FUNDAMENTALS OF RELATIONAL COMPLEXITY THEORY

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ABSTRACT

"Relational Complexity" is emerging as a new science that can explain the origin of both the living and non-living world. Its basic tenants are quite simple, but controversial due to prior limits on scientific thinking, particularly the mechanistic world view. In this new view, both living systems and mechanisms emerge as special cases of the general, relational complexity. The basic relationship is between existent and potential aspects of nature, which is an information relation crossing the subject-object boundary. The theory is compatible with both Western and Eastern thought and offers a means to integrate these quintessentially opposite world views. It can also provide a solid theoretical foundation for structure-function epistemology in ecology that is not predicated on, or thus limited by, mechanistic assumptions.

Keywords: Complexity, relation, nature, living, systems, ontology

INTRODUCTION

A new science of creative natural relations may be emerging from Western systems theory. Its foundation, called "*relational complexity,*" was rigorously formalized by the late Dr. Robert Rosen between 1972 and 1999, in his quest to answer the question "what is *life itself*." The theoretical foundation of relational complexity theory constitutes a new way of seeing nature in terms of pre-mechanistic information relations between realized and potential systems informing each other (Kineman 2007a). In this view one does not imagine life emerging from a special arrangement of mechanisms, but rather *life* and *mechanism* identify special cases of an information relation. The resulting view of the natural world thus includes the mechanistic, but is radically and profoundly broader in its more general entailment. As an analytical framework, it is capable of representing origins and seemingly vital and teleological aspects of nature, without returning to pre-scientific concepts that became logically untenable in prior views.

In modern science we now realize that description cannot ultimately be purged of subjectivity even though it requires objectivity. Rosen's genius was to accept both facts and thus to incorporate subjectivity into his view of nature, as an expansion rather than a replacement of the mechanistic world view. In the finest tradition of integral thinking, which Einstein described of his own method of arriving at relativity theory (Einstein 1924), Rosen constructed a theory that holds two seemingly contradictory but inescapable facts of modern science to both be true, thereby producing a higher order synthesis. The two thus paradoxical facts of science that were reconciled are: (a) collective states of nature depend on prior states, *and* (b) isolated states of nature depend on perception. The kind of description or analysis that results from combining these conclusions treats perception itself as part of nature (a basis for 'mind') and thus perception is a necessary part of our description of nature. Many others in modern science and throughout antiquity have hinted at this basic relationship. Science itself is a natural phenomenon in this view, being a human realization of a "modelling relation" (Rosen 1991).

Foundations of Relational Complexity

Here I describe the fundamental tenants of this new science, as a synthesis of ideas presented in other papers and in Rosen's work. A basic synthesis is needed to establish programs of research and education in this new field. It is very important in any new science that those exploring it agree on working assumptions at the outset, to form a community that can progress according to a common line of inquiry. Too often in system science, and certainly in studies of complexity, life, and consciousness, we diverge to explore multiple theory foundations. The result is that we do not develop beyond the foundations. The rest of the scientific community, seeing us constantly re-inventing our foundations, yawn and if interested at all, make a note to check back at some future date to see if we have gotten anywhere. We must get somewhere. And so we must agree to agree, at least long enough to be convinced or unconvinced of certain views. I am therefore proposing that the foundational concepts presented here are suitable for such agreement for working purposes, and that a group of interested scientists should gather together to develop this science, along with educational curricula. From my own work, it is clear to me that the fruits of such study will be great in cosmology, ecology, informatics, philosophy and ethics. There may hardly be a field of human inquiry that is not touched by clarifying this shift in perception.

THE BASIC RELATION

I have shown elsewhere that Rosen's "modelling relation" is both a meta-model for epistemology (it describes science) and an ontology for nature (it describes origination) in relational theory. Both relations are reproduced in Figure 1. I have also shown that this relation is infinitely constructible, both holarchically and laterally, thus allowing it to be proposed as a fundamental structure of reality.

