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Theory of emergence: introducing a model-centred approach to applied social science research

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This paper explores a model-centred approach to augment the development and refinement of the theory of emergence. Its focus is on the relational process of leadership as an emergent event in complex human organisations. Emergence in complex organisations is a growing field of inquiry with many remaining research opportunities, yet a number of its central themes continue to be loosely connected to practical application and reliant on equivocal translations from root meaning. This paper offers a novel model of semantic conceptualisation of theory and phenomena with simulations to strengthen the theory–model–phenomenon link, building on the work of previous authors. Strengthening this link yields numerous applications, including making sense of complex organisational dynamics and supporting a wide range of theory-building research methods in applied social science and interdisciplinary research. The paper begins with a reflection on the main ideas of the theory of emergence, followed by discussion on prevalent model-centred approaches. A programme of semantic conceptualisation to expand real-world application of the theory of emergence is proposed.

Introduction

Over the last few decades, the study of complex systems, known as 'complexity theory', has been making its way into the social sciences (Anderson, 1999; Goldstein, 1999; Wheatley, 1999; Marion and Uhl-Bien, 2001; Osborn *et al.*, 2002; Plowman, Solanski *et al.*, 2007). This relatively recent application of complexity principles has generated a deeper understanding of the non-linear, complex and adaptive behaviours within and between organisations that give rise to the emergence of form (Lichtenstein *et al.*, 2006; Uhl-Bien *et al.*, 2007). Complexity theory applies an understanding of leadership and organisation less as an art of prediction, and more as one of sense-making, cultivated participation, interaction and influence between individuals across all levels of the organisation where leadership itself is viewed as an emergent event (Lichtenstein *et al.*, 2006). However, the utility of the concept of emergence in applied social science research and practice relies on a tenuous theory–phenomenon link which, as argued in this paper, remains relatively underdeveloped despite its central importance to the robustness of theory and its real-world application. The effective isomorphism of theory and structures in real-world behaviours is vital to the reliability of theory, without which there are few reasons to believe a theory of emergence for human organisation exists (McKelvey, 1999).

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This paper presents a model-centred approach to augment the development and refinement of the theory of emergence. Its focus is on the relational process of leadership as an emergent event. The paper begins with a reflection on the main ideas of the theory of emergence, followed by discussion on prevalent model-centred approaches. Finally, a programme of semantic conceptualisation to expand real-world application of the theory of emergence is proposed. This proposed programme refers to the application of interdisciplinary theory to diverse phenomena through empirically-linked conceptual models. To this end, the semantic conceptualisation process involves testing compatibility between models, and offers significant possibilities to extend applied social science and interdisciplinary research into complexity and emergence.

The concept of emergence is interwoven with the broader umbrella of complexity theory, and refers to novel and coherent forms (structure, pattern, order) arising from the dynamic interplay among elements at successive layers within a complex adaptive system (Goldstein, 1999; Chiles *et al.*, 2004). Many classic examples of emergence exist in patterns that arise spontaneously in ecosystems, economics, chemistry, physics and the social sciences. Complex systems are adaptive if they possess this capacity for emergent order (Anderson, 1999). The emergence of self-organised structure and strategy in communities of practice occurs both with and without managerial control, within and beyond the boundaries of the organisation (Mintzberg, 1994; Plowman and Duchon, 2008). If emergence is to be understood as a product of underlying human interaction, researchers must first observe and measure the nature, dynamics and increments of interpersonal influence and their consequent links to system-level behaviours (Hazy, 2008; Lichtenstein and Plowman, 2009).

Complexity theory is derived from a broad and well-documented intellectual movement rejecting nineteenth century assumptions and incorporating the non-reductionist tenets of early-1900s *gestalt* and holistic thinking, explorations into the mechanisms of feedback, communication and control in cybernetics (Weiner, 1948), and the broadly-diffused general systems theory view of organisations as ecosystems of interdependent actions and consequences (Skyttner, 2006). Drawing on the precepts of general systems theory, cybernetics and the observation of dissipative structures in chemical systems (Nicolis and Prigogine, 1977), later works have posited further adaptations from the natural, physical, chemical and mathematical sciences to human social systems, including a punctuated equilibrium of discontinuous and radical technological change (Tushman and Anderson, 1986), evolutionary and emergent processes of self-organisation in the context of the modern firm (Brown and Eisenhardt, 1997; Chiles *et al.*, 2004) and of humans as agents with 'schemata', a malleable set of rules (Anderson, 1999). The application of complex adaptive systems to human social systems has performed well as a metaphorical device, but lacks a definitive link to root theory through compatible conceptual models. Distinguishing between complexity as a lens through which greater understanding may be acquired, and applying this understanding as a concrete definition remain areas of interest in complexity research. The current practice of describing organisations as complex adaptive systems (directly from root theory) serves well as a metaphor, but if researchers are to say these phenomena are complex adaptive systems, the theory must be adequately tied to the phenomena through a more concrete process. Morgan's (1998) exploration of the use of various metaphors to describe organisations suggests they have been useful as a sense-making and conceptual tool. However, the distinction between metaphor and reality must be clear.

