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A Decision Making Construct for Complex Situations

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ABSTRACT

A DECISION-MAKING CONSTRUCT FOR COMPLEX SITUATIONS

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The uncertainty inherently associated with complexity challenges decision-making processes, indicating a need for a construct for decision making in complex situations. A review of the literature on systems, complexity, and paradigms indicates that such a construct must be internally consistent with well-defined philosophical foundations and further that systems and complexity (as used in complex situations) are not necessarily internally consistent with traditional philosophical foundations. Therefore, a decision making construct for complex situations requires research into different foundations. This research addresses these gaps, deriving axiological and methodological components based on a set of principles consistent with the ontology and epistemology of Sousa-Poza and Correa-Martinez (2005). The combination of these four philosophical components is asserted to establish a Complex Situations Paradigm providing a foundational perspective for complexity and systems.

The characteristics of this research require particular attention to the appropriate research methodology. Canons for research are typically based on philosophical foundations of rationalism or empiricism; hence this research derives a set of generalized canons based on a specific definition of knowledge, which must be instantiated as specific research canons for a given philosophical foundation. The methodology for this research must be consistent with said canons and the associated definition of knowledge.

The product of the research is an internally consistent philosophical foundation for complex situations based on a research methodology using instantiated generalized canons, and an application of the associated methodology to derive a decision making construct. The contributions to the literature are the maturation of underlying theory for complex situations and the generalized research canons. The contribution to theory is the internally consistent philosophical foundation for complex situations, the Complex Situations Paradigm, and the associated discussion of canons. Finally, the contribution to practice is the decision making construct itself, applying the elements of the paradigm to frame action at diverse levels in complex situations.

Areas for further research include the derivation of methods based on the CSP methodology; applications of the underlying constructs to facilitate understanding of complexity through a method designated forensic complexity, and exploration of CSP principles to explore ramifications of cognitive aspects.

This dissertation is dedicated in memory of

the best man I have known,

Vaughn Edward Brewer;

and to my beloved bride,

Darlene Morgan Brewer.

Ad astra per aspera.

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CHAPTER I: INTRODUCTION

Background

Complexity presents itself in various forms such as chaos, wicked problems, non-linear dynamics, and soft systems, and arises from diverse sources such as mathematics, systems theory, dynamics, and biology. However it presents, complexity reveals a fundamental characteristic of uncertainty. This challenges traditional modes of thought in fields designed to reduce or eliminate uncertainty. Decision-making, in particular, is problematic in situations where unpredictable consequences are to be expected and traditional deterministic or probabilistic approaches are not appropriate. Systems theory, confronted by issues related to complexity, has responded with a wealth of alternative methodologies described as *soft* systems (as contrasted with traditional *hard* systems). The system analyst is then simultaneously enabled and constrained by this host of methodologies which by their nature must be uniquely tailored to the problem situation – and yet the problem retains its inherent uncertainty. Across these and other fields, there is a clear need to move beyond traditional deterministic and probabilistic approaches to accommodate complexity.

This fundamental characteristic of uncertainty brings to mind the foundational aspects of certainty – knowledge, reality, and the methodologies used to relate the two. However, without prejudice to existing methodologies, and acknowledging that some methodologies devote significant effort to the underlying paradigm (e.g. Sinn, 1998), this has tended to be a dialog of traditional epistemological and ontological perspectives with methods and methodologies created and evolved around problem situations. (Sousa-Poza

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This dissertation uses American Psychological Association parenthetical citations.

& Correa-Martinez, 2005; Keating, Sousa-Poza, and Kovacic, 2005) and others have initiated a dialog exploring constructs for complex situations, framing the discussion around the elements of epistemology, ontology and methodology which carries potential to enrich research and application via an alternative approach. Indeed, to address an issue that confounds traditional approaches, one must explore such alternative approaches beginning with the foundational issues of philosophy.

This research presents a study of the problem, reviewing the literature in the areas of complexity, systems and the associated philosophical basis for each. The results of the literature review provide the basis for developing the desired construct and the concomitant philosophical foundations, but further indicate a need for development of research methodologies that reflect the philosophical foundations for the research. This gives rise to the notion of generalized research canons – canons derived from a definition of knowledge – that are instantiated for a particular philosophical foundation. A Complex Situations Paradigm (CSP) is derived from a set of principles indicated from the review of the literature, guided by the appropriate instantiation of these generalized research canons. The desired decision making construct then becomes a consequence of applying the CSP.

Purpose of the Study

The purpose of this research is to develop a construct for decision making in complex situations using an internally consistent philosophical foundation.

Research Questions

In areas of complexity, decision making in the traditional sense is problematic as unpredictability is inherent in the situation, especially where deterministic or probabilistic

approaches are inappropriate. Hence, the overall goal of this research is to gain insights into some construct that will facilitate decision-making. Based on the review of the literature, one of the salient issues for any such research is proposed to be one of *internal consistency*, namely that derivations and conclusions must be consistent with associated philosophical foundations. This point is asserted to be so critical that it is proposed as one of the foundational axiological principles for this research; and as such the specific goal of the research is to develop an internally consistent decision making construct for complex situations:

Q_1: What is an internally consistent decision making construct for complex situations?

This, however, is an action (development of a construct) and not a reason, and so begs the simple question why; e.g. what is the reason such a construct needs to be created? To attach a benefit to any particular solution is inappropriate – even gross overgeneralizations such as *increase profit* or *better mankind* presuppose a context that is not yet in existence. Therefore, the axiological foundations must also address the notion of this reason why (referred to as a value premise) in order to provide a complete expression for the philosophical foundations underpinning the decision making construct.

Study Limitations and Delimitations

The single most significant limitation is the subject matter itself – complexity. Since, by definition, this involves the unpredictable, the study cannot rationally attempt to predict the unpredictable and must instead focus on the nature of complexity. This limitation is foundational to the general timbre of the research, focusing on philosophical foundations so that an understanding of complexity – versus an understanding of that which

in and of itself is complex - is the central area of study. As will be further outlined, this further constrains the research methodology to be strictly accountable to foundational principles – which, in practice, obviates the use of many traditional quantitative or qualitative approaches. This strict accountability becomes paramount as it must serve as one of the principle justifications for the assertions of knowledge claims.

Significance of the Study

Sousa-Poza and Correa-Martinez (2005) provide the initial discussion of alternative philosophical foundations for complexity and systems, introducing the concept of a complex situation. This research furthers that discussion, extending the initial philosophical foundation to include epistemological, ontological, axiological and methodological underpinnings - forming, arguably, the key elements of a paradigm (Guba & Lincoln, 1989; Creswell, 2003). Further, the discussion of research canons suitable for alternative philosophical foundations provides a new perspective with the potential to enable multi-disciplinary research beyond this particular application.

The contribution to theory is the internally consistent philosophical foundation for complex situations – the express purpose for the research - and the associated discussion of canons. Specifically, this research focuses on the subject of complexity itself (as opposed to a discussion of causes or symptoms) by addressing the philosophical foundations for complexity within the context of a situation, therefore contributing to a unique dialog on complexity.

Finally, the contribution to practice is the decision making construct itself. Though this will necessarily be a broad construct, it provides a foundation for discourse on reduction to practice in this inherently challenging area – and, as with any research, may

hold direct potential for practice. Due to the breadth of the approach, it is reasonable to assume that there will be serendipitous discoveries of additional areas of research and methods of reduction to practice.

CHAPTER II: LITERATURE REVIEW

Overview

The literature review used a tree-based search of electronic databases at Old Dominion University Library, using the starting point of Sousa-Poza and Correa-Martinez (2005), which was augmented by a search on all the terms system, epistemology, ontology, axiology and methodology. For efficiency, database searches concentrated on those sources which aggregate multiple journals (specifically JSTOR, Wiley, Sage and the Institute of Electrical and Electronics Engineers Xplore databases). This provided a sufficiently small but relevant set of references to frame successive searches, with each level pruned by a cursory review. The essential results are presented in Figure 1, with the analysis of major elements of the review – complexity, systems, and philosophical underpinnings – provided in this section.

Complexity

As an emerging multidisciplinary field, complexity includes diverse perspectives for defining and understanding its meaning, providing the opportunity to assess and adapt these perspectives to a particular application. The evolution of thought contributing to complexity, through multiple lineages with a concomitant diversity of perspective, speaks to underlying principles that are necessarily interpreted through the lens of the parent discipline. This diversity can illuminate and confound these underlying principles; yet from those principles it is possible to establish a reference point for understanding complexity and in doing so frame a definition useful for that reference.

