivered information system is common even with the simplest systems. How much more difficult it is to create effective information systems to support decision making and group processes, to provide the organisational backbone, to support the information flow within the organisation. Systems to objectify, control and isolate complex webs of organisational issues tend towards failure, misuse or disuse. In attempting to provide a concrete form to organisational activities which are often tacit, indistinct and evolving in nature, these system ignore the dynamic flux of organisational form and activity. They try to provide certainty in the face of uncertainty, objectivity in the face of subjectivity, uniformity in the face of multiple contexts and views, and static, designed processes in the face of dynamic, evolving processes.

Information systems act on organisations by halting, or at least slowing down, the interminable change brought about by organisational dynamics. By slowing down organisational change through the process of fixing organisational activities in an artefact, they lend stability to organisational processes and enable purposeful action. Without the classification of organisational objects and the locating of the organisation in stable time and space we would end up with a vague, unwieldy and shapeless mass of human experience (Chia, 1998). Information systems are tools for the simplifying of the complex. By focusing on particular organisational elements they render the world more controllable. This focus is clearly essential. However, the focus is achieved at the expense of context. In creating this temporary stability and order, we mask the dynamic and chaotic nature of the organisation. We suppress the tacit knowledge, the politics, the interpretive experience, and the cumulative influence of the organisation s history and development. These complex organisational dynamics do not go away. They bubble away under the surface, frequently emerging and creating unexpected effects on the information systems and organisations.

It is surprising, then, how many information systems succeed, at least far enough to support the continued existence of organisations. It is also surprising that the gap between the organisation modelled in an information system and the organisational reality is not larger and that the damage caused to organisations does not outweigh the benefits more frequently. Perhaps this is a function of the extent of dependence on information systems and willingness to invest continually in IT. We cannot live without them, but we struggle to live with them in a harmonious environment. We experience a series of gaps, or mismatches, between the information systems understanding of organisational structure and dynamics and the reality, between the modelled system and the technological artefact, between the fixed, defined requirements and the continuously drifting user requirements. There is a gap that we are always aware of. This gap between prepositional knowledge and organisational narrative (Chia, 1998), between the reductionist, objective, scientific model and the diverse, complex, subjective human systems plagues the discipline of information systems, its research and practice.

The discipline of information systems stands in this gap and struggles to reconcile computer science and management. We are aware of the inadequacies of surveys and the identification of success factors for example, to explain the role of information systems in organisations. And yet we know that the provision of narratives and stories provides little of concrete value in terms of certain and reproducible principles that IT managers and business managers can take hold of in everyday practice and planning. This gap plagues the development of information systems, the attempts to turn user requirements into delivered system and to cope with the ever-changing dynamics of organisations. Information systems may be located on the edge of chaos (Beinhocker, 1997), balanced between the order stability of reducible, intellectually analysable scientific systems and chaotic, unpredictable, intuitively understood social systems.

If we are to understand how ideas for information systems emerge, how they are developed, become embedded in the organisation and finally reach obsolesce, and if we are to advise organisation on the progress and planning of systems, we need to develop new theories that provide better explanations of the organisational phenomena of information systems and realistic guidance to practitioners on the organisational integration of information systems.

The information systems discipline should draw strongly on sources in organisation studies, social psychology, sociology and strategic management. Ideas from the organisational literature should be used and interpreted to shed light on the distinctive problems in the study of information systems. One such field of study which has recently received attention in organisational studies is the area of chaos theory and complexity science. Dynamic approaches to strategic management are being developed (Stacey, 1996). Organisations are being considered as complex, dynamic, non-linear systems which do not evolve in a steady, predictable way. These ideas should resonate in the field of information systems. This paper briefly overviews some of the concepts in chaos theory and considers their applicability in information systems for explaining the phenomenon of information systems in organisations. While the concepts of chaos theory may provide some help in the explanation of information systems in organisations, it is difficult to identify their applicability in predicting management practice or providing generalisable principles since unpredictability is part of the nature of chaos theory. Furthermore, since, as Griffin et al (1998) and Chia (1998) discuss, chaos theory and complexity science can be applied in ways that are both objective, scientific, reductionist and generalisable and that are subjective, interpretive and individualist, the theories may not promise significant progress in crossing the conceptual gap which plagues information systems study. However, they do provide a means of extending our descriptions of information systems and sensitising practitioners to some of the problems in information systems. Their value in the latter case may lie in the extent to which they resonant with the practitioners experiences.