In the maiden volume of *Emergence: Complexity and Organisation*, McKelvey (1999) contends that the future success of complexity sciences hinges on the execution of a systematic agenda linking theory development with mathematical and computational models, and the testing of models with real-world structures via a process of semantic conception. Semantic conception is defined in this paper as a process whereby scientific theories are shaped in the form of conceptual models, with theory used for the specification and testing of those models (Thompson, 1988; Suppe, 1989). In semantic conception, theory is linked to real-world phenomena through conceptual models with rules and parameters. To this end, a model-centred isomorphism of theory is required to support the interdisciplinary transfer of ideas and concepts across the sciences, particularly between epistemological branches. Over the last decade, a range of case studies has contributed to the conceptual development of emergence in and around organisations, testing, adapting, confirming and refining measurement instruments and theoretical constructs (Lichtenstein, 2000; Chiles *et al.*, 2004; Plowman, Baker *et al.*, 2007). In parallel, a series of computational and mathematical models has been presented and is available for wider use (March, 1991; Tyler *et al.*, 2005; Hazy, 2008). Expanding the model-centred approach discussed in this paper first requires an examination of the conceptualisation process as it applies to the theory of emergence in human organisations.

Conceptualisation process for a theory of emergence

One of the first accounts of an empirical theory of emergence is provided by Rueben Ablowitz (1939), who claims its concepts and terminology were derived from diverse sources, including J. S. Mill's *Logic*, G. H. Lewes's *Problems of Life and Mind*, S. Alexander's *Space, Time and Deity*, C. L. Morgan's *Emergent Evolution* and *The Emergence of Novelty*. Ablowitz offers a description of emergence as the sublime force that 'accounts for the transformation of quantity into quality', together with earlier definitions, including the 'tendency of units of one kind in combination, to constitute units of a new kind, with more complex constitution and new qualities due to the new togetherness of the parts' (Sellars, 1922). However, Ablowitz chooses to illustrate the ideas of emergence with a number of examples, one being the characteristic liquidity of water, a quality not possessed by its atomic components, hydrogen and oxygen. Although Ablowitz's example was soon debunked with subsequent theories of quantum bonding (Goldstein, 2010), his original idea remains valid while suggesting the need for circumspection in its use.

The novel concepts of emergence have challenged the existing lexicon in a search for ways to describe complex and counterintuitive ideas. At first glance, it may appear that the study of complex systems is defined as much by what it is not, as by what it is (Marion, 2008). Complexity theory employs a vast range of negative prefixes such as *non*-linearity, *un*certainty, *un*predictability and *dis*equilibrium, emphasising that the emergence of coherent form can occur spontaneously through the interplay of underlying components that interact on the basis of simple rules without centralised coordination or control (Anderson, 1999; Goldberg and Markoczy, 2000). The idea of emergent order would be more difficult to imagine were it not for the use of metaphorical device stemming from the act of interdisciplinary borrowing at a conceptual level, such as the seamlessly moving flock of birds that reflects a cascade of small, relatively simple, localised interactions (Reynolds, 1987). Similar swarm behaviours are exhibited by fish, ants, bees or buffalo. While

these examples offer insight into the simple rules that facilitate harmonious movement of a collective of individuals, a direct translation to unfamiliar territory potentially serves to stigmatise the field (Burnes, 2005). The problem arises from the translation of ideas in a manner far removed from their root meaning. For obvious reasons, humans are not the equivalent of ants, bees, birds, liquids or gases. This issue is exemplified by Burnes (2005) in the assertion that

> there is a world of difference between restructuring an organisation because science has discovered that this action is necessary, and doing the same thing because that is what a computer simulation has shown that a flock of birds would do if faced with wind turbulence.

This particular stream of criticism argues that complexity theory's success as a metaphorical device has exceeded its utility as a practical tool for organisations and management, an issue that is firmly rooted in the process of semantic conception, referred to in this paper as the translation of theory to its respective phenomena through conceptual models. To contextualise our examination of a model-centred approach to semantic conception, we first revisit the anchoring themes of emergent self-organisation and the nature of dynamic interaction and influence as they apply to complex firms.

Emergent self-organisation

Emergent self-organisation has been referred to as the anchor-point phenomenon of complexity theory, a process whereby system-level order spontaneously emerges as a result of dynamic interactions among individual agents (Anderson, 1999; Chiles *et al.*, 2004; McKelvey, 2008). At the point of reaching a critical threshold, systems collapse or re-organise/re-combine into new configurations (McKelvey, 2008; Lichtenstein and Plowman, 2009). Foundation elements of complexity dynamics were devised by Nicolis and Prigogine (1977) in their identification of antecedent conditions that explain how order is generated (especially in chemical systems) through spatiotemporal 'dissipative structures' that arise through the mechanics of energy dissipation. Dissipative structures result from high sensitivity to initial conditions far from equilibrium states, and through amplification of small change, emergent self-organisation and reinforcing feedback (Nicolis and Prigogine, 1977; Anderson, 1999; Lichtenstein and Plowman, 2009). Everyday examples of dissipative structures can be found in the convection of liquid or cyclones, visible in the collective movement of components (Nicolis and Prigogine, 1977).