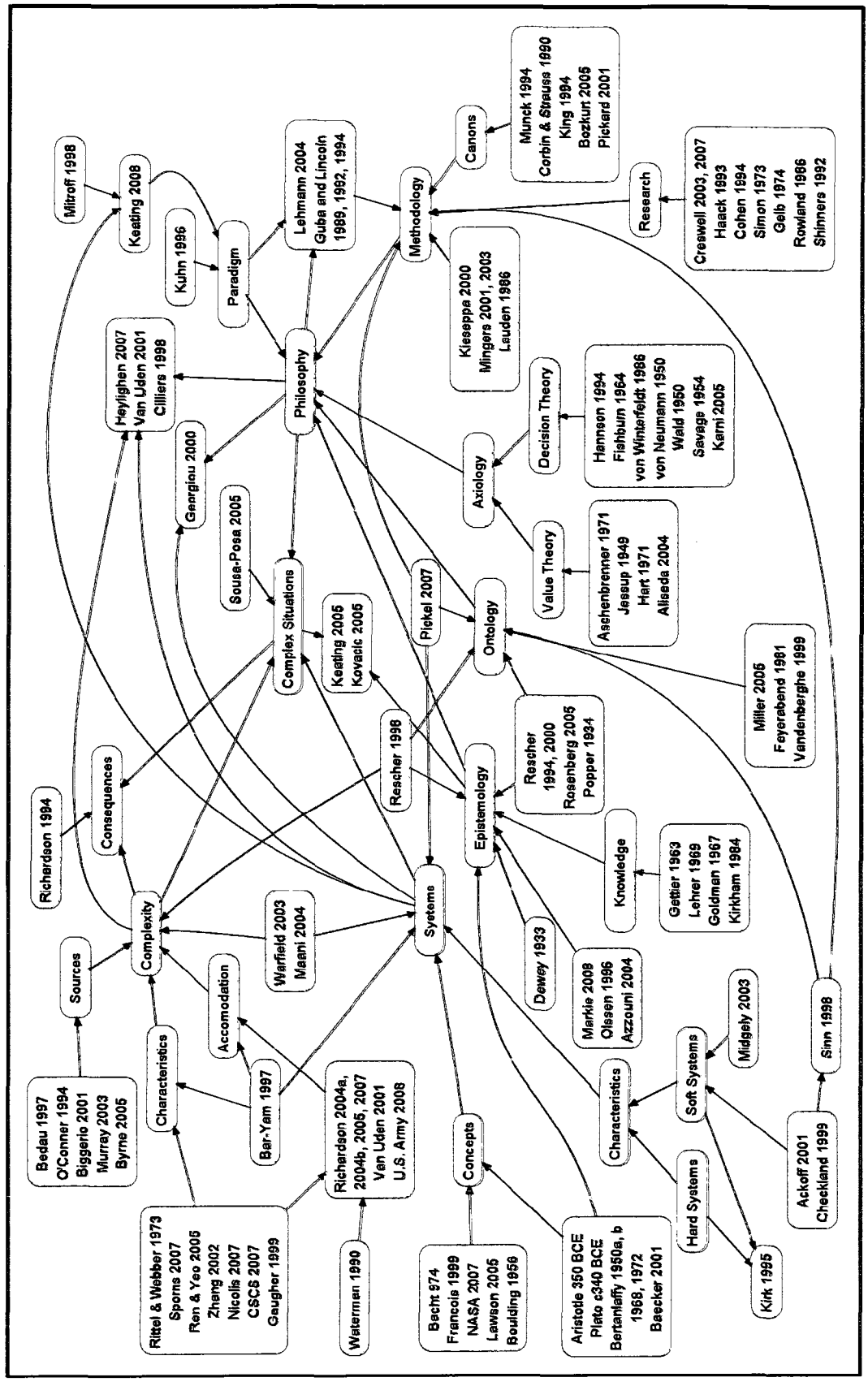

Figure 1. Research Mind Map

There are seemingly as many definitions of complexity as there are references, for example:

> We consider a system "complex" if it is composed of diverse components that interact in interesting (nonlinear) ways (Center for the Study of Complex Systems, 2007, para. 1).
>
> Being anxious to move beyond the semantic debate, we have taken a "complex system" to be one whose properties are not fully explained by an understanding of its component parts (Gaugher and Appenzeuer, 1999, pg. 79).
>
> A system perceived as complex induces a characteristic phenomenology the principal signature of which is the multiplicity of possible outcomes, endowing it with the capacity to choose, to explore and to adapt. This process can be manifested in different ways: The emergence of traits encompassing the system as whole that can in no way be reduced to the properties of the constituent parts. [...and ...] The intertwining, within the same phenomenon, of large scale regularities and seemingly erratic evolutionary trends (Nicolis and Rouvas-Nicolis, 2007, Section 1).
>
> Complexity theory is a new set of interdisciplinary sciences from which explanatory principles and models of complex dynamic systems composed of many interacting parts are emerging. It includes chaos theory, and relevant concepts of self-organization and emergence (Ren and Yeo, 2005, pg. 695).
>
> The complexity of a physical system or a dynamical process expresses the degree to which components or interactions display nontrivial structure. High complexity is achieved in systems that exhibit a mixture of order and disorder (randomness and regularity) and that have a high capacity to generate emergent phenomena (Sporns, 2007, para. 1).
>
> [Complex systems] are characterized by the nonlinear interactions between many elements (Zhang, 2002, pg. 83).

All of these disparate definitions echo similar themes; concepts of emergence and systems (diverse, interdependent, etc.) are common. These two ideas are, to some degree, in conflict. A system may or may not be emergent; and if some entity displays emergent characteristics in an irreducible fashion then a systems description is not appropriate as it

implies a level of reducibility. Such definitions of complexity and complex systems represent more of an outgrowth of earlier systems work – e.g. when a system of things normally understood reaches a level of interdependency and begins to display emergent behavior, it transitions to become an (irreducible) complex system. This conflicting terminology is avoided by Sousa-Poza and Correa-Martinez (2005) through the adoption of the term *complex situation*.

Emergence speaks to the simple fact that something unpredictable can happen. As an example, weak emergence is used in one sense (Bedau, 1997) that refers to cases such as the creation of a new characteristic from two unrelated characteristics – hydrogen and oxygen combining to create water and energy, for example. For this discussion, emergence is used in a sense of strong emergence; O'Conner (1994) describes this as a combination of "supervenience, non-structurality, and novel causal influence" (pg. 97) – a rich set of potentially non-ergodic interactions.

A tendency in the literature (seen in the definitions above) is to address sources and characteristics of complexity – for example, Biggiero (2001), Byrne (2005), and Murray (2003) provides categories of complexity, and Rittel and Webber (1973) provide a list of characteristics (here, for wicked problems). Less clear is what can be done in the face of complexity, though this has produced several approaches broadly grouped as soft systems methodologies (e.g. Ackoff, 2001; Checkland, 1999b; Midgley, 2003). Kirk (1995) also provides a comparison of hard and soft systems approaches. These represent a type of decision construct for complex situations that tend to be solution focused – e.g. given the source, minimize the effects or given the characteristics, ameliorate the consequence. Richardson (2004a, 2004b, 2005, 2007) provides a sustained discussion oriented on the

latter approach. However, it is not necessarily as clear what the solution is or should be – consider Van Uden, Richardson, and Cilliers (2001) who summarized the consequences as follows: "Essentially complexity-based analysis is a move away from the contemporary authoritarian style, in which a dominant perspective bounds the analysis, to a more democratic, or adhocratic (Waterman, 1990) style that acknowledges the 'rights' and value of a range of different discourses" (pg. 13). This clearly reflects a more postmodern perspective; but it is relevant to reflect that the unpredictable nature of complexity could, from an alternate philosophical perspective, be used as a call for increased authority (e.g., Smith, 2003). The U.S. Army's *Commander's Appreciation and Campaign Design* (2008) reflects a sort of middle ground between centralized authority and adhocracy – while the notion of a central authority and mission remains paramount, this pamphlet encourages a strong degree of interaction between the actors supporting a proscribed mission.

If unpredictability is considered to be at the core of complexity, additional characteristics of complexity can be considered as supporting or amplifying that central characteristic. Consider several characteristics presented in the earlier discussion: interdependence, non-linearity, emergence, and chaos. Interdependence essentially implies a system with feedback and feed-forward paths that result in non-linear dynamics, particularly with respect to system stability. Non-linear dynamics, aside from potentially resulting in systems with no closed-form solution or systems sensitive to initial conditions (chaotic), may also result in a loss of linear superposition with the associated loss of reducibility. Emergence "arises because the collective behavior is not readily understood from the behavior of the parts" (Bar-Yam, 1997, pg. 10); and (as discussed above) can be further subdivided into local emergence (where unpredictable behavior arises from a small

part of the system) and global emergence where the unpredictable behavior arises from the system as a whole. Chaos describes particular kinds of non-linear dynamics which may show fractal behavior or include attractors. In summary, through all of the disparate concepts of complexity, the notion of unpredictability is a consistent underlying principle.

Sousa-Poza and Correa-Martinez (2005) significantly generalize this notion of unpredictability as the core concept of complexity, defining it as "proportional to the probability of having/making an erroneous knowledge claim" (section 3, para. 2). This probability of erroneous knowledge claims directly impacts understanding; indeed, complexity as "a construct associated with the fallibility of understanding" (section 3, para. 2). The definition provided by Gaugher and Appenzeuer (1999) also frames complexity with respect to understanding. It remains, then, to examine understanding and assess the implications of complexity (as so defined).

A standard definition of understanding is "to comprehend; to apprehend the meaning or import of; to grasp the idea of" (OED, 2008). Dewey (1933) speaks to the same concept but is more explicit in the impact of understanding: "To grasp the meaning of a thing, an event, or a situation is to see it in its relations to other things: to see how it operates or functions, what consequences follow from it, what causes it, what uses it can be put to. In contrast, what we have called the brute thing, the thing without meaning to us, is something whose relations are not grasped. . . . The relation of means-consequence is the center and heart of all understanding" (pp. 137, 146).

From this perspective, higher complexity implies a lower probability of establishing this means-consequence relation – causality is lost, and the ability to understand is limited in kind. Also, understanding rests with the observer; hence complexity in a situation is

linked to the observer and the observer's understanding of the situation. An understanding of complexity permits the observer to place a low understanding of the situation in context, establishing a different form of means-consequence relation for a complex situation where the lack of causality is understood to be a characteristic of the situation. From this perspective, understanding a complex situation becomes not a paradoxical statement but a statement that incorporates the limits of understanding.

Complexity in a situation therefore directly influences understanding of that situation, requiring the observer to understand complexity in order to understand the situation in a tractable context. Understanding is related both to knowledge and the ability to place that knowledge in context; hence an implication of complexity is a limit to understanding of the situation. The concept of understanding a complex situation must be refined and ultimately supplanted with the concept of understanding complexity. The observer is faced with a situation where the statement *I don't know* (with respect to the complex entity) has been replaced with *I can't know*, certainly a critical concept to understand.