By objectifying the basic relationship between actual and potential existence (the modelling relation), a clear mathematical foundation for non-dualism is obtained. This view is revolutionary. Accordingly it is controversial among Western trained scientists, for the simple reason that we have wished to explain all of nature in terms of mechanisms alone. However, it is surprisingly congruent with ancient Eastern philosophy and science (Kineman and Kumar 2007). The Upanishads of India, for example, describe the ultimate reality as just such a relationship. The Taittiriya and Mandukya Upanishads, for example, describe existence (in Sanskrit, sat) and awareness (chit) as a single reality or one-ness, the true experience of which is bliss (ananda). The Chandogya Upanishad similarly describes the ultimate reality as existence (sat) and non-existence (ti) yoked or bound together (yam). The Sanskrit word Satyam thus means the ultimate and complete reality, which is Truth. Hence, in ancient wisdom, it is the combination of two logical opposites that constitutes a creative relation and is the origin of all existence. (Muller 1884).

The relational view is definitive, therefore, in its acceptance of material existence describable as mechanism, in relationship with its logical opposite, which is the pure absence of mechanism. By taking the relationship itself to be the reality, we can then explain complex phenomena, where a system will appear to any outside observer as exhibiting unpredictable or uncertain behaviour. This occurs naturally, as a consequence of the relationship between material existence (represented in sat) and perception of that existence (represented in chit), that relationship defining the essence of connection and interaction. That relationship can be imagined as the 'awareness' of each material system of another, which then underlies our scientific concept of interaction.

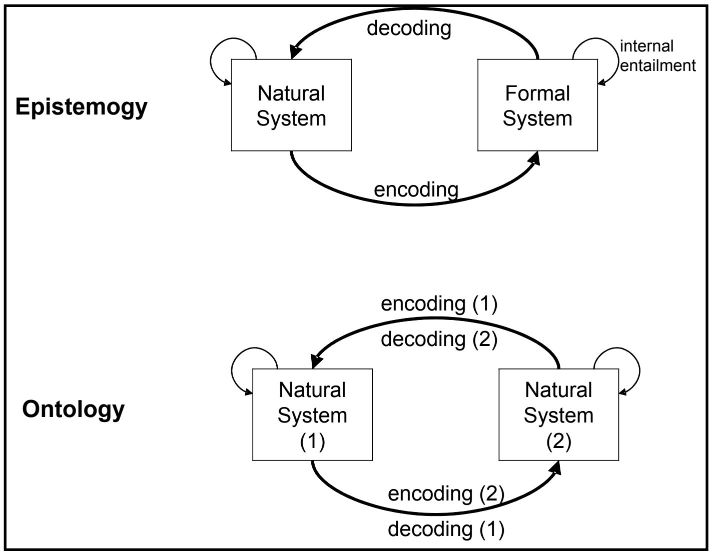

Figure 1: Two Applications of the Modeling Relation

The modelling relation identifies the most basic duality underlying all other dualisms: that between observer and observed. This duality is well known in all fields of academic inquiry. Development of relational theory based on such complementarity is directed toward comprehension of the non-dual in terms of information relations that represent the properties of wholeness. In other words, we rip the fabric of reality by observing it (and ourselves), creating dualistic perception and thereby departing from both experience and knowledge of the natural unity (the Biblical fall from grace in the Garden of Eden). We then seek to recover that knowledge through information relations, and we seek to recover that natural feeling through the experience of relationships. In this way, the root of relational theory is rather obvious and intuitive to many people today, there being endless descriptions of it in popular and traditional literature. But there has not been a coherent scientific theory of this relation that can bring a practical common understanding until now.

As science, this approach of course remains intellectual, but it can nevertheless share ideas in the quest for ultimate, experienced knowledge, which in Vedanta is referred to as jnana (true knowledge, or wisdom), or the path of jnana yoga (joining with or through jnana). In Vedanta, and most other deep philosophical inquiries, our worldly perception is recognized as dualistic (dvaitic); whereas the knowledge and experience one aspires to for knowledge, peace and happiness is non-dualistic (advaitic). 'One-ness' in Christianity is a similar idea.

Such relations that extend across the subject-object boundary (both sides of which may be present as perception, and also dissolved in action) must be treated as creative (i.e., ontological) information relations. Rosen identified these relations as 'encoding' and 'decoding.' As such, they account for a continuum of natural systems and behaviours from matter to organism, and they may be taken as defining the most essential and fundamental aspect of mind in nature; an idea that accordingly must regain modern currency.