With the aid of a multitude of local interactions and feedback loops, individual behaviours are amplified then dissipated across systems from which collective tendencies spontaneously emerge (Anderson, 1999; Lichtenstein, 2000). Self-reinforcing feedback stabilises the system at the collective level, at which point coherent structures, patterns and observable forms of order begin to emerge (Anderson, 1999). Self-organisation in open systems occurs only with the continuous importation of energy (Prigogine and Stengers, 1984; Anderson, 1999; Chiles *et al.*, 2004). When energy build-up reaches an unstable threshold, or 'edge of chaos' (Osborn *et al.*, 2002), agents suddenly dissipate energy in a cascade of adaptive tension-breaking, thereby generating order through energy dissipation (Marion, 2008). Unpacking the active elements in the process of self-organisation and translating

these concepts to human behaviour is a critical step in enhancing the practical application of emergence in organisations and management.

As there are fundamental differences between particles and human beings, a substantial level of abstraction is required to apply the Nicolis and Prigogine (1977) dissipative structures theorem to human social systems, particularly when quantifying the mechanisms by which the importation and dissipation of energy are achieved. The terms for this abstraction are evident in the expressions used to describe the nature of 'energy' in social systems: Chiles *et al.* (2004) describe fluctuations in energy as new events, activities, financial resources, market growth; Anderson (1999) refers to new sources of energy as members, suppliers, partners and customers; whereas Marion (2008) refers to 'any agent that controls energy' with implications for the inter-relational processes of leadership. Such definitions give an inexact idea of what energy is and how it is imported, transferred and maintained among human agents in dynamic and complex social systems, where system boundaries are invariably porous, changing and subject to negotiation and perception. Defining these boundaries is necessary before the system's behaviour can be understood. The absence of satisfactory definition limits the conceptualisation and measurement of specific human behaviours as mechanisms for energy importation, transmission and transference (Macintosh and Maclean, 1999; Lichtenstein and Plowman, 2009). Further refinement of terms is required if they are to be useful in practice.

Principles of self-organisation apply to organisations given appropriate conditions, such as multiple agents with schemata, intricate webs of interdependency and interaction, importation of energy, amplifying and reinforcing feedback, disequilibrium, continuous change and so forth (Anderson, 1999). The application of principles of self-organisation to modern firms is, however, not without obstacles. Among these is the long-held expectation placed on managers and leaders to make the decisions that will lead to desired outcomes (Burns, 1978; Plowman and Duchon, 2008).

Leadership, dynamic interaction and influence

The conduct of leaders and emergent outcomes arising from interactions among individual agents do not need to be opposite sides of the coin; for instance, emergence does not imply that leaders are unnecessary, but rather that they are potent actors in the creation of social pattern and system-level order. The nature of leadership in human systems contrasts with physical and chemical systems that do not possess equivalent socio-cultural attributes. One example is the understanding of leadership as a function that can transcend transactional processes in the form of transformational, idealised or charismatic influence (Burns, 1978). In the physical system, there can be a presumption that equivalent agents are of roughly equal status. This is not the case with human actors in social systems, where influence is not equitably distributed. System histories are also known to be a salient in determining future states, given the effects of structural inertia (Hannan and Freeman, 1984) and sensitivity to initial conditions. The complexity viewpoint positions leadership as an emergent characteristic of dynamic interaction and influence occurring among agents in a complex system, mutually contingent on follower attributes, such as need for autonomy (Lichtenstein *et al.*, 2006). Leadership behaviours have the potential to foster the conditions necessary for emergence to occur through interactions with members across all levels of an organisation, a concept that Macintosh and Maclean (1999)

refer to as 'conditioned emergence'. Exploring further through a meta-analysis of complexity leadership research, Lichtenstein and Plowman (2009) identify four behavioural processes that co-generate the conditions for new emergent order: disrupting existing patterns of behaviour; encouraging novelty; sense-making from patterns and symbols; and stabilising feedback.

Understanding the nature of dynamic interaction among individual agents is a crucial aspect of emergent self-organisation in human social systems, making it a common element in defining the boundaries of complexity theory. Numerous authors have employed variations that incorporate common themes to describe complexity theory as the study of interacting agents/units that together form a complex system (Anderson, 1999; Goldstein, 1999; Plowman, Solanski *et al.*, 2007; Marion, 2008; Lichtenstein and Plowman, 2009). Hence, a system that entirely prohibits interaction is incapable of complex adaptive behaviours. Agent interaction has also played a pivotal role in redefining leadership (via complexity leadership theory) as a process that expands beyond the capabilities of the individual, where leadership itself is an emergent event, a product of 'relationships, complex interactions, and influences that occur in the "spaces between" individuals' (Lichtenstein *et al.*, 2006). Understanding the character of interaction between individuals is where the associated paradigms of complexity, emergence and leadership converge (Lichtenstein *et al.*, 2006; Goldstein, 2008).

The dynamic interaction and interdependencies among components within and around complex systems make calculating behaviours for the purpose of practical application in 'real-world' systems a challenging task, especially given the multitude of variables that affect behaviour in open systems (Nicolis and Prigogine, 1977; Anderson, 1999; Marion and Uhl-Bien, 2001). This aspect is embedded in discussions by many complexity theorists, yet remains an area of concern. For example, Burnes (2005) suggests that computer simulations and interdisciplinary semantics are not enough to generate reliable predictions of macro-level behaviour, which restricts the application of complexity to the laboratory environment. However, a key benefit of idealised computational and mathematical models is the ability to isolate variables and the principles on which emergent outcomes are based for use in a theory–model–phenomena conceptualisation (McKelvey, 1999), also serving to support an expanding horizon of empirical method. An illustrative metaphor would be testing the aerodynamics of an aircraft through simulation before sending it out on the runway. McKelvey (1999) elaborates on the concept by suggesting that experimental accuracy should be developed in parallel with ontological adequacy (to represent a specific portion of reality) via a systematic agenda linking model structures to the real world. A revisitation of this fundamental and continuing agenda follows.