Treating understanding (and by implication knowledge) as the underlying principle behind the diverse lineage of complexity, it is immediately noted that a major shift in perspective has occurred – the focus has moved from the monolithic concept of a complex thing (or collection of things) to include the observer. Drawing on the complex situation construct established by Sousa-Poza and Correa-Martinez (2005), the observer is inextricably bound to the complex situation, and so establishes a reference point for assessing perspectives on complexity. The impacts on the observer as a reference point can then be assessed with respect to this underlying principle.

This explicit introduction of the observer introduces the requirement for a strong analysis of philosophical foundations, including such fundamental issues as epistemology and ontology. These discussions are often assumed in engineering subject matter areas where positivist empirical approaches are dominant in the discourse – with some notable exceptions (e.g. Heylighen, Cilliers & Gershenson, 2007; Georgiou, 2000; Sinn, 1998; Sousa-Poza and Correa-Martinez, 2005). The latter proposes pragmatic idealism, exploiting ideas of Rescher (1994, 2000) to propose an ontological foundation for exploring complexity. Due to this critical emphasis on philosophical foundations for discussions involving the observer, this research endeavors to make these philosophical assumptions explicit.

In this sense, complexity directly contradicts the basic assertion of systems concepts – systems concepts assert the understanding of the whole as more than the sum of the parts, while complexity asserts the loss of the means-consequence relationship that is central to understanding. *Complexity contradicts the assertion that more knowledge results in more understanding; it challenges the notion that reality is fundamentally comprehensible.* This introduces the concept of fallabalism, which can be taken to be a justification for inaction (as no action can be rigorously supported); but as this discussion presumes a value premise driving action, the perspective of pragmatic idealism (Sousa-Poza & Correa-Martinez, 2005) is appropriate. This also foreshadows a consideration of philosophical foundations – for example, from a purely empiricist perspective reality is implicitly asserted to be.

Systems

Introduction

A systems perspective asserts the understanding of the whole as greater than the sum of the parts. Systems perspectives are typically considered to have a philosophical foundation in empiricism; however, this is shown to not be (in general) internally consistent. An internally consistent definition of a systems perspective is required for a discussion on notions of complexity and accommodation of complexity. A discussion of the assumptions required for an internally consistent systems perspective frames the development and application of systems perspectives within complex situations.

Hellenic philosophy provided two significant concepts that contribute to the evolution of systems thought: the notion of systems from Aristotle (1994), or the whole is greater than the sum of the parts, and Plato's concepts of dualism (1892) such as material/immaterial, or mind/body. The former notion speaks to holism and synthesis; the latter speaks to particularism and analysis. Bertalanffy (1968) sums up the analytical trend in western scientific thought: "It was the aim of classical physics eventually to resolve natural phenomena into a play of elementary units governed by 'blind' laws of nature. This was expressed by the ideal of the Laplacean spirit which, from the position and momentum of particles, can predict the state of the universe at any point in time" (p. 75). This perspective encountered difficulties over time as it became apparent that elements in combination can produce results that cannot be constructed from consideration of the elements alone, resulting in the conclusion that "It is necessary to study not only parts and processes in isolation, but also to solve the decisive problems found in organization and order unifying them, resulting from dynamic interaction of parts, and making the behavior

of parts different when studied in isolation or in whole" (ibid). From this perspective, a system is the whole in the largest sense – it is the whole, the parts and the relationship of the parts. This is well summarized by Checkland (1999b): "The systems paradigm is concerned with wholes and their properties. It is holistic, but not in the usual (vulgar) sense of taking in the whole; systems concepts are concerned with wholes and their hierarchical arrangement rather than with *the* whole" (Chapter 1, 2.1).

This clearly asserts a causal relationship between the holistic and the particular. The very need for the notion of systems is predicated upon a need for understanding – the establishment of causality (a fundamental element of the means/consequence relationship of Dewey [1933]) – under conditions where consideration of the parts alone will not explain the behavior of the whole. This concept is challenged by the notion of complexity where understanding is inherently limited - when consideration of the whole does not provide the desired means/consequence relationship. Paradoxically, complexity is a consequence when a large number of interacting entities are involved – e.g. definition of a richly interacting system with a known set of entities, relationships and boundaries becomes self-defeating in that understanding becomes inherently limited. From a traditional systems perspective, this implies that the system is not well-defined – yet when notions of complexity indicate that no systems definition exists that can provide understanding, it is necessary to revisit concepts of systems from a different perspective.

The comment of a need for understanding was presented above, begging the question that understanding is required for some reason. This seemingly trivial point implies that there is a need for a means/consequence relationship; here, generally taking to have ultimate realization in some decision to shape an environment towards some value

premise. This further asserts the existence of a capacity of some entity to make a decision – e.g. some independent capability to sense, understand, decide and act. The need for system concepts is derivative of a need for understanding, which is derivative of a need to predict the future so these actions can be oriented towards a desired future. The collision of concepts of systems and complexity is apparent; hence to accommodate a discussion on complexity a discussion on system concepts must include notions of understanding, decision and action. Baecker (2001) states that "systems theoretical thinking is an epistemological device to look at the ways in which, by communication, three distinctions are established and implemented: (a) the social distinction between actor and observer, (b) the ecological distinction between system and environment, and (c) the temporal distinction between past, present and future" (pg. 70). This encompasses the elements of the complex situation from Sousa-Poza and Correa-Martinez (2005) and frames the elements of understanding, decision and action.

This research seeks to dissect not systems but the concepts of systems in order to frame a debate on how these notions relate to complex behaviors. This requires a discussion of systems, underlying philosophies, and the role these concepts play in understanding. A critical axiological principle is the idea of *internal consistency*; e.g. that a concept must be consistent with its inherent philosophical assumptions (here focusing on epistemology and ontology). This is closely related to the Type IV error of Keating (2008) relative to Mitroff (1998): engaging a problem/situation with incompatible and irreconcilably divergent worldviews, such that success is unattainable. From this basis, a discussion of complexity provides a perspective on the role and consequences of system concepts as a means to promote understanding. This discussion incorporates this as a

context for application of systems concepts, asserting a rational foundation that appropriately accommodates a necessarily systemic perspective.

Concepts

The notion of a system is an ancient, and in one perspective, a well defined concept – so well defined that the debate as to the meaning and consequences thereof have continued for thousands of years. Bertalanffy (1950b, 1968, 1972), Becht (1974), Checkland (1999b), and François (1999) provide a history of systems which will not be repeated here; the intent of this discussion is simply to frame definitions and consequences for further debate. This includes a discussion on the need for understanding which systems concepts strive to fulfill, and the philosophical basis for systems concepts.

Systems definitions can be found in reference, theory and practice:

> A set or assemblage of things connected, associated, or interdependent, so as to form a complex unity; a whole composed of parts in orderly arrangement according to some scheme or plan; rarely applied to a simple or small assemblage of things (OED, 2008).

> A system can be defined as a complex of interacting elements (Bertalanffy, 1950b, pg. 143).

> A system comprises dissimilar elements combined in some way to produce a new entity with properties that are different from those of any of the constituent elements (Lawson, 2005, pg. 1).

> A "system" is a construct or collection of different elements that together produce results not obtainable by the elements alone (NASA, 2007, pg. 3).

These definitions all carry the intellectual genetics of Aristotle: the whole is more than the sum of the parts. However, they do not make explicit one key element of the definition: that there is a system itself; e.g. it is bounded. Additional qualifiers lead to the notions of

an *open system* or *closed system;* Bertalanffy (1950a) makes reference to a bound of some significance (and foreshadow the issue of incompleteness for later discussion) where interactions across the boundary implies an open system. Consequently, this research uses a working definition of a system that has characteristics including a boundary, entities, and relationships. These do not define a system but are characteristics of a system - it is possible to have a boundary, entities, and relationships and not have a situation where the whole is more than the sum of the parts. Therefore, a systems concept necessarily asserts that understanding of the whole requires an understanding of the entities, relationships and boundaries that cannot be attained through consideration of the entities themselves – an increment that may be referred to as the *systemic delta* in understanding, using systemic as "of or pertaining to a system" (OED, 2008). Further, the system environment is that which is external to the boundary; hence the relationships include those between entities and those between entities and the environment.

NASA (2007) makes understanding another explicit aspect of a system; the need for system concepts arises because consideration of the parts is insufficient to understand the whole. As outlined earlier, understanding is used here in the sense of OED (2008) and Dewey (1933) which focuses on a means-consequence relationship carrying with it an implicit presumption of causality.

Understanding via system concepts carries a tension between analysis and synthesis – where analysis seeks "separation of a whole into its component parts" (MW, 2008), synthesis is "the composition or combination of parts or elements so as to form a whole" (MW, 2008). Though the notion of a system explicitly focuses on synthesis, the definition carries with it elements of analysis - an important context for systems concepts as it assigns

significance to reconciliation of the two. This tension is also significant as there is an implicit notion that one cannot understand the (bounded) whole without an understanding of the bounded entities and relationships. A systems perspective intended to be holistic carries with its own definition the requirement to be necessarily particular. Further, the essence of the holistic vs. particular debate is seen in discussions on categories, or levels, of systems that reflect some measure of resolution (in the sense of the inverse of granularity) as in Boulding (1956).

However, subject to the particular ontology used, the elements of a system (entities, relationships and boundaries) can considered as knowledge of rational *things*, and the systems perspective is no more than an inclusion of the knowledge necessary to establish understanding. In short, system concepts imply that more knowledge results in more understanding. While seemingly a trivial assumption, it nonetheless becomes relevant in subsequent epistemological discussions.

System concepts may be held to be empiricist in nature – e.g. that reality itself is a system or has systems in it, and understanding is gained through increasing knowledge of them. If there exists a definable set of entities, relationships and boundaries then the designation is appropriate; but as reality in general does not necessarily make such differentiation, this is a constructivist perspective. An empiricist perspective also implies that the bounding of a system does not impact understanding – that a system can be isolated (or the isolation reduced to a tractable number of finite interactions). This perspective implies that reality is comprehensible, and systemic in nature (at least at relevant levels of resolution). In this case, if there is error using a systemic perspective it is a result of a difference between the representation of the real system and the real system itself that can

be ameliorated through learning. However, it is clear that a system is a function of its definition so it is equally possible to assert a rational basis for systems – that a system is a rational construct intended to be representative of some reality. Given these two viewpoints, it is essential to establish a philosophical foundation as a context for framing subsequent conclusions toward an internally consistent argument.