THE CONCEPTS OF CHAOS THEORY

The concept of chaos suggests an absence of organisation, a disorder in which uncertainty and unpredictability predominate. This would seem a strange field of study to unite with information systems which is predominately concerned with order. However, chaos refers to what might be called ordered disorder. The idea of chaos is

married to that of complexity. Complex systems may exhibit chaotic behaviour which is not a lack of order, but order of a complexity that is difficult or impossible to describe in simple terms, that cannot be broken down into simple equations, that requires complex narrative to describe it. The patterns in chaotic behaviour are present, but not regular or easily predictable. While we are considering chaos in the context of organisations, which hold a complexity of human behaviour and action which will give rise to chaotic phenomenon, it should be noted that some of the simplest phenomenon, for example, a pendulum swinging amongst magnets or a simple population of fish in a pond, can give rise to chaotic behaviour in which the way the pendulum will swing, or the way the population of the pond will change are chaotic and unpredictable. The concepts of chaos may support a better explanation of organisational behaviour than the more traditional explanations of scientific management because organisations are complex and dynamic phenomenon.

The study of chaos theory has been defined as *the qualitative study of unstable, aperiodic behaviour in deterministic, nonlinear dynamic systems* (Kellert, 1993 quoted in Tsoukas, 1998). It is itself part of dynamical systems theory, a branch of system theory with a strong mathematical foundation. This strong scientific foundation attracts many management theorists to the ideas which have been legitimised through their use in physics, biological sciences and economics. However, the concepts may be used as a vehicle for treating organisational phenomenon in an interpretive manner. Their use is not limited to positivist research approaches.

The following discusses the terms in the above definition.

Qualitative. The element of qualitative study is clearly of interest to the information systems researcher who takes an interpretive stance. Rather than taking a quantitative approach, in which precise variables are measured at a certain point in time, chaos theory lends itself to a interpretive approach in which patterns emerge over time. The interactions of actors within the organisation, and their effect on information systems is best served by narrative studies which draw out patterns of behaviour and in which paths of influence can be traced. Therefore we would seek through narrative discussion of the development of an information system, for example, to show how events have influenced its progression and to analyse the process using the concepts of chaos theory. Indeed the chaotic patterns of organisational behaviour in the adoption of information systems cannot be studied by the collection of information at a single point in time. Surveys may be singularly inappropriate for unearthing phenomenon which depend on the repeated influence of historical events and context on the current system.

Unstable. Many organisational studies and information system studies assume that organisations reach some stable optimal state. Stages of growth models for defining the progression of information systems in organisations and software development models such as the Capability Maturity Model assume that knowledge and understanding of the development and use of information systems within organisations progresses stepwise towards an optimal level of maturity. Chaos theory would support the idea that organisations and IT structures never settle into a mature, stable situation. Not only can things progress backwards, but also forwards by unpredictable leaps. Furthermore, the unstable behaviour of IT within an organisation will not resist small disturbances. Small changes in management style, changes in

suppliers, small incremental upgrades of software can have unexpected and catastrophic consequences. The effect of small events, be they technological or managerial, have wide reaching effects on the development of IT within the organisation. This is the so-called, iconic, butterfly effect phenomenon, where it is imagined that the flap of the wings of a butterfly in South America, causes storms in the North.

This sensitivity to initial conditions is a distinguishing feature of chaos (Tsoukas, 1998). In studying how information systems come to be present in an organisation, it is important to study the initial conditions, and the string of events, often individually insignificant, which have large effects on development and procurement decisions. For example, in one organisation the discovery of the idea of decision support systems, as a result of a visit to a trade conference, led an IT manager to move an organisation s IT in a new direction. Another example might be where a decision to commit to one type of technology or supplier had unexpectedly large effects at a later time when a change in IT platform was considered and found to be impracticable.

The effect of initial conditions and small events in the history of an IS development within an organisation will be amplified by feedback. This is a key idea of chaos theory, that future state of a system, for example, the IT department or a particular business information system in an organisation, depends on an earlier state. This can be described as an iterative operation of a function upon itself. For example, in the case of a fish population, the current level of the population f(x) is dependent on its previous state, multiplied by a growth factor:

$f(x) = K(f(x))$.

If we then add a limiting factor, say determined by the maximum population that the pond can sustain:

$f(x) = K(f(x))\ (1- f(x))$,

chaotic behaviour ensues as a result of this feedback.

Such feedback gives rise to emergent properties and new patterns of order. The amplification of errors, for example, through feedback operating upon the results of successive steps in a system development procedure may result in unexpected effects, a failed systems development project or one that takes a significantly different direction from that originally planned.