A model-centred approach to emergent self-organisation

The study of emergence in organisations does not mark the beginning of previously non-existent phenomena, but rather the application of a new lens, capable of detecting and making sense of complex and dynamic behaviours (Goldstein, 1999; Marion, 2008). Over the course of the last two decades, the lens of complexity and emergence has been applied to an increasingly wide variety of fields, each iteration providing insights and perspectives and in many cases direct feedback for the application and refinement of theory.

Emergence and complexity in organisations are dealt with in various ways in classic organisational theory, such as Mintzberg's (1994) inclusion of emergent strategies to describe the practical reality that unplanned activity is a key process of strategy, and this in turn requires a departure from the traditional focus on planned and deliberate activities. Cohen *et al.* (1972) deal with complexity in the form of organised anarchy in which opportunities for choice are viewed as a garbage can into which problems and solutions are thrown and choices are ultimately made, depending on the mixture of cans available, their labels, and the speed of collecting and removing garbage. The garbage can model highlights the importance of energy input, problem and choice 'load' at a given point, and the observation that decision outcomes frequently do not resolve underlying problems (Cohen *et al.*, 1972). Lewin (1952) explores behaviours within the concept of group dynamics; a group is more than the sum of its individual members and behaves in ways not necessarily representative of each member (commonly referred to as 'groupthink', a process that often leads to substandard decision making).

As proposed more than a decade ago by Goldstein (1999), the study of emergent phenomena has been ripe for exploration, particularly in the areas of emergent (informal) leadership and emergent networks. Communities of practice that emerge within and beyond the boundaries of the organisation provide a practical example of emergent networks and informal leadership influences (Juriado and Niklas, 2007). In conceiving a framework of research prospects, Goldstein (1999) locates major research opportunities that can be illustrated within a simple matrix of sources and types of structure applicable to organisations. Goldstein's grid contrasts source of organisational structure (imposed and self-organised) with type of structure (hierarchical and participative), and is reproduced here (see Figure 1). The upper right quadrant 'emergent networks' is highlighted by Goldstein (1999) as a new area of research and refers to 'authentic' instances of emergence in complex firms. Goldstein's grid is a useful tool to position and contrast literature in relation to hierarchical, imposed, participative and self-organised organisational dynamics.

Goldstein's prediction of a fertile research agenda has proved correct, with significant growth of inquiry occurring over the last decade. Goldstein (1999) and

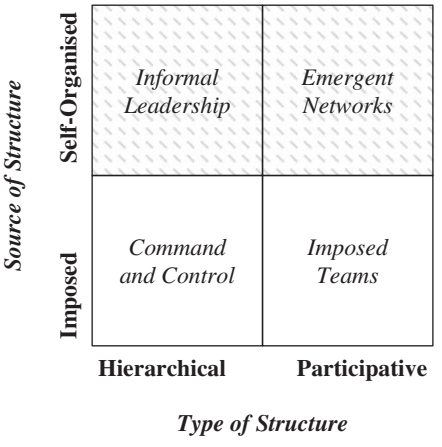

Figure 1. Emergence and organisational dynamics.
Source: From Goldstein (1999) (shaded areas added).

McKelvey (1999) both point out that ontological adequacy would be a key requirement for giving credence to a theory of emergence. Goldstein also suggests a notion of ontological plurality to accompany the observation and understanding (across multiple levels of analysis) of new subsystem levels coming into being through emergence. In parallel, McKelvey proposes the use of a systematic conceptualisation process that avoids axiomatic reduction; in other words, not deriving ontological adequacy by means of a single model and in turn increasing the potential for external validity. McKelvey details this systematic process of semantic conception by suggesting that theory is always 'hooked' to models, each model consisting of experimental testing via an 'idealised physical system' (computational or mathematical models) with ontological adequacy testing undertaken through isomorphism of idealised structures against real-world phenomena that fall within the scope of theory.

From these foundational processes of theory building, we are led to two crucial questions: have we realised the opportunity of Goldstein's promised research, and have we achieved the systematic agenda proposed by McKelvey? To illustrate, a hybrid grid is presented, juxtaposing the former (Goldstein) proposed research agenda and the latter (McKelvey) idealised model-centred mode of conceptualisation, expressed here as simulated *versus* non-simulated empirical method (see Figure 2). Figure 2 represents a limited exposition of selected articles (n=13; see Table 1), applying thin search parameters (relevance, citation frequency, primary data collection) to identify articles relating to emergent networks and emergent leadership that contribute to the research agenda proposed by McKelvey and Goldstein. A number of search platforms were used to locate prominent articles that employ primary data collection methods. Although this reveals a relatively small sample of literature, it is apparent that non-simulated methods have been the dominant feature over the course of the last decade. The use of the grid allows this selection of literature to be positioned with reference to other works. From this brief review, it is also apparent that simulated methods of emergent leadership that are capable of providing detailed insights into relational processes are a less-explored combination. There has also been growing use of computational and mathematical modelling in theory development (Levinthal and Warglien, 1999; Hazy, 2006), but even these more conceptual

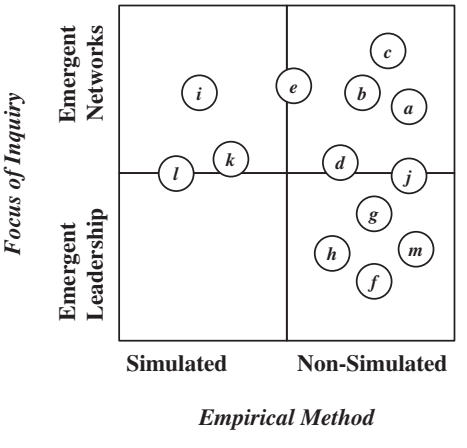

Figure 2. Focus of inquiry and empirical method grid.