Internal Consistency of the Systems Perspective

A systems perspective, as discussed earlier, rests on acquiring sufficient knowledge of the system itself. Further, the assertion that a bounded domain within reality itself is systemic is equivalent to an assertion of a comprehensible reality - since systems concepts assert understanding, a bounded domain of reality as a bounded system must be understandable. In addition, system concepts also necessarily assert that a bounded portion within reality itself can be understood as a system. To be consistent, a systems concept must successfully reconcile these assertions.

A systems representation is limited; by definition, it has bounds. Further, a representation of a thing cannot be the thing itself. This distinction of representation of a thing and the thing itself can be considered in Kantian terms as phenomena and noumena, using a literal interpretation of the concept of noumena as a thing *in and of itself.* Certainly both phenomena and noumena exist and thus are part of reality; and further, changes in noumena over time can potentially result in changes in phenomena. In order for the systems representation to be representative of reality, it must acknowledge the existence of both phenomena and noumena, and therefore must derive a representation of noumena based on phenomena and on the noumena of the systems representation itself – which asserts a comprehensible causal relationship between noumena and associated phenomena.

The direct equivalence of specific phenomena with related noumena is analogous to an assertion of a correspondence theory of truth where that which is observed is presumed to be directly reflective of reality. To state that the systems representation deduces the representation of noumena from phenomena would require this assertion – that phenomena are directly reflective of noumena and therefore constitute premises for deduction. Considering the bounded nature of the systems representation, this assertion cannot be true in general (though it may be true in specific cases); hence the representation of noumena and therefore of much of reality must be inductively derived and is therefore subject to error (in the deterministic sense; in the probabilistic sense the potential for error is acknowledged). In the absence of this direct correspondence, a consequence of this line of reasoning is that systems concepts are not in general internally consistent with a purely empiricist philosophy: a bounded representation with a fixed resolution cannot conclusively represent reality.

Systems can be purely rational constructs – rational entities, relationships and boundaries such as organizations, business practices, or procedures. From a Platonic rational ontological perspective, this presumes *system-ness* to be a universal characteristic and a system to be an instantiation of this universal characteristic. However, the general tendency is to assert a bounded domain within reality as a system, which is a direct assertion of empiricism. In addition, for complex systems, unpredictability itself must be accepted as an innate truth – Warfield (2003) directly includes a "science of complexity" (pg. 514) within the construct of systems science. As such, systems can be internally consistent with rational philosophy, but not in general and not as typically applied. For a more specific example of the lack of consistency between a particular perspective on

systems and rationalism, consider the ontology for systems from Pickel (2007), which clearly expresses an empirical perspective:

1. Systems are the basic entities of the natural and social world.
2. Systems are real entities.
3. There are material, mixed, and non-material systems.
4. Each concrete system is directly or indirectly related to all other systems which form their proximate or distal environment.
5. While some systems are nested and ordered hierarchically, others are non-nested and overlap.
6. Systems have a different spatial and temporal reach.
7. A system consists of components and their relations with each other (organization or structure). Particularly important are, in addition, a system's environment (other systems), as well as the key processes (dynamics or mechanisms) that make it work.
8. In addition to linear or proportionate causal effects, there are non-linear or disproportionate causal effects. (pg. 394)

Sousa-Poza and Correa-Martinez (2005) note that a shortcoming in purely pragmatic philosophy is addressed by the inclusion of idealism (rejecting the notion of fallibalism as removing the basis for action). As a consequence, this research asserts pragmatic idealism as a suitable basis, and assesses (among other things) if systems concepts are internally consistent within that philosophical framework. This assertion is without prejudice to alternative foundations that retain the characteristic of internal consistency (e.g. post-modernism) but simply asserts pragmatic idealism is one such foundation.

Philosophical Foundations

The essential philosophical foundations for this research are broadly construed to be the elements of a paradigm. The concept of a paradigm itself is richly debated, but is generally consistent with "a conceptual or methodological model underlying the theories

and practices of a science or discipline at a particular time; (hence) a generally accepted world view" (OED, 2008). Kuhn (1996) used the term to refer to the set of practices that define a scientific discipline during a particular period of time; describing what is to be observed and scrutinized; the kind of questions that are supposed to be asked and probed for answers in relation to this subject; how these questions are to be structured, and how the results of scientific investigations should be interpreted.

In general these can be interpreted as epistemology (study of knowledge), ontology (study of being), and methodology. However, Lehmann (2004) provides an interpretation that defines a paradigm as a worldview relative to the branches of philosophy: metaphysics, epistemology, and ethics. In the latter case, "the praxis for applying the theoretical constructs in epistemology into behavioral codes of conduct" (pg. 19). While the branches of philosophy are many and varied, and can be debated ad infinitum, this distinction is of some import as it shifts the emphasis on *how* to the ethics that form the basis of how. This is reflected by Guba and Lincoln (1994), which discusses a paradigm as comprised of epistemology, ontology, axiology and methodology. From this perspective, the notion of methodology in isolation is sterile absent a reason or goal for the methodology.

The generation of a decision-making construct implies the means to make a decision; this section presents a brief discussion of epistemology, ontology, decision theory, axiology (the study of values), and their relevance to complex situations, ultimately concluding that the determination and choice of a desired future state require an internally consistent philosophical foundation, including an axiological and methodological basis consistent with the selected epistemology and ontology. This choice for complex situations is particularly critical, as it requires consideration of axiological principles for decision

making under unpredictable (vs. uncertain) circumstances. Since pragmatic idealism is proposed as a basis for this research, which provides an epistemological, ontological and axiological foundation, decision theory and methodology are a principal focus of the review.

Epistemology

Markie (2008) provides a definition of rationalism as the adoption of at least one of three claims:

> The Intuition/Deduction Thesis: Some propositions in a particular subject area, S, are knowable by us by intuition alone; still others are knowable by being deduced from intuited propositions.
>
> The Innate Knowledge Thesis: We have knowledge of some truths in a particular subject area, S, as part of our rational nature.
>
> The Innate Concept Thesis: We have some of the concepts we employ in a particular subject area, S, as part of our rational nature (Section 1.1).

An alternate perspective is that of empiricism, which can be briefly stated via the "The Empiricism Thesis: We have no source of knowledge in S or for the concepts we use in S other than sense experience" (Markie, 2008, Section 1.2). In the simplest perspective, the opposition of rationalism to empiricism is in the source of knowledge: it is either derived from reason or from experience – and in the extreme sense, it is derived solely from one source or the other. These positions are echoed in the philosophical perspectives of positivism which in the purest sense holds all knowledge to be gained through experiential means, and constructivism which in the purest sense holds all knowledge to be constructed

within the intellect. A critical discussion of constructivism is found in Olssen (1996), which places it in the context of realism.

This debate of the rational vs. the experiential is traceable to positions set forth by Plato and Aristotle. Plato (1892) held that ideas (*eidos*, or Forms) are real and universal and matter is a specific instantiation of a form. Therefore *treeness* is real and the *tree* is an instance of treeness - agreeing that a thing is a tree constitutes implicit agreement on the treeness of the thing. This hints at an underlying assumption of the duality of the material and immaterial – or body and soul – within Platonic philosophy; the mind is seen as distinct from reality and therefore perceptions within the mind have a fundamental reality. In a sense, knowing is unique and real, and the known is an instantiation of knowing – and therein lies the root of rationalism and constructivism. Concisely phrased, reality is a subset of knowledge. In this perspective, the presence of the duality is central to the construct. Conversely, Aristotle (1994) submits that a particular substance is a combination of both matter and form; in this view, universals exist only as they are instantiated. Therefore, the *tree* is real, and *treeness* is a quality of the tree. The essence of the argument is the existence of a unitary objective reality; something that knows is part of this reality, hence knowing is subsumed by reality. In concise phrasing, knowledge is a subset of reality. The diametrically opposed conclusions of the two philosophical perspectives reflect back to the notion of internal consistency with philosophical foundations. A perspective that rests upon a duality (whether material/immaterial or mind/body) permits subsuming one to the other; a perspective that rests on a unity necessarily subsumes all to that unity.

The comparison across the extremes of rationalist and empiricist epistemology represents only a fraction of the overall epistemic debate. Rosenberg (2005) provides an in-depth summary of the history of this dialog with respect to the philosophy of science; of particular interest is the assertion that empiricism has a preeminent role as "the 'official' epistemology of science" (pg. 23). This dialog evolved into post-positivism or postmodernism, emphasizing (in various forms) the role of the observer in not only the collection of data and generation of knowledge, but the development of the questions that frame inquiry. The introduction of this degree of epistemic relativism poses a serious challenge to a rigorous definition of knowledge generation – as Popper (1934) stated, "We do not know, we can only guess" (pg. 278). This indicates the need for significant caution and clarity when departing from the (asserted) assured reality of empiricist epistemology. As pragmatic idealism (Sousa-Poza & Correa-Martinez, 2005) introduces both the observer and the solution form (the form of interaction) in the complex situation, this degree of rigor in the generation of knowledge claims is essential for the proposed research. van Uden et al. (2001) and Cilliers (1998) also explore the relationship between postmodernism and complexity; in these cases they tend to reduce the uncertainty to an application-focused level (e.g. more agile, more flexible, more responsive) that displays a transformative teleology within a formative environment (Stacey, 2000).

Finally, Azzouni (2004) provides a set of epistemic conditions for observations that reflect a "tracking" requirement:

- What's observed is largely independent of what observers expect to see in the sense that what they'll observe can contradict what they expect to observe. (What they observe is in significant ways independent of what they believe about what they'll observe.)
- There are (autonomous) means of adjusting and refining observations [-] one can move for a closer look, for example, or squint. By 'autonomous', [*sic*] I

mean that these methods are learnt and executed in ways largely independent of our theories about our senses; we practice navigating by our sense, and not by applying theories about how our senses work.