Feedback in organisational behaviour, in which the effects of previous decisions or environmental events are amplified, will make it impossible to identify in a research context the exact effect of a particular organisational variable on the outcome of an information systems project. The results of factor surveys can easily be brought into question: There are few problems in the social sciences where the value of one of more explanatory variables has not been influenced at some point in time by that which we wish to explain (Eve et al, 1997, quoted in Tsoukas, 1998). Chaos theory would suggest that naive attempts to identify information system success factors are bound to be inadequate or fruitless. Past events and history will always have a distinctive and unpredictable effect on present activity and future plans. There is a real

persistence of the past in the present (Chia, 1998). Griffin et al (1998) give the example of a manager who realised that it would be necessary to go back to the inauguration of the company, or even before , to fully describe the evolution of a single decision .

Aperiodic. Chaotic systems do not manifest any fixed, permanent patterns. Variables associated with the system do not repeat values, although they remain within a fixed, definable space. Such aperiodic behaviour is highly complex and permanently sensitive to small perturbations. However, it is not in a state of total disorganisation nor is it patternless. Studies of fractals illustrate this. Patterns emerge, persist for a while and then die off to be replace by apparent randomness and then the birth of new patterns. These patterns are dynamic, never exact copies and in a state of flux. Indeed, the randomness may not be random, but an expression of patterns which are too complex to perceive. In information systems development patterns may emerge and guidelines may be established on their basis which provide some value for the organisation. However, it is a mistake to think that these patterns are fixed in time and space or are context independent and generalisable. A chaotic view of information systems must also be a contingent view, accepting the important of context, both spatial and historical in the development of an information system.

Deterministic. Tsoukas (1998) suggests that chaotic systems are deterministic in that, given the initial conditions, there is one unique end point or goal of the system which can be mathematically derived. Small changes in the initial conditions may generate very different endpoints. If we consider an isolated system, in which initial conditions are determined and the system then runs to completion without any further intervention, then we can clearly determine the endpoint. Complexity is magnified with organisational systems where, not only is the system sensitive to its initial conditions, but there is a constant intervention, a constant adding of new conditions, constant environmental change whether resulting from the human actors within the system, organisational effects or external environmental effects. The expression of this in precise mathematical terms becomes humanly impossible and we are reduced to narrative description and interpretation by the observer. A qualitative approach is demanded in which we analyse general patterns, identify relationships and transformations, and seek process explanations. The static analysis of the value of variables at fixed points in time is inappropriate.

Nonlinear. The progression of chaotic systems, such as organisations, is characterised by changing patterns which never repeat themselves. The progression of these patterns is not linear, rather periods of inactivity may be punctuated by sudden change. Patterns of interaction are developed over time, affected by feedback loops. The history of an organisation does not progress in a linear manner, improving stepwise towards a goal of maturity. Tsoukas (1998) describes the circular texture of organisational phenomena in which old practices are perpetuated through feedback and new practices emerge unpredictably. Old mistakes are repeated in new original ways. IT departments do not learn from previous failures or successes. However, even if lessons are learnt from previous IS development experience, chaos theory would suggest that the recording of those lessons in terms of standards and best practice will not guarantee future success since the unexpected will occur, new patterns will emerge and intentional practice will result in unintended, unexpected effects.

Dynamic. It goes without saying that organisations are dynamic and changing. They are in a constant state of flux, being created (or born), developing and dying. They are constantly learning, changing in response to environmental forces, changing human networks and changing concepts. Chia (1998) identifies a concept of dynamic complexity: there is an inherent fluidity in [organisational] situations ; human systems are by nature fluid, transient and perpetually changing ; organisations may be described as perpetually changing configurations of relations which are continuously transforming themselves .

It is not surprising that attempts to fix user requirements often end in failure; that developers criticise users for never making their minds up, without attempting to understand the dynamic environment within which they are working; that a gap between information systems and the requirements appears almost before implementation is complete and rapidly widens. There is, consequently, a need for information systems to be made more flexible and to recognise the need for adaptation. However, this should not exclude a need for some stability in business practice, a recognition that some business processes change more slowly than others and that some basic information systems can be provided which, while not meeting the exact organisational requirements (an impossible task due to the inherent flux of organisational processes), are good enough for the job and provide a stable basis for some everyday transactions.

Information systems practitioners and developers tend to act as if the organisation and its processes are stable and static, capable of being analysed and encoded permanently in an information system. Although the attitude of the IS department is often one that seeks change in technology and systems, its expectations of the organisation which is serves are different: IT expects to model stable systems. Chia (1998) suggests that every stable situation that we observe occurs because our rate of change is coincident with the rate of change of the system we are observing.