THE ONTOLOGICAL DOMAIN: CAUSAL ISOLATION

Rosen's very thorough development of the mathematical and philosophical foundation for relational theory thus allows a new science to be articulated that is compatible with both

Western and Eastern thought, and that vastly improves our ability to understand complex phenomena.

In simple language the idea of relational theory is to describe nature in terms of material systems that represent (model) each other and that are themselves expressions of such models. The result of this approach is to relax the mechanistic constraints on what we think nature can do. Less constrained systems in nature may then exhibit self and universally creative phenomena because of causal loops (self-entailments, or "impredicativities") that are not otherwise allowed in mechanism. These are information feedback loops that are considered to be responsible for all behaviour and complexity, generating system dynamics and structure. When fully constrained, or reduced to equivalence between model and system, these relations account for classical existence and behaviour. That has been the primary subject of Western science for centuries. When unconstrained, i.e., unreduced, they account for complex existence and behaviour, which is now obvious in quantum, cosmological, and dissipative systems phenomena (such as whirlpools or other energy vortices). In a sense, these systems 'buy' various forms of self-causation by dissipating energy. When they are more organized, unconstrained modelling relations may then account for living systems and their phenomena. This hierarchy of system types explains why mechanism and reductionism have become a problem in modern physics, and why they have been such a bane in life and social science; while at the same time they have been a necessity. Both constrained and unconstrained relations are involved in nature. We can no more propose that nature is comprised solely of unconstrained relations than we were able to get away with the idea that it is comprised of only constrained relations. Everything interesting about existence has to do with crossing this threshold (or in some spiritual ideals, transcending it).

The key to the formation of such complementarities, or causal loops in nature, ranging from the constrained to the unconstrained, is the existence of a causal boundary; i.e., some form of causal isolation. Because this is a view in which nature is essentially self-causing, as systems distinguish themselves and separate their causes must go with them. Causation thus becomes at least partially isolated. The collective properties of nature that might be ascribed to general and universal laws, properties of common causation, require interaction and are the properties of interaction; they arise in a system, or for that aspect of a system, that is interactive. It is also clear that to the extent that interaction is delayed temporally or separated spatially, causation itself becomes more independent of the larger system (of interaction or observation). In that case, the 'absolute laws' of nature, i.e., the commonly shared laws, no longer explain the behaviour of separately defined parts. Those parts (or more properly, 'components') have internalized the very same laws and perhaps additional ones.

Two material states or systems thus interacting should exhibit complexity when their isolation is apparent against a background of collective definition, where isolation is not apparent. In other words, the difference between self definition of states of a system, and the definitions imposed by other systems externally, becomes apparent with some form of system isolation. Two kinds of physical isolation that are now well-known, are quantum and relativistic. These correspond to isolation in time and space, respectively. In both cases, we see natural complexity exhibited; in quantum behaviour and in relativity (Kineman 2000). However, as in the theory of quantum decoherence on the one hand, or the formation of relativistic matter (from the big bang) on the other, classical systems emerge from numerous and rapid interactions, where the interactive properties of the collective background overwhelm the properties of isolated system interaction and thus dominate the results of additional measurement. This is a very simple theory that accounts for the fact that at classical scales, and in the absence of any other form of causal closure, quantum and relativistic behaviours become insignificant and material properties therefore appear classically mechanistic.

THE EPISTEMOLOGICAL DOMAIN

While the ontological domain of relational theory is modelling relations (Figure 1), the epistemological domain is information itself, described by Rosen as "encoding" and "decoding" relations. These relations are entirely contextual (existing in the "ambiance" of any modelling relation) and thus analysis in these terms is both hierarchical among nested systems, and lateral among related systems. The result is representation of a natural holarchy, where indeed "*everything is connected to everything else*," as the popular saying goes, but in ways we can now understand through relational analysis.

The mathematical domain for description in this science is *category theory* (Louie 1985; Louie 1985). Category theory deals with the causal mappings of one entity into another according to various functions that govern the transformation. Modelling relations, which form the foundation of relational thinking, can be translated into the highly graphical language of category mathematics. A typical expression in this mode might be, for example: f: A -> B, which means the function, f, governs the transition from a set of conditions A to a set of conditions B. In relational theory, these entities, A, B, etc., can themselves be functions, thus allowing various kinds of causal feedback to develop. The relationship of this analysis to the ontology presented as modelling relations is clear, because function can be associated with decoding and structure can be associated with encoding. The result is thus some appropriate form of structure-function analysis (Kineman 2007b).