- What's observed can be monitored, either in the sense of detecting what things observed do over time (watching an insect), or in the sense that time can be taken to explore different aspects of them (climbing a mountain).
- Certain properties of the object observed can be used to explain why, and in what respects, observed things can be observed (pg. 383).

This reflects the interdependency between epistemology and ontology: "The epistemic processes, which establish truths that we're committed to, must be sensitive to the objects *about which* we're establishing those truths" (pg. 372), which reinforces the rational requirement for consistency across the elements of the philosophical foundation.

Ontology

General approaches to the nature of existence tend to focus on the differentiation between an objective reality (realism) and a subjective (or constructed) reality (non-realism, under various forms such as post-modernism). Miller (2005), Feyerabend (1981) and Vandenberghe (1999) outline the debate in some detail, the latter being from the perspective of sociological theory. In this instance, a more precise focus as defined by Rescher (2000) is used. The pragmatic assertion is that of a mind-independent reality in order:

1. To preserve the distinction between true and false with respect to factual matters and to operate the idea of truth as agreement with reality
2. To preserve the distinction between appearance and reality, between our picture of reality and reality itself
3. To serve as a basis for intersubjective communication
4. To furnish the basis for a shared project of communal inquiry
5. To provide for a fallabilistic view of human knowledge
6. To sustain the causal mode of learning and inquiry and to serve as the basis for objectivity of experience (pg. 100).

Note that this preserves aspects of realism and non-realism, in a manner similar to postmodernism. These distinctions provide a sense of direction for subsequent development. Having established the distinction for the observer, pragmatic idealism rejects fallabalism not in the sense that error can be present, but in the sense that action must still be taken (e.g. a decision must be made). Further, the notions of causality and learning are directly related to knowledge generation, and indicate that this foundation can be related to understanding. Finally, there is an emphasis on intersubjective communication and communal inquiry that indicates the need to address multiple actors involved in knowledge generation.

Decisions and Decision Theory

A discussion on decisions can tractably begin with a discussion not just of what they are, but why they are. A decision – "to come to a conclusion, make up one's mind; determine, resolve" (OED, 2008) – represents a choice between perceived alternatives. This very aspect of choice presumes that 1) an individual exists to make the choice, that 2) two or more alternatives exist and that 3) there is a reason to prefer one over the other. Decisions as a result must have an underlying ontology and epistemology – there is an assertion of a reality (something to decide about), knowledge of that reality (choices to decide between) and an awareness of reality and choices (self-awareness in some form).

Decision theory is the selection between alternatives based on preference; or alternatively phrased, "decision theory is concerned with goal-directed behavior in the presence of options" (Hannson, 1994, pg. 6). A significant body of work exists with respect to decision theory in general; a brief history is provided in the introduction to Fishburn (1964), an accessible discussion is provided by Hannson (1994) and an in-depth

discussion is provided by von Winterfeldt and Edwards (1986) and Raiffa (1968). This discussion is largely concerned with an analytic approach to rationalize decision making – to develop quantifiable means that result in guidance for selection of an alternative. These approaches fall into the broad categories of normative and descriptive decision theory; a normative decision theory is a theory about how decisions should be made, and a descriptive theory is a theory about how decisions are actually made.

Of interest here are the elements of decision theory relevant to the philosophical elements of epistemology, ontology, methodology and axiology; a brief review of the major elements of thought in decision theory provides a basis for extending the discussion to these considerations. In the process, this discussion omits a significant body of work to focus on essential elements for such considerations, but in a general sense decision theory emphasizes probabilistic perspectives illustrated by Expected Utility approaches, in both classical and modern applications.

The central problem of decision theory is making decisions in uncertain circumstances. Classical (Bayesian) approaches seek to make decision making tractable through a set of assumptions that assert a rational agent; for example, Hannson (1994) summarizes Bayesianism as: the Bayesian subject has a coherent set of probabilistic beliefs; the Bayesian subject has a complete set of probabilistic beliefs; when exposed to new evidence, the Bayesian subject changes his (her) beliefs in accordance with his (her) conditional probabilities, and finally, Bayesianism states that the rational agent chooses the option with the highest expected utility (pg. 37-38). Based on these assumptions, various laws of probability theory are applied, assigning probabilities to consequences that are ultimately assessed relative to some value premise. The premise of a rational agent has

been the subject of much effort associated with classical expected utility approaches; considerations other than probabilistic often impact decision making, and the difficulties in accommodating these impacts are the subject of significant later work. Utility theory and games (e.g. von Neumann & Morgernstern, 1950; Wald, 1950) represent efforts to increase the robustness of these approaches; Savage (1954) developed Subjective Expected Utility (SEU) as a concept to accommodate issues with the rational agent concept. SEU "postulates a preference structure, depicted axiomatically, permitting the numerical expression of the decision maker's valuation of the consequences by a utility function, that of his beliefs by a (subjective) probability measure on the set of all events, and the evaluation of acts by the mathematical expectations of the utility with respect to the subjective probability" (Karni, 2005, pg. 4).

Additionally, dialog in decision theory has incorporated various structures, phases or stages for decision making – an example is found in Dewey (1910, pgs. 72-77), where problem-solving consists of five consecutive stages: (1) a felt difficulty, (2) the definition of the character of that difficulty, (3) suggestion of possible solutions, (4) evaluation of the suggestion, and (5) further observation and experiment leading to acceptance or rejection of the suggestion. Though numerous such organizations are available, the essential element for this discussion is the trend towards analysis – the dissection of the problem to a level tractable for metrification of consequence for assessment relative to some value premise. Also, the basis asserted for a decision is derived through analysis – a dissection of consequences given means – hence if this analysis is improper the basis for a decision is improper. As an example, given a selected epistemology and ontology, a perspective treating an irreducible as a reducible will by definition create a lack of understanding and

defeat analysis. Another example is seen from a systems perspective, where incorrect bounding of a construct for reality can omit entities and/or relationships and therefore introduce error in the determination of consequence. The ability to analyze – again a function of being and knowing – is implicit in the ability to make a decision.

Decision theory provides a significant body of work to treat diverse interpretations – probabilistic, subjective, both, and others – but the common themes are analysis and metrification. Further, though all of these approaches deal with making difficult decisions (those where the consequences relevant to the value premise are not immediately apparent), in both simple and difficult decisions the fundamental requirement is that there is some means to determine consequence and some value premise permitting some metrification of choice through assigning objective or subjective values to consequence. A consistent philosophical foundation for decision theory must therefore accommodate analysis, providing some means to determine value and consequence. The former speaks to axiology, the latter to ontology and epistemology.

Axiology

Axiology (from the Greek *to speak of values*) is a branch of philosophy addressing the study of value (OED, 2008). Value is "the relative status of a thing, or the estimate in which it is held, according to its real or supposed worth, usefulness, or importance" (OED, 2008). Value theory therefore has a significant breadth of subject matter: "acts or processes of mind involved in our responding, appraising, and judging and in the creation of values ... concepts we make use of in these acts or processes of evaluation ... the presentation of completely general and ultimate apprasive concepts such as good" (Aschenbrenner, 1971, pg. 4). The breadth of inquiry is further illustrated by Jessup (1949):

"Among writers on value there seems to be fair agreement that these things include: (1) value-feelings (pleasures and pains and affective dispositions; (2) volitional activity (based on felt tensions), setting up ends or purposes, the drive toward which is not simply additive of the moments or points of felt-pleasures along the way; (3) value-judgment (appraisal or evaluation), which may reject, censure, or approve of both feeling and will; (4) the value objective, which may be any thing, quality or situation, actual or ideal, and of any degree of intricacy" (pg. 127). Keeney (1992) provides a treatment of the role of values in decision-making, contrasting value-focused thinking to alternative focused thinking – in particular focusing on the ability to create decision opportunities. Notwithstanding the breadth of inquiry for value theory as illustrated in the above and in Hart (1971), elements of interest for this discussion include those related to being, knowledge and praxis (Lehmann, 2004).

The notion of value necessarily requires a subject and a predicate, or a judgment and a subject of the judgment - both valuing and valued entities are presumed. These are essential ontological assertions towards the existence of each; however, no further assertions are required at this level of definition. Whether a rationalist, empiricist, realist, pragmaticist or other ontological foundation is asserted, all can result in valued and valuing entities. Rational foundations may assert entities derived through reason; empiricist foundations may assert an experiential basis for the same. In a broad sense, then, axiology is dependent upon an ontological foundation - whether it is derivative of this same foundation remains to be examined.

The epistemological foundations for axiology are clear in the sense that knowledge of the thing valued is available (though again the specific philosophy may vary). However, from the descriptions quoted above there are additional aspects to be examined – the above

quotations make clear reference to value as both individual and situational. That there is even a debate on values indicates there is variation across individuals – the concept of subjective expected utility is a mechanization of this variation. Either values are universal and constant and the discovery of these values differs across individuals, or values are individual and situational and consequently differ across individuals. Therefore, as with the earlier ontological argument, axiology will be dependent upon and derivative of an epistemological foundation.

The extent of this dependency is significant as the discussion of value requires a discussion on the nature of self-awareness. That there is a need to choose indicates a reason to choose – i.e. there is some purposive end for the individual making the decision. Though the dialog on values (and decisions) deals with far more pragmatic ends, at the heart of the dialog there is an assumption of an ultimate purposive end that creates the need for a self-aware individual to make a choice. Further, this requires the ability to create some representation of alternatives, and discern some benefit towards the ultimate purposive end. These ideas are implicit in value theory and decision theory and must be accounted for in the supporting ontological and epistemological foundations.