Table 1. Review of selected empirical works plotted in the grid at Figure 2

Ref.	Author	Description
a	Chiles *et al.* (2004)	In-depth case study into organisational emergence/recombination of a collective across musical theatres
b	Plowman, Baker *et al.* (2007)	In-depth single case study of the emergence and amplification of change within mission church
c	Lichtenstein (2000)	Multiple case studies on emergence in several high-potential technology-enabled new venture firms
d	Blackler *et al.* (2000)	Comparative case study of three strategy teams within a single high-tech firm, processes of organisation via networks of activity
e	McKendrick *et al.* (2003)	Emergence of organisational form in the global disk array market (note: this study is based on archival data)
f	Pescosolido (2002)	Observation of how emergent leaders influence interacting groups, multiple case analysis of jazz music and rowing groups
g	Kickul and Neuman (2000)	Survey of 320 university students on the behaviours of emergent leaders and their relationship to team processes and outcomes
h	Carte *et al.* (2006)	Emergent leadership across 22 self-managed virtual project teams of university students
i	Zott (2003)	Simulation study on the emergence of intra-industry differential firm performance, the link between capabilities, resources and performance
j	Huygens *et al.* (2001)	Co-evolution of firm capability using multiple case studies of firms within the music industry
k	Prietula and Carley (1994)	Thirty computational modelling simulations of individual and collective behaviour of agents in varying conditions
l	March (1991)	Modelling of two cases involving mutual learning of an organisational code, and learning and competitive advantage
m	Hazy (2008)	Case study of influence-signalling in an growth-stage entrepreneurial firm

approaches provide further opportunity for application in primary data collection (Lichtenstein *et al.*, 2006).

The publication of the studies presented by Anderson (1999), Lichtenstein (2000) and Chiles *et al.* (2004) demonstrate that the method of systematic inquiry based on direct theory–phenomenon conception has been reasonably well-accepted into the process of theory building for complexity. Figure 3 illustrates the theory–phenomenon ('organisation science') conception discussed here (McKelvey, 1999). The direct theory–phenomenon conception applies a recursive cycle of continuous refinement where formalised models are developed in parallel with theory, and ontological adequacy is established through predictions (directly from theory) and confirmation/disconfirmation against sampled, real-world phenomena (McKelvey, 1999).

Figure 3. Organisation science conception.
Source: McKelvey (1999).

Among the key limitations of the direct theory–phenomenon link identified by McKelvey (1999) is the need for high instrumental reliability and justification of ontological adequacy that rests on the predictive accuracy of theory to real-world scenarios. Both are areas of concern if there is an absence of ontologically-adequate models that are accompanied by appropriate idealised experimentation (i.e. computational models) where instrumental reliability is high enough to formulate prediction, and generalisability within specified parameters. The semantic conception process addresses the risk of *post hoc* phenomenological labelling, given the generally higher levels of instrumental reliability and recursive testing available in a simulated environment (McKelvey, 1999). As alluded to earlier, semantic conception may be used to generate principles upon which the conception of 'energy' and the mechanisms for its dissipation in human social systems can be generally applied. The prominence of a theory–phenomenon approach (Lichtenstein, 2000; Chiles *et al.*, 2004; Plowman, Baker *et al.*, 2007) may be associated with a tendency to undertake non-simulated empirical methods that centre around real-world case studies, such as those proposed by Eisenhardt (1989), in which idealised model–phenomena testing is less apparent. Lee's (1989) exploration of the 'controversial' division between objectivist and subjectivist schools of thought describes what appeared to be a widening gap between these major approaches to organisational research. Lee raises several methodological concerns about the use of objectivist or natural science-based experiments with organisations, highlighting the difference between laboratory conditions and the organisational setting that affects replicability, generalisability and the rules of logic in qualitative analysis to describe how systems function.

Investigations of complexity impose particular challenges on researchers beyond those presented by simpler, hypothetico-deductive research. Figure 4 illustrates a model of semantic conception suggested by McKelvey (1999) as the preferred tool for exploring emergent phenomena. According to the model of semantic conception, theory is always linked to and tested via (idealised) models, where theory attempts to explain the behaviour within a model, and models attempt to explain phenomenological behaviour (McKelvey, 1999). From this viewpoint, formalised computational and mathematical models take a central role in theory development. The process of semantic conception posits that theory, models and phenomena are distinctly separate entities. Thus, theory attempts to explain the behaviour of only models (McKelvey, 1999), with ontological adequacy achieved by isomorphism of the model against that portion of real-world phenomena (McKelvey, 1999).