Classical nature (congruent with mechanistic analysis) can be shown to emerge from this kind of complexity, not as the fundamental reality (i.e., material "building blocks" of nature), but as a shared and constructed condition of complex system interactions in which a mechanistic background must form from collective interaction. We thus find a classical scale in nature where complexity, owing to the spatial and temporal isolation of material events, becomes insignificant compared to the common frame of reference these events collectively produce. To whatever extent causal boundaries are thus absent, interaction thus defines a shared measurement (or state) space in which the creative modelling relation appears reduced (fully commuting between model and its realization).

Aside from the physical cases of isolation that exist at the limits of physical and perceptual scale or in dissipative systems, there is another kind of causal isolation that may have developed from dissipative systems, that is found in organisms. While all recognized living systems are dissipative systems, organisms do more by employing complexity to build life strategies. This kind of causal isolation can be described as holistic, because it rests on the development of identity, where an internal system definition distinguishes it and causally isolates it (in part) from its context, or environment. This kind of isolation is an actual causal 'closure' of the system. Figure 2 reproduces Rosen's fundamental closure diagram for the case of organisms, which is a minimum requirement for their definition.

Organisms capture and express the complexity of modelling relations by a higher level of system organization than that of an inorganic dissipative system. They close "efficient" and higher Aristotelian causes within the organism to produce metabolic (M) and repair (R) functions. Repair includes reproduction. Such living organization can be described as comprising internal system models that account for the system-specific functions. Collectively, these internal entailments confer identity, which then may or may not be cognized depending on the degree of cognitive function.

From this basic theory of complexity, where all interactions are considered in some way primitive ‘models’, it is not hard to imagine conditions under which this more developed kind of internal system model might form. All the archetypical ingredients for life exist in relationally complex systems, and their ‘emergence’ from physically complex systems is a matter of hitting upon a loop causal structure that serves to acquire energy (metabolism) and to produce a second function that serves to maintain the first (repair). From that organization alone, evolution can maintain these basic functions and add more, including the cognitive components that we observe. Evolution, in this view, would clearly be driven by both passive and active selection. Active selection from learning and decision making, as James Baldwin proposed (Baldwin 1896), is a logical consequence of internal modelling relations (Kineman and Kineman 1999; Kineman 2002). It is also not hard to imagine, and in fact it is axiomatic in this view, that aspects of life as we experience it in our human form, exist, albeit in primitive form, in all of nature.

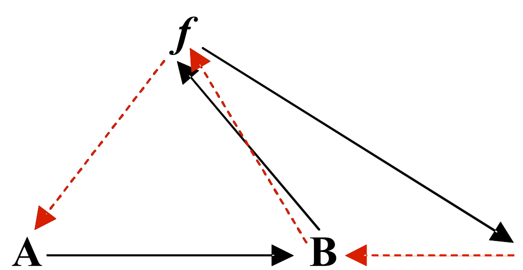

Figure 2: Efficient causal closure (self-entailment). Dashed red line indicates functional expression (decoding), solid line indicates system structural change (encoding). *f* = metabolism, _ = repair/reproduction.

Analysis of complex systems can be performed by relating structure and function, which are the epistemological units of the modelling relation. Figure 2, in fact, can be broken down into seven modelling relations that close internally except for structural and functional presence in the environment (Figure 3). Reproduction and repair entail the organism structurally with its environment as a defined material system (defined by its genetic code and its phenotypic pattern of material organization). Metabolism entails the organism with its environment through behaviour. The organism thus participates functionally and structurally in its outer surroundings, which subjects the organism to the processes of adaptation and evolution.

By recognizing the way that structure-function epistemology obtains from the ontology of modelling relations, the original system complexity can be reflected in a relational system analysis. Generally, this involves representing realized and potential structure-function relations in the organism and its context (Banathy 1999; Kineman, Banathy, and Rosen 2007).