In the extreme, this becomes a debate as to whether axiological foundations exist independent of self-awareness. In the total absence of self-awareness, there is by the above arguments no valuing entity, and the debate is reduced to the notions of value independent of valuation – an inconsistent concept unless the ontological foundation asserts value as an inherent characteristic of existence, one that is discovered in the presence of self-awareness rather than assigned. Hence there are two cases to consider: either value is assigned by the valuing entity, in which case there is an ontological assertion of existence and self-

awareness and a derivation of value through epistemological assertions; or it exists as an ontological assertion and is revealed through an epistemological assertion. The former presents a constructivist perspective, the latter a positivist perspective – but in both cases it can be asserted that axiology is not only dependent on ontology and epistemology, but derivative of them as well. As methodology has already been presented as requiring a reason (value) for application, the complete suite of a study of being, knowledge, values (derivative of the same), and praxis (methodology) then forms a coherent structure for a paradigm.

In summary, axiology as the study of values possesses certain key characteristics relevant to decision theory:

- it presumes a reality, including the valuing entity and the thing valued;
- it presumes a valuing entity to have knowledge of the thing valued;
- it is dependent on and derivative of an epistemological and ontological foundation, and
- it presumes an individual with some ultimate purposive ends for valuing.

Further, decision theory provides an additional key characteristic that there must be some analytical means to determine consequences of courses of action.

Complexity, Axiology, and Decision Theory

Understanding implies a sense of causality – the "means/consequence relationship" (Dewey, 1933, pg. 146) – that is at odds with unpredictability. For decision theory, the impacts are significant – much of decision theory deals with uncertain circumstances, not unpredictable circumstances. Under uncertain circumstances, behaviors are stochastic whereas in unpredictable circumstances, behaviors are neither stochastic nor deterministic.

The adoption of a time-independent perspective as opposed to a time-dependent perspective does not necessarily result in any change in the probability of an erroneous knowledge claim within the perspective. Unpredictable behaviors, for example, may be chaotic (deterministic but having such sensitivity to initial conditions that future outcomes cannot be determined to an arbitrary degree of accuracy) or complex (emerging from rich interactions of multiple entities). Further, complex behaviors are sensitive to history – every instance is unique and will have a unique associated future. In such cases it is not possible to quantify consequences – e.g. assign a probability to outcomes – as any such assignation has as little or as much meaning as any other. The selection of a given choice becomes irrelevant under such circumstances; simply put if it is not possible to know what outcome will occur in the instance or over time, it is not possible to choose between outcomes.

In such conditions, notions of assigning value to outcomes may seem moot as nothing can be done with the assigned value. However, it is appropriate to consider that considerations of value may return to a more fundamental discussion on the reason for making a decision – the notion that there is a purposive end. Consideration of decision-making, and the associated axiological foundations, returns to the reason to make a decision at all - which, per the earlier discussion, is dependent upon and derivative of ontological and epistemological foundations for axiology and decision making. This must be phrased in a manner that incorporates those cases where consequence can be defined (e.g. there is a prior distribution) and where value can be assigned (e.g. there is a utility function). As consequence and value have been previously asserted to be based on some selected philosophical foundation, any consideration must be internally consistent with

those foundations; hence the basic assertion is that a decision is justifiable if it is internally consistent with philosophical foundations. Here, justification is used in the sense of "To show or maintain the justice or reasonableness of (an action, claim, etc.); to adduce adequate grounds for; to defend as right or proper" (OED, 2008). Rather than serving as an axiomatically specific term, it instead captures the conceptual subtleties of operations in unpredictable circumstances where the basis for decision is not clear – certainly not in the traditional sense, and potentially not clear in any sense. This is reflected by Aliseda (2004): "explanations are public objects of 'justification', [*sic*] that can be checked and tested by independent logical criteria" (pg. 341), and further by Rescher (2009a): "The prime directive of cognitive rationality is to maintain consistency" (pg. 3). The logical criteria are provided by the philosophical foundations – a rational deductive approach.

Finally, this must be stressed as a necessary axiological principle but it is by no means asserted to be sufficient – there will almost certainly be additional axiological considerations in every particular situation (for example, ethics, morality, etc.) that are not treated here. The justification principle is highlighted here as particularly relevant to this discussion, for decisions both in research and in practice must be similarly justified. Therefore internal consistency, including a robust axiology, is a requirement for both research and practice.

Methodology

Kieseppä (2000) presents methodology as one of the principle consequences for epistemological and ontological choices. Mingers (2003) provides a summation of methodology as the general study of methods of intervention or research (as in a course in Research Methodology); the particular methods used in a specific project or study (as in

"what was your research methodology?"); and a generic combination of methods that is commonly used as a whole (as in soft systems methodology, strategic options development and analysis, or survey methodology covering the design and analysis of questionnaires) (pg. 559). Methodology is distinct from methods; for example the methodology traditionally associated with logical positivism is the process of empirical scientific inquiry. Popper (1934) regarded methodological rules as conventions – the "rules of the game of empirical science" (pg. 53) (which indicates the association held with methodology at that time). Development of a methodology cannot focus on rules, but the way in which rules are to be generated. To speak of a *quantitative* or *qualitative* methodology is not necessarily consistent as these presuppose a specific method – not the guidance for generating specific instantiations of a method.

Further, Guba and Lincoln (1989) emphasize the growing tendency to shift "across paradigms" (p. 157) in methods. This raises serious issues with the notions of internal consistency; of course, it is not necessarily an issue when moving between methods that are consistent with a given methodology – for example, both quantitative and qualitative approaches can be consistent with empiricist epistemology. This tendency cannot be held to be true across diverse epistemic foundations; again caution and clarity is demanded. Axiological and methodological components of the foundation will naturally have a focused relationship; Lauden (1986) notes that "The methodology of inquiry has to be supplemented by the axiology of inquiry" (pg. 351). In practice, this indicates the need for co-development of these elements of the foundation.

A methodology may well be seen as an *a posteriori* meta-construct for a collection of methods developed for inquiry within an overall philosophical foundation, which

provides little guidance for *a priori* development. However, it can be framed from the definition focusing on the "rules" for scientific inquiry, which leads to the assertion of the tautological relationship that a *research methodology must provide guidance for the selection of methods for generating knowledge within a given philosophical foundation.* The reference to methods for generating knowledge immediately brings to mind canons for research. These are generally used as conventions for the design and execution of research, but the requirement is highly similar and thus suggests a close relationship between methodology and research canons. This also incorporates a subject that is not often explicitly treated in research methodologies – the definition of knowledge itself. From this perspective, development of a methodology can use the other elements of the philosophical foundation and research canons to facilitate selection or generation of methods for research. This is illustrated in Figure 2, which will be further augmented in the discussion on research canons below.

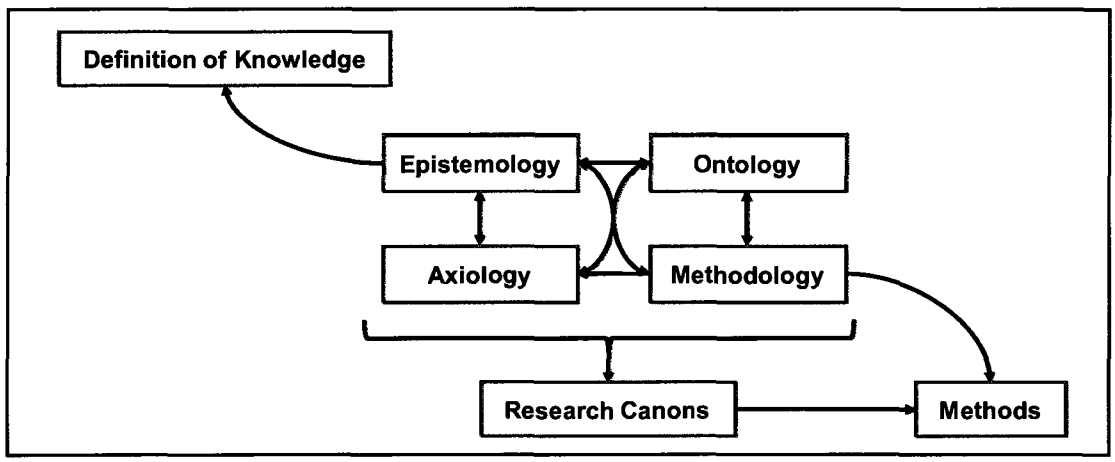

Figure 2. Initial Relationship of Methodology, Canons and Methods

As further guidance for the initial direction of the research, given that the methodology must be developed in concert with the other elements of the paradigm, it may be possible to exploit known relationships between those other elements. An example of this can be found in (Rescher, 1998) illustrating the tension between the "ontological and epistemological dimensions" (pg. 114):

[Ontological]	[Epistemological]
Unexplainable	Not (yet) explained
By chance	By some cause we do not know of
Spontaneous	Caused in a way we cannot identify
Random	Lawful in ways we cannot characterize
By whim	For reasons not apparent to us (pg. 114)

By way of comparison, Pickel (2007) presents a methodology for systems as follows:

1. The conception of system is basic to and relates all sciences and disciplines. Individual humans are both systems and components of systems.
2. Systems exist independent of the models, conceptualizations, or theories through which we try to understand and explain them.
3. Materialist and idealist reductionisms in the social sciences are rejected.
4. Conceptualizations in terms of "part-whole" or "base-superstructure" are insufficient to capture the complex order of real social systems.
5. Conceptualizations for more complex orderings need to be developed.
6. Time and space are crucial dimensions in accounting for systems (e.g., path dependency, co-evolution).
7. While the concept of system as entity may suggest stasis, the mechanisms or dynamics of any system are central in explaining emergence, persistence, and dissolution of concrete systems.
8. Causal relationships cannot be inferred from linear correlations (pg. 394).

This is a blend of higher level assertions (*conception of systems is basic*), rules for practice (*account for time and space*), and constraints (*cannot be inferred*) that may assist in developing methods – though more explicit framing may be desired in practice.