There are several limitations to the existing conceptual approaches illustrated at Figure 3. These have resulted in McKelvey's empirical predictions being unrealised and – consequently – Goldstein's research agenda not being entirely fulfilled. The limitations of McKelvey's semantic conception model are first that it is heavily

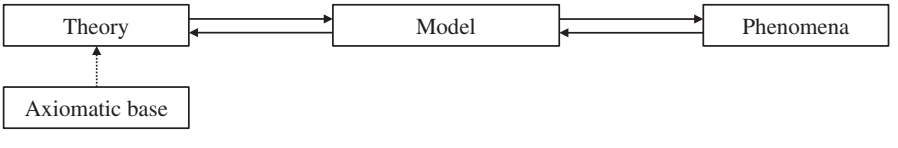

Figure 4. Semantic conception.
Source: McKelvey (1999).

weighted to a narrow array of research methods (idealised or simulation-based testing), yet numerous and arguably more prominent contributions to the complexity literature fall outside this scope, such as those referred to in Table 1. Secondly, McKelvey's approach does not outline the necessary interdisciplinary link required to make the leap from one field of study to another (via conceptual models), despite this practice being a common characteristic in the complexity literature. In McKelvey's simulation-based approach, concepts are isomorphs of derivative and single theories. They improve the flexibility of the (organisation science) theory–phenomenon link, but leave a fragmented field of study. While McKelvey's model illustrates the linkage among theory, models and phenomena, the important relationship among abstractions that take shape as conceptual models is absent.

McKelvey's semantic conception model can be logically expanded through a discrete process of conceptualisation that supports both the organisation science (theory–phenomenon) conception and semantic (theory–model–phenomena) conception methods, so as not to rule out any particular methodological approach. A novel model of semantic conceptualisation is offered here at Figure 5. A more extensive conceptualisation process presents numerous benefits. It tightens the (organisation science) theory–phenomenon conceptual loop through ontologically appropriate conceptualisation (addressing the 'metaphorical device' issue), while simultaneously lending support to formalised computational and mathematical models, expanding and testing semantic conceptualisation between models, as necessary. The 'original' McKelvey semantic conception provides for conceptualisation embedded within theory–model links: what is discussed here is a pragmatic, explicit and broadly applicable process of conceptualisation in support of current and potential empirical works, regardless of their approach. A robust conceptual model applicable to the services industry (for example) may comprehensively define and describe the minimum number of inputs or behaviours required to achieve transformation, as proposed in theory and confirmed through models (Johns and Lee-Ross, 1998; Checkland, 2000), in terms that are fit for purpose in either simulated or non-simulated methods. In this scenario, future studies would benefit from being tied to a common link, or general method, to the explicit meaning of active ingredients that form part of a complex system so as not to rule out all reducibility.

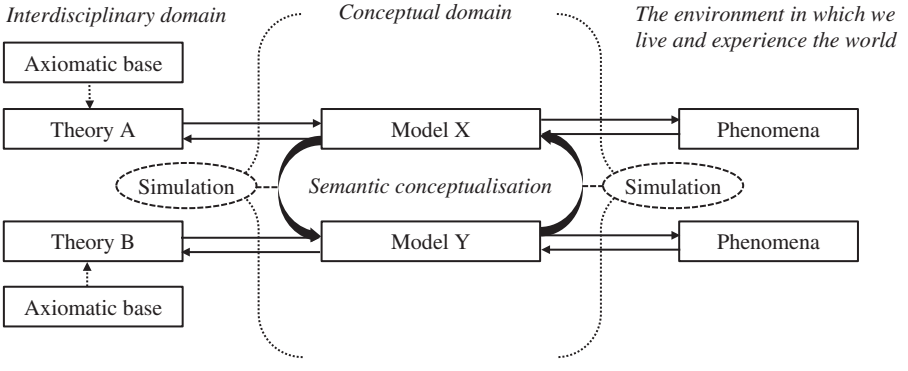

Figure 5. Model for semantic conceptualisation of theory and phenomena with simulations.

The new model for semantic conceptualisation (Figure 5) offers greater variety of empirical method and broad scope for the interdisciplinary application of multiple theories to seemingly disparate phenomena, such as the behaviours of water molecules in human systems. A recursive cycle of conceptualisation to verify the comparability of models enables several pathways from theory, through models to phenomena. An example of this process of abstraction is provided at Figure 6: theory *a* linked to model *x*, which is then recursively-linked to model *y*, in turn capable of explaining multiple phenomena, provided the conceptual models are valid and consistent – which continue to be hooked via the theory–model–phenomena link – and provided the interpositions have practical consequences. The model supports theory building as a recursive process that involves continual study and conceptual development, adaptation, and refinement of theory that is informed by its use in real-world applications (Lynham, 2002). Simulation-based research may be used to strengthen the semantic conceptualisation process through the interchange of phenomena-based variables. The use of models in this process may take a variety of forms, depending on the fluidity and complexity of subject matter. For example, the model can be adapted to enable interpretive models for human social culture to be explored with thick description, non-reductionism and with at least semiotic utility (Geertz, 1973). A tool such as this supporting interdisciplinary importation through conceptual modelling is of enormous use to the nascent theory of emergence, and of importance across the sciences that deal in both reducible and holistic constructs, and the relationship between them, in applied research and theory building.