THE CONSEQUENCES OF CHAOS THEORY

The ideas described by chaos theory have relevance for both researchers and practitioners. In this section we briefly develop four themes of relevance to researchers: the importance of emergent behaviour, the influence of an essentially arational body of knowledge on decision-making and information systems development, the significance of choice and selection and the significance of chaos theory for the application of information systems research and prediction.

Emergent Behaviour

One of the key ideas that follows from chaos theory is that organisational behaviour and consequently information systems behaviour, in terms of for example, usage, implementation, spread and business effect can emerge in a manner which cannot obviously be predicted and is not easily explained by looking at the isolated behaviour of the individual parts of the system. Chaos theory suggests that the aggregated behaviour resulting from the interaction of simply described constituent parts produces unexpected levels of complexity and novelty. The interaction of business units even with simple individual behaviours result in a complex web of organisational behaviour which is neither easily explainable nor predictable. Simple

rules of interaction may give rise to highly complex structures that no one thought of before (Tsoukas, 1998).

A key aspect of this emergent behaviour is the effect of feedback, as discussed above. Small events have large effects. For example, the discovery that an editorial system within a newspaper was not Year 2000 compliant has led to the procurement of a new state-of-the-art commercial package for the editorial department. The procurement was not intended and went against established policies that all systems should be developed in-house for reasons based on costs. This unexpected procurement has resulted in a recognition that the nature of the editorial task can be changed significantly, changed motivation and orientation to jobs and a spreading dissatisfaction with the existing technology within other organisational functions whose shortcomings are highlighted when compared to the new system. Furthermore, changes in motivation are leading to changes in dress and attitude, according to the managing director. These changes are ongoing and may lead to even more significant effects on the business in the future. Thus a small technical event - the lack of year 2000 compliance - may lead through a trail of events to dramatic organisational changes; all amplified by feedback.

Since the intentional leads to the unintentional and events link together resulting in cumulative effects, it is essential for the information systems researcher, in seeking to provide explanations for emergent phenomena, to pay detailed attention to the interlinking historical events, the trail of actions and reaction, which over time leads to successful implementation of a information system or to abject failure. Researchers have used the ideas of chaos theory to explain, for example, the 1987 stock exchange crash. Such approaches may fit well into information systems research.

Previous interaction brings about the organisational rules, roles and meaning that is currently experienced. Chaotic behaviour gives rise to a circularity of events. Patterns of information systems development repeat themselves in ways that are intuitively similar but are not stable, linear or predictable. Chaotic behaviour does not mean random behaviour but behaviour that is irregular and variable. General patterns can be analysed but the precise behaviours of variables at particular times is not predictable. It is the information systems researchers task, through narrative, to identify these chaotic patterns, which could be described as organisational fractals, and describe them in ways which resonant thorough the research and practitioner community. It is through this resonance that information system research may lead to change in practices or new practices.

The emergent behaviour between information systems and the organisations they inhabit may be described and understood better through the application of the concepts of chaos theory. Information systems, because of their social foundations may not be reduced to objective certainties or prescriptive frameworks.

The Arational Body of Knowledge

When an information systems researcher seeks to understand the body of knowledge within an organisation that leads to decisions and actions, it quickly becomes clear that little of this is embodied in the information systems. The knowledge that leads to decisions, activities and products is primarily tacit and difficult to encode. It involves

experience, intuition, creativeness and insight. Frequently, the more significant knowledge within organisations concerns change, progression, events, movements and activities. Information systems are good at storing knowledge about objects but hit difficulties in describing process, progression and change.

Decisions are based on understandings, prejudices and opinion embedded in the history of the organisation. We are working in a domain where knowledge is based on opinion as much as scientific and verifiable facts. Movements of markets, investment decisions, and business judgement are often based more on opinion than hard facts, despite the intervention of information systems. Decisions are based on past histories, or at least the manager s present understanding and interpretation of the past. These decisions are likely to be arational - not irrational or random, but not explainable in simple logical words, in other words chaotic.

A key element of this arational body of knowledge which drives organisational decisions, creates chaotic patterns, unpredictable and novel consequences and complexity greater than that envisaged by the initial decision is the prejudices of the organisational actors. These prejudices may be derived from past history (individual and organisational) organisational form, culture and context. They are of great interest to IT practitioners because they explain the apparently irrational decisions which managers may make concerning the development of IT and the acquisition of systems. But they are not irrational if understood in terms of prejudices and the sequence of historical events which leads to a present organisational situation. The prejudices are part of the initial conditions which give rise to the information systems phenomenon for which we are seeking an explanation. Chaos theory suggests that our organisational system may be very sensitive to these initial conditions.