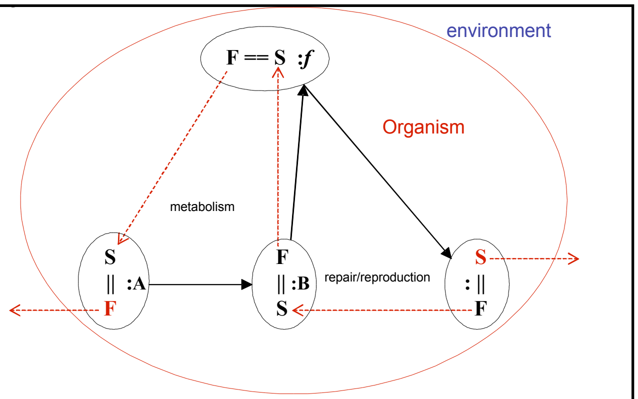

Figure 3: Efficient causal closure in terms of Structure-Function relations.

BASIC PRINCIPLES

The modelling relation considered as a natural unity thus explains the origin and complex nature of both the living and non-living world. Although revolutionary and controversial, it provides a unique and scientifically world view in which a theoretical synthesis can be achieved between the mechanical and the complex. Some basic tenants of this synthesis are:

1. Nature is best imagined in terms of interconnected and holarchical relationships between explicit forms (realized material systems) and implicit forms (the contents of natural models).

2. The explicit form is an observable (measurable or classifiable) material existence that might otherwise be described in terms of energy and matter (but not limited to those concepts).

3. The implicit form is the reflection or specification of an explicit form. The implicit form (analogous to a 'formal system' in mathematics) may be thought to exist in "the organization" of a directly or contextually related system. It is an aspect of a natural, material system, and is thus part of nature.

4. The relationship between explicit and implicit forms is a "modelling relation" as described by Robert Rosen. This relation defines natural complexity. The explicit and implicit forms, when recognized in this relation, account for all that we can know or infer symbolically of the natural world. Modelling relations can thus be taken as the fundamental theoretical units of analysis of nature at all scales and all systems.

5. Modelling relations are information relations in the sense that each related system 'encodes' to or 'decodes' from one system's organization to the other's. In this precise way, systems can be said to 'interact' (i.e., to act together and between each other). In the general case, encodings and decodings are not exact and thus do not fully commute. They are comprised of abstracted patterns (from observation or interaction). Abstraction is thus a feature of the natural world, and material (measurable) states are its result.

6. The obvious presence and predictable persistence of a general mechanical (classical) world of observable states, arises from the collective effect of multiple (complex) modelling

relations, to the extent that their interactions are not isolated from the general system of interactions. The classical world that is generally given to mechanistic description is thus a special, reduced case of general relational complexity where explicit and implicit forms (a system and its implicit 'model') are sufficiently constrained that they are essentially equivalent, and causality is sufficiently general that behaviour can be described precisely. Nevertheless, complex relationship remains latent.

7. Organisms represent a different case of relational complexity, where modelling relations have themselves been internalized. Such internalization closes efficient causation. Functional relations combine to produce self-entailed organization. The minimum functions required are metabolism and repair (which includes reproduction). Metabolism and repair functions, in turn, entail the organism with its environment.

8. By internalizing modelling relations themselves, organisms thus develop sophisticated models that allow them to adapt to persistent conditions in anticipatory ways. By innovating, they can actively drive their own evolution in a Baldwinian sense, especially to the extent that such models may be said to involve cognition, choice and will.

CONCLUSION

Modelling relations, as the presumed 'reality' of nature and appropriate basis for analyzing its complexity, are thus to be considered ontological entities. They are assumed components of living nature in that they comprise a fundamental way of thinking about nature. As such, this view of nature is more general than the mechanistic view, underlying classical, complex, and living systems. Modelling relations are capable of representing the origin of natural systems and their laws: they provide a conceptual bridge across traditional duality, without compromising known science on the one hand (e.g., of mechanisms) and obvious unexplained phenomena on the other (e.g., of complex and living systems). Relational theory is capable of dealing with systems that originate themselves and their own behaviour. The modelling relation translates directly to epistemological and empirical elements, which are the modelling relation's 'encodings' and 'decodings,' corresponding respectively to 'structure' and 'function.'

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