CHAPTER III: RESEARCH METHODOLOGY

Overview

The research design centers around the proposed knowledge claims: a decision making construct internally consistent with philosophical foundations. The development of philosophical foundations dictates a rational deductive approach with the concomitant emphasis on credible premises and defensible arguments. The decision making construct itself must be derived to be consistent with the philosophical foundation, again dictating a rational deductive approach. The issue of external validation (or the equivalent form as specified by the research canons) is problematic for complex situations; no matter how much data is collected it is disingenuous to presume that conclusions based on prior data will be predictive of future events – when those events are unpredictable in neither the temporal domain (deterministic) nor the frequency domain (probabilistic). The initial purpose of the study was refined based on literature review and methodology development to capture this issue; it speaks of justification of the construct (e.g. internal consistency with philosophical foundations). The fundamental characteristics of complexity restrict the notion of *proof* – aside from the postmodern claims of relativism and fallabilism based on the nature of inductive reasoning, there is no single solution for unpredictable events. As such, this research is necessarily constrained to an assessment of decision-making within that environment – not the environment itself – and must acknowledge that canons such as repeatability will not be applicable across cases. The goal of the research is to develop the decision-making construct, providing insights for the analyst to apply to a particular situation. This requires a deliberate assessment of canons and their role in research incorporating philosophical foundations.

Canons

Introduction[*]

The purpose of research is to gain knowledge. Credible research requires rigorous consideration of what knowledge is and how it can be gained, expressed as canons for research. Though canons may vary across particular research communities, the purpose remains the same: to ensure knowledge is developed in a defensible manner. This defense must necessarily include ontological considerations of the nature of being; there is something to be known and there is someone to know it. Since knowing is itself an epistemological statement, research canons must possess an epistemological and ontological perspective. For research in areas with different philosophical perspectives, the duality present in various branches of philosophy (positivism / constructivism, rationalism / empiricism, etc.) may demand choices that will preclude building some forms of knowledge and enable building others. The choice of canons becomes critical for the researcher in areas sensitive to such variations in perspective; but for multi-disciplinary research such as complexity considerations of canons and reconciliation of potential dichotomies in resulting knowledge claims becomes both paramount and problematic. As discussed above, canons also hold a close relationship with methodology.

Rather than building canons on disparate foundational philosophical perspectives, they can be constructed on a common element for reconciliation – knowledge – to yield a set of "generalized research canons" based on a specific definition of knowledge. These generalized canons, applied to a particular philosophical perspective, instantiate a specific set of research canons; allowing resulting knowledge claims, even though derived from

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[*] The content of the generalized canons section, generated in the course of this research, was previously published as (Brewer, V., & Sousa-Poza, A, 2009) and is used here, by permission of the authors, for completeness in presenting the research.

potentially irreconcilable philosophical perspectives, to retain common reference points for reconciliation.

Research Canons

A canon is "a general rule, fundamental principle, aphorism, or axiom governing the systematic or scientific treatment of a subject" (OED, 2009). Canons are presented in the literature on research methods, sometimes as rules (Munck, 1994) or procedures (Corbin & Strauss, 1990). They are developed within specific disciplines to meet the particular requirements of the discipline; a treatment of canons for qualitative research (King, Keohane, and Verba, 1994; Guba & Lincoln, 1994), quantitative or mixed methods (Creswell, 2007) yields different results. The common end state is a set of guidelines, procedures and rules for the conduct of credible research within the discipline.

A point not emphasized in these treatments is the end state of research itself. In the above definition for canons, the notion of *scientific* as "producing knowledge" (OED, 2009) is illustrative – the end state of research is to build knowledge, accompanied by concomitant epistemological and ontological issues. Canons evolved within a given discipline to enable credible research, and in doing so they necessarily instantiated a philosophical perspective appropriate to that discipline. This implies the existence of an unstated canon common to all instances: that of internal consistency with philosophical foundations. However, philosophical foundations for canons are not explicitly addressed in the literature (with some exceptions).

Bozkurt and Sousa-Poza (2005) provide a review and analysis of research canons which, in addition to asserting the requirement for internal consistency with underlying philosophy, generates generalized categories of canons for the dualistic perspectives of

positivism and constructivism (Table 1). These incorporate considerations of other categories of canons, such as Pickard and Dixon (2001) and Guba (1992).

Table 1. Research Canons from Bozkurt & Sousa-Poza, 2005

Positivist	Constructivist
Internal Validity	Credibility
Generalizability	Transferability
Reliability	Dependability
Objectivity	Confirmability

Other sets of canons can be grouped (subject to debate and discourse) within these categories; Table 2 provides an illustrative grouping of rules from (King et al., 1994) within this framework.

However, the categories in (Bozkurt & Sousa-Poza, 2005) were derived by abstracting common themes in existing sets of canons. The ability to place another set of canons within those categories only serves to illustrate that a higher level of abstraction is possible. This is the case illustrated in Figure 3, where the explicit or implicit philosophical foundations are the basis for building knowledge – which then leads to difficulties in resolving knowledge claims across different philosophical foundations.

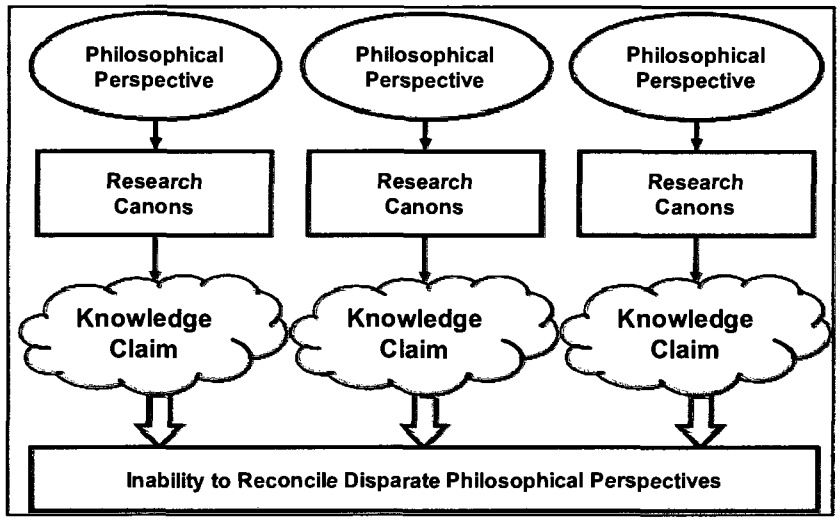

Figure 3. Application of Research Canons

Table 2. (King et al., 1994) Canons Mapped to (Bozkurt & Sousa-Poza, 2005) Categories

Bozkurt & Sousa-Poza (2005)		Illustrative Comparison to (King et al., 1994)
Positivist	**Constructivist**	
Internal Validity	Credibility	Logical Consistency Conditional Independence I (independent explanatory variables) Leverage (explain as much as possible with as little as possible)
Generalizability	Transferability	Relevance I (real-world) Relevance II (scholarly) Omitted variable bias Efficiency (did you ignore that which does not?) Indeterminacy I: Sufficient cases Indeterminacy II: Single explanatory variable
Reliability	Dependability	Unit homogeneity (consistency within cases) Conditional independence II (cases really are independent) Selection Bias Validity of data collection Reliability of data collection Replicability of data collection Level of generality Blindness (do not use old data to test old theories)
Objectivity	Confirmability	Testability Falsifiability Summarize data with focus on outcome Honesty (report weakness in case selection biases) Honesty (report measurement errors)

Also, though the incorporation of philosophical perspectives addresses the "unstated canon" of internal consistency, it does not address canons as a means to accomplish the fundamental goal of research – building knowledge. The first step in this process, then, is to define knowledge.

Knowledge

The definition of knowledge is both an ancient and ongoing discussion in the literature, warranting its own branch of philosophy (epistemology). The intent here is not to repeat this rich discussion, but instead to accept the generally held Platonic definition – and therefore accept the debate and limitations associated with that definition. As will be seen, even this approach requires accepting some initial choices to enable application of the definition.

The Platonic definition of knowledge is belief with some account (Plato, 1892), generally referred to as a Justified True Belief (JTB). Gettier (1963) demonstrated that issues arise with the reliability of justification. This is further discussed in Lehrer and Paxson (1969), who assert that the JTB must be undefeated, and Goldman (1967), who asserts that the JTB must be causal (the latter holding some implication for dealing with complexity). These discussions, and others, are generally applied to create a definition of JTB(+), where the (+) indicates additional criteria to address Gettier conditions. In order to develop a suitable foundational definition of knowledge, the (+) must be rendered into a suitable form for discussion.

A basic lexicon can be established to develop the JTB(+) construct, starting with the notion of belief. The inclusion of the qualifier *true belief* belies that an individual can have *beliefs* that may or may not be true; here referred to as *ideas* in the sense of "mental

image, conception, notion" (OED, 2009). A belief then becomes an idea held by an individual to be true – either a reflection of reality in terms of direct correspondence with reality or a true reflection of reality in terms of coherence with a set of propositions related to reality. The establishment of the truth of this belief for the individual then constitutes that individual's justification – in other words, *justified* implies the assertion that an individual's true belief can be communicated to others. Examples of these may include beliefs held on faith – an individual may hold them to be a true belief, but also be cognizant that the justification is so personal as to negate communication. In order to establish a belief as knowledge, there must be some manner by which another individual can accept this belief as justified and true – i.e. the reliability of justification addressed by the Gettier conditions.

In moving to an expression of (+), it is appropriate to note that the ultimate goal incorporates a process perspective – that of building knowledge – and must therefore address both process (building) and substantive (knowledge) perspectives. In the most general sense, the (+) must capture these two perspectives. The process component of reliable justification may be designated as a method – "a special form of procedure or characteristic set of procedures employed (more or less systematically) in an intellectual discipline or field of study as a mode of investigation and inquiry" (OED, 2009). Likewise, the substantive component of reliable justification may be designated as the context - the parts that surround the justification and give it meaning.