The model of semantic conceptualisation can be applied in support of a systems-thinking approach to organisational learning. For example, in practice an organisation may consider theories in use and mental models to inform and develop simulations to facilitate the transition to a more workable or sophisticated mental model, using data from the semantic conceptualisation process. While mental models are an ingrained way of understanding the world, building further understanding about the existing form of these models individually and at the system level through simulations would support Senge's (1990) notions of a learning organisation.

The study of complex systems avoids overly simplistic forms of reductionism in the sense that the behaviour of whole systems is not directly assured through analysis of a single component held in isolation with all other factors assumed to be constant (Anderson, 1999; Goldstein, 1999). Therefore, a successful model for the conceptualisation of emergence ideally treats reductionism and holism as complementary strategies necessary to achieving coherence among multiple scales of

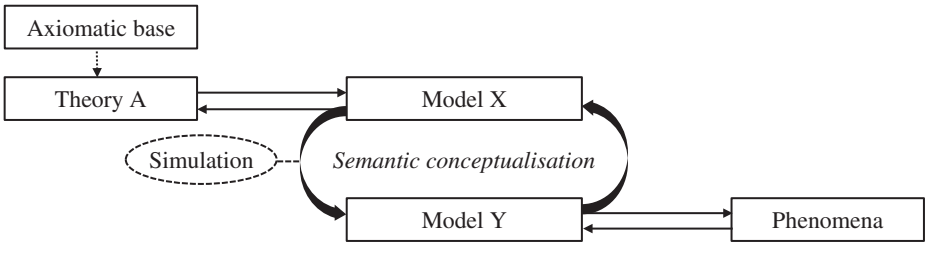

Figure 6. Example of semantic conceptualisation of theory, models and phenomena with a simulation.

analysis (Anderson, 1999). The idea of multi-level and irreducible phenomena is supported by Polanyi (1968), who describes mechanisms, such as knowledge, with the use of boundary conditions that are dependent on, but irreducible to, the laws of nature. Cases of holistic phenomena are described as such because they are irreducible; for instance, the relation of mind to body, and the multi-level nature of knowledge about the physical world (Polanyi, 1968). From this perspective, the semantic conceptualisation process is capable of incorporating multiple axiomatic bases and multiple models, opening greater possibilities for coherence between successive or meso-level analysis while maintaining ontological adequacy. Such a process is well-grounded in the philosophical tradition of pragmatism to link recursively theory with practice (Dewey, 1905), such that it achieves the representative utility of 'good' theory (Lynham, 2002).

A note on the utility of 'good' theory

Theory can be broadly defined as 'coherent description, explanation and representation of observed or experienced phenomena' of practical use to describe, explain, diagnose and further understand phenomena (Gioia and Pitre, 1990). The real-world practical utility of theory is ideally the antithesis of reflections posed by Blumer (1954) on the state of 1950s social theory. This suffered 'glaring divorcement' from empirical science and a series of 'grave shortcomings' as a result of defective modes of inquiry. Thankfully, several modern variants that define 'good' social theory assert there is no need for an artificial divide between theory and practice. Hence, theory has utility value to help us act in certain ways, and is continually informed by, and applicable to, real-world practice (Van de Ven, 1989; Lynham, 2000; Corbin and Strauss, 2008). Consistent with this assertion, theory building can be described as the 'ongoing process of producing, confirming, applying and adapting theory' (Lynham, 2000), to which end theory-building methods ideally possess two inherent qualities: validity and utility (Van de Ven, 1989). As surmised by Gioia and Pitre (1990), 'it would be useful for theory building to be viewed not as a search for the truth, but as more of a search for comprehensiveness stemming from different worldviews'.

Among the difficulties encountered in the process of theory building is overcoming broadly-accepted views by posing new ways of viewing or understanding everyday phenomena. With its own emergent qualities, theory faces this challenge. Although the existence of a greater number of alternative paradigms to explain, predict or define organisations and their actors is likely to deliver more comprehensive understanding of organisational realities, the incommensurability of paradigms is also likely to produce scholarly fragmentation – a possible cause of confusion among practitioners (Gioia and Pitre, 1990; Burnes, 2005). Further strategies to address this dilemma include the development of a multi-paradigmatic bridging tool (see Gioia and Pitre, 1990). Such a tool may be capable of exploring the permeability between parallel constructs, and may be used to extend the semantic conceptualisation process as a part measure to address compatibility issues arising from interdisciplinary borrowing. The continual pursuit of theory building is driven by a range of factors, including the pursuit of a comprehensive understanding about our world and how we experience it, and the need to formulate ways to address issues or problems that reality presents us (Lynham, 2002). Thereby we advance the vocation of research.