The information systems researcher should understand that there are layers of knowledge beyond the simple rational data held by the information system, be it a simple database or an Intranet. This arational knowledge lends complexity to the organisational system. An understanding of its influence on information system development and implementation may be helped by the use of chaos theory concepts as an interpretive tool. The body of arational knowledge within the organisation must be recognised by the researcher. We must ask: what is that knowledge and what is the population of conclusions that could be selected based on that knowledge? Each conclusion will lead to a different events pathway, to different patterns and complex organisational outcomes.

Choice and Selection

Key to the emergence of organisational behaviour and the development of complex and chaotic interactions within information systems are the choices available and the selections made by organisational actors. Furthermore choice and selection are key elements of information systems. The use of an information system involves choice and selection: which menu option to select, which record to alter, which description to select. The development of information system involves choice and selection: which object to include and which to exclude, which process to model and which to ignore, which technical platform to use, which user to enrol in the development process and

which to omit. There is also choice and selection involved in the development of information systems strategies. All these selections, which may be individually simple, contribute to the give rise to complex and unpredictable behaviour as suggested by chaos theory. Simple choices made by individual actors act in concert to create effects that are greater than the small choices would suggest.

The organisational actor has the freedom to act in ways which, influenced by the arational body of organisational knowledge gives rise to emergent behaviour. This emergent behaviour, based on selections made, gives rise to adaptation to the environment. The organisation adapts to the business environment, the information system adapts to the organisation. This adaptation does not give rise to equilibrium and stable states but creates further instability, because the elements that the information system is adapting to are themselves changing. This adaptation is irreversible - you never go back to a previous state, although you may enter a state which is worse than the previous. Furthermore the selections made by individual actors or system affect each other such that co-evolution occurs. The interaction of selections give rise to event paths that lead to the conditions the researcher is trying to explain.

Therefore it is important that the information systems researcher understands the possible choices and the actual selections made within an organisation in determining how an information system has emerged.

It should be noted that what is not select may be as important as what is selected. Options not selected may have significant effects at a later stage. For example, not selecting a particular technology platform may cause problems if that technology is used by suppliers or customer at a later time, resulting in cross-organisational incompatibility.

Prediction

The selections made by organisational actors may be unpredictable but not unintelligible. Interpreted in the light of historical paths of events it may be reasonably clear why an IT investment decision was taken and why it resulted in particular outcomes. However, this could not be predicted. The chaotic system precludes the possibility of long term prediction, not because the patterns are not there but because their complexity is such to defeat human and machine intelligence. In the chaotic system the identification of highly predictable factors in, for example, information system success, is difficult, if not impossible. Rule based methods will break down and fray at the edges where they come into contact with organisational complexity.

In predicting the behaviour of an organisation in response to an information system and the effect of the information system on the organisation simulations may not help and cast-iron theories may not be appropriate. The emergence of technological change is path dependent, understandable in hindsight but not predictable.

It is not the position of the information systems researcher to provide prescriptions for information system practice as a result of her research. Rather, in using a chaotic style (Tsoukas, 1998), the researcher seeks to present the choices and indicate general

outcomes of some selections. Importantly, by understanding the role of historical sequences of events in establishing organisational patterns the researcher can highlight the presence of past influences in current activity.

CONCLUSION

While information systems are developed in order to simplify and fix organisational behaviour, their interaction with the organisation results in complex behaviour which is emergent and unpredictable. Newer information systems such as Intranets and the Internet do not even simplify organisational behaviour: they provide an increasing complex web of information and knowledge which may add to the complexity of the organisation.

An understanding of this complexity requires new frameworks and approaches to thinking about information systems. Chaos theory and complexity science may provide a contribution to this. Information systems behaviour within organisations emerges as a result of many small interactions between the system and the organisation. The effect of the small events is enhanced through feedback resulting in complex behaviour with could not obviously be predicted from the individual small interactions with the information system.

The information system researcher seeks to understand the role of information systems within organisations and the process by which they come to be established, and to influence organisational dynamics and behaviour by analysing the historical event paths and identifying the initial conditions. An understanding of opinions and prejudices, and of the possible choices available and the selections made can lead to a rich understanding of information systems phenomenon expressed through narrative and its interpretation.

But where does Chaos theory get us when we need concrete solutions to information systems problems? How do we deal with issues of return on investment, translating requirements into artefacts and planning IS strategy if the future is unpredictable? We recognise that, based on previous emergent behaviour and the arational pool of organisation knowledge, IT decisions are made from a pool of choices. The information systems researcher can seek to contribute to the pool of arational knowledge in such a way that the intuition of the manager is enhanced such that new decisions are more suited to the complex, adaptive organisational environment.

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