Implications and issues

The model for semantic conceptualisation of theory and phenomena with simulations introduced at Figure 5 in this paper has numerous practical applications, including further development and refinement of a theory of emergence and supporting a range of theory-building methods in applied social science research. Further development and refinement of a theory of emergence has implications for the study of organisations and management. Prigogine (1997), Marion (2008) and Plowman and Duchon (2008) argue that the world is inherently unpredictable and in a state of continuous flux such that organisations must possess a capacity to adapt. It is not enough to simply predict change. It is also suggested by Plowman and Duchon (2008) and Lichtenstein and Plowman (2009) that the emergence of order and structure may persist either with or without managerial guidance, which has profound implications for the notion of 'leadership'. As explanations of organisational phenomena have moved along a continuum of focusing on the functioning and properties of parts to configurations of parts within emergent whole systems (from parts to wholes) (Goldstein, 1999), the focus associated with human agents within complex systems has also moved from behaviours and traits of individuals to characteristics of interdependency, interaction and relations among components in context (from individuals to interactions) (Lichtenstein *et al.*, 2006; McKelvey, 2008). The implication of such a shift in conceptualisation is not to suggest that organisations should abandon all structure or routine, but rather that they should re-examine what may previously have been considered 'givens' for the creation of order and stability (Marion, 2008), such as the predetermination of specific futures, direction of change, elimination of disorder and formal designation of leadership (Plowman and Duchon, 2008). Similarly, concluding that the world is inherently unpredictable does not concurrently imply a state of constant chaos. Rather, there is an intermediate space between the two extremes of utter determinism and a world of pure chance (Prigogine, 1997).

The development of a theory of emergence is more likely to benefit rather than be weighed down by the use of formalised computational and mathematical models, within a balanced empirical spectrum (McKelvey, 1999; Goldstein, 1999; Marion and Uhl-Bien, 2001; Lichtenstein *et al.*, 2006). For this purpose, a range of computational and mathematical modelling approaches is on offer (March, 1991; Prietula and Carley, 1994; Kaczmarski and Cooperrider, 1997; Levinthal and Warglien, 1999; Moldoveanu and Bauer, 2004; Hazy, 2006, 2008). The formalisation of multiple models will benefit from the addition of discrete efforts to advance the semantic conceptualisation process, building on the notions of McKelvey (1999) as extended here. Given the nascent stage of various strands of complexity theory (Marion and Uhl-Bien, 2001; Schneider and Somers, 2006), it is probable that semantic conceptualisation will also assist in resolving issues relating to interdisciplinary importation and the conceptual ill-fit problem (Anderson, 1999; Burnes, 2005). The conceptual model presented in this paper should have broad appeal for researchers interested in multidisciplinary research, and in meso-level and emergent fields where behaviour of a certain kind at one level leads to the generation of structure or form at another level.

In relation to future case study selection and practical application, the isomorphism of the semantic conceptualisation process to real-world scenarios need not be a stifling task. Kauffman (1993) posits that the ingredients necessary for the creation of emergent order may be as simple as a group of heterogeneous agents, a motive to connect and a sufficient number of connections with other agents (McKelvey, 2008).

Based on this description, locating a complex organisation may be a relatively straightforward process. Adding to this mix is the need for the right conditions, such as the diagnostic use of critical values (or threshold states) above the first critical value ('edge of order') and within second value ('edge of chaos') (Osborn *et al.*, 2002; McKelvey, 2008), the intermediate of which is somewhat philosophically referred to by Prigogine (1997) as the 'narrow path'. The model of semantic conceptualisation can be used in these cases as a tool for multi-paradigmatic bridging and connecting models to explain, with a diverse array of measurement instruments, phenomena of various kinds occurring at multiple levels.

Conclusion

This paper has provided an exploration of the existing theory–model–phenomena link commonly used in complexity research. Despite the growing body of research pertaining to a nascent theory of emergence, its central themes are based on a limited theory–model–phenomena conception that does not adequately support those conceptual abstractions. Take, for instance, the direct transfer of microscopic concepts to macroscopic levels of analysis. Strengthening the conceptual link beyond metaphorical device is essential to a robust process of theory building and holds numerous applications, such as underpinning further social science research and theory-building pursuits. Without an effective isomorphism of theory and structures to real-world behaviour, it is an arguable conclusion that a theory of emergence for human organisation does not currently exist. Such is the importance of ontological adequacy and the interchange between conceptual models. It facilitates the practice of interdisciplinary science that characterises much of complexity research.

This paper has identified a range of concerns relating to the ontological adequacy of model-centred conceptions and challenges of instrumental reliability in direct theory–phenomenon conceptions. It is supported by literature demonstrating methodological selection. This study finds that while the research has been fruitful, major limitations are associated with the direct transfer of concepts to unfamiliar territory without adequate support from a structured model of semantic conceptualisation. For example, while it is accepted that complex systems require continuous importation of energy to achieve the conditions required for emergence, authors apply an inconsistent understanding of what energy is in this context and how it is imported, transferred and maintained among human agents, instead relying on a direct abstraction from the chemical or molecular world. Such abstractions also suffer from comparably low instrumental reliability and the impracticality of studying complex human systems in isolation from their environment. For these reasons, the former McKelvey (1999) model of semantic conception has not been successfully realised within subsequent empirical research. The novel model of semantic conceptualisation offered in this paper enables a stronger conceptual framework to underpin and support further research.

A range of possibilities remains in exploring novel applications of emergence and the products of dynamic interaction to extend the existing body of research using formalised computational models and real-world case studies that are tied together by a common thread or conceptual link. This paper makes a contribution to the execution of a comprehensive programme of semantic conceptualisation, building on previous studies, to support theory–model–phenomena linkages, and ontological adequacy that lead to a wider variety of research methods than proposed by previous

authors. Such a process is supported by a stepwise positioning of semantic conceptualisation within the broader frame of a general method for theory-building research. The contemporary method of semantic conceptualisation provided in this paper is recommended for applied social science and theory-building research, particularly in relation to complex and emergent phenomena.

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