However, Kirkham (1984) explicitly states that justification "cannot be improved by insisting that ... premises must be arrived at by a reliable method" (pg. 506). Given a variety of methods, one must determine a method that is reliable – an additional criteria that

invites infinite regress. The use of *reliable method* here must be associated with *reliable context* – there must be some reason to presume the method is reliable, though that presumption may engender associated issues.

One impact of this definition is that it takes more than one person to build knowledge. This may be resolved in the sense of the lexicon presented above – but this does little to prevent misinterpretations in broader use. An individual may hold that he or she has knowledge in the JTB(+) sense – a knowledge claim – but if another individual rejects the justification, method or context then the knowledge claim does not rigorously meet JTB(+) criteria. In this sense, a justified true belief implies that an individual asserts meeting the JTB(+) criteria independent of the judgment of another individual, and knowledge to be that which fully meets the JTB(+) criteria. In either case, research canons must acknowledge this aspect of the JTB(+) definition in generating formalized representation of the criteria to build knowledge between individuals. To summarize the lexicon:

- Idea: A mental image, conception, notion (OED, 2009).
- Belief: An idea held to be true.
- True Belief: A belief held to be reflective of reality.
- JTB: The assertion that an individual's true belief can be communicated (externally justified).

This progression ultimately results in:

- Knowledge Claim: The assertion of a JTB(+).
- Knowledge: The acceptance of a JTB(+).

This definition presumes an ontological foundation (the existence of someone who knows and someone to whom that knowledge is justified) and an epistemological foundation (that

there is *knowing*). Further, there is an implication that there is variation across individuals; otherwise such justification would not be necessary.

Generalized Research Canons for JTB(+)

If one accepts the JTB(+) definition of knowledge, and that research canons seek to build knowledge, then these canons should be directly traceable to the asserted definition of knowledge. By way of comparison to Figure 3, Figure 4 presents the objective condition: the derivation of generalized canons from a definition of knowledge such that there is some basis for reconciling knowledge claims across disparate philosophical foundations.

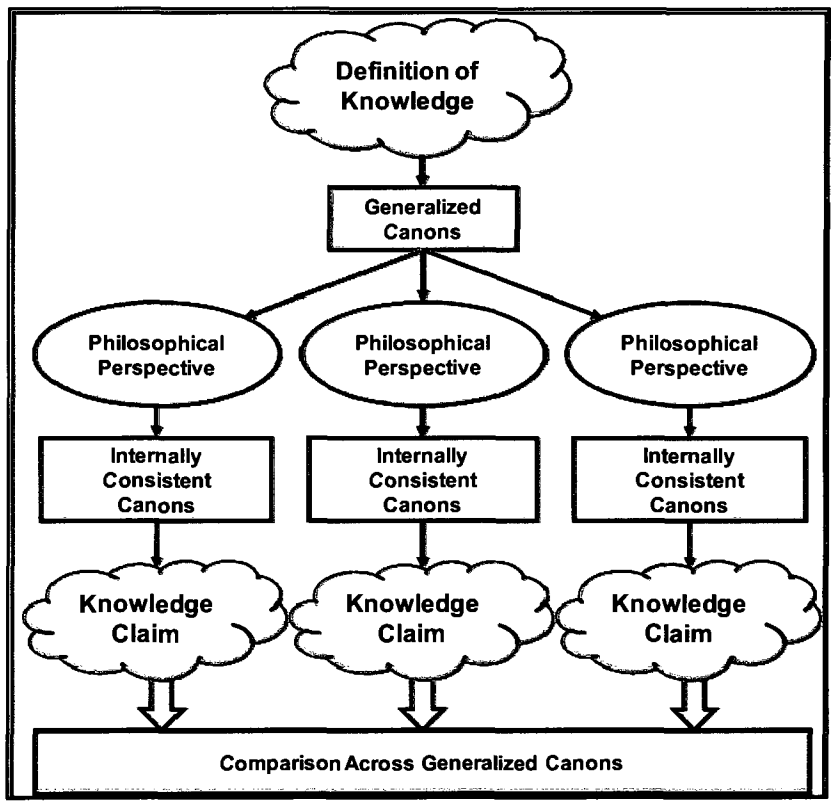

Figure 4. Application of Generalized Research Canons

Following the lexicon presented earlier, this discussion begins with what would ultimately become knowledge: a belief. The first canon is therefore the assertion of the truth of the belief; i.e. that it is reflective of reality. Truth is used in the sense of "consistent with fact; agreeing with the reality; representing the thing as it is" (OED, 2009). This is not inconsistent with a representation of the unreal, as the representation itself is real; but it does speak to the notion of a representation as reflective of reality. The assertion of truth begins with an idea as a construct within the individual; one that an individual would hold either as reflection of reality in terms of direct correspondence with reality or a true reflection of reality in terms of coherence with a set of propositions related to reality. In a general sense, the former can be held to be a subset of the latter – that is, correspondence with reality is coherence with a set of propositions held to be directly reflective of reality. Therefore, the challenge to establish truth is to generate that set of propositions, and demonstrate that the idea is coherent with that set of propositions.

Given a true belief, the next step in the maturation towards knowledge is a second generalized canon of justification, earlier presented as the assertion that an individual's true belief can be communicated to others. The phrase *justification* is used in the sense of JTB(+); e.g. it must assert (for a knowledge claim) or accept (for knowledge) truth external to the individual – hence knowledge is not established absent the presence of JTB(+) across individuals. This introduces two other ontological considerations, as both communication and another individual are postulated, but does so without conditions – the ways and means of communications and the form of the other individual will be subject to the particular philosophical foundation for a specific instantiation of canons.

Where truth speaks to the assertion of an individual's belief as reflective of reality and justification to the assertion of the ability to establish that truth external to the individual, a reliable method speaks to the ways of justification and a reliable context to the means of justification. Here, means are all of the resources (data sources, environment, etc.) that are used in the ways of justification. This places the method of justification in a venue (a scene or setting) which must be contained within a shared domain of ways and means between individuals for reliability to be established (via concurrence across individuals).

As discussed earlier, inconsistencies with philosophical foundations can introduce error into the justification, method or context. Internal consistency of a knowledge claim with its own philosophical foundations is therefore a prerequisite to establishing knowledge. This is not necessarily a generalized canon in and of itself, as it is specifically asserted as an axiological principle, but must be borne in mind for both research and practice.

From the above discussion, the set of generalized research canons for JTB(+) knowledge is defined as:

- Truth: the research must establish that an individual's belief is reflective of reality (whether through correspondence or coherence);
- Justification: the research must provide for establishing truth external to the individual;
- Method: the research must establish reliable ways of justification; e.g. addressing the process or temporal validity; and

- Context: the research must establish reliable means of justification, addressing the resources used in the ways of justification.

Table 3 provides a direct comparison of the generalized canons from Bozkurt and Sousa-Poza (2005) and generalized JTB(+) canons. Arriving at a compatible destination from two different starting points is simply the absence of negation and does not validate the approach per se; but does provide a measure of inductive support.

Table 3. Comparison of Generalized Categories from (Bozkurt & Sousa-Poza, 2005) and Generalized JTB(+) Canons

Bozkurt and Sousa-Poza (2005) Generalized Categories		**Generalized JTB(+) Canons**	**Criteria**
Internal Validity	Credibility	Truth	Establish an individual's belief as reflective of reality
Generalizability	Transferability	Justification	Establish truth external to the individual
Reliability	Dependability	Method	Establish shared ways of justification
Objectivity	Confirmability	Context	Establish shared means of justification

Generalized Research Canons for Illustrative Philosophies

Examination of perspectives in opposition provides insights on the underlying philosophical foundations; in this instance, the perspectives of rationalism and empiricism will be used as illustrative examples to frame the respective roles of knowledge and reality. Though similar discussions are allowable under different philosophical bases, these philosophies will be used to extract a point of diametric opposition that is problematic for complex situations (here, diametric opposition is used to indicate a point of disagreement between two philosophical foundations and does not obviate the potential for duality within

a philosophical foundation). This permits subsequent comparison with a different philosophical foundation as a means to reconcile diametrically opposed positions.

For more extreme interpretations of rationalism, the applicability of generalized JTB(+) canons ends with truth and justification – what is innate is known and true; and what is derived from that in a consistent fashion is likewise known and true. The reliability of method is the reliability of the justification, and the reliability of context is the reliability of the innate; a justified true belief is knowledge and requires no additional conditions. As earlier stated, the notions of communication and the individual communicated to are governed by the foundational philosophy. Hence, the context for justification is the existence of innate knowledge and the method for justification is the internal consistency of reality (universals).

For empiricism, the earlier canons presented in (Bozkurt & Sousa-Poza, 2005) are directly applicable. Truth is established from sense data, which must be acquired in a credible manner. Justification must establish that this true belief can be communicated to another individual, either by generalizing a specific case or by transferring to commensurate cases. Since sense data is the singular source for reality, the method for justification must be reliable (or dependable) so as not to introduce extraneous error. Finally, the context must be objective or confirmable so as to be accepted by both individuals. The notions of communications and individuals communicated to are commensurate with the primacy of sense data.

Table 4 summarizes the internally consistent canons for these two philosophical foundations derived from the generalized JTB(+) canons. This makes the disparate

foundations explicit, but equally explicit is the relationship of each to the definition of JTB(+) knowledge.

Table 4. Internally Consistent Canons for Illustrative Philosophies

Generalized JTB(+) Canons	Empiricism	Rationalism
Truth	Internal Validity Credibility	Axiomatic / Reason
Justification	Generalizability Transferability	Internal Consistency of Argument
Method	Reliability Dependability	Innate
Context	Objectivity Confirmability	Internal Consistency of Reality

This discussion allows refinement of the relationship between methodology and canons discussed above. Using the concept of generalized canons completes the linkage between the definition of knowledge, the philosophical foundations, and methods by way of the instantiated set of canons (Figure 5). The importance of the definition of knowledge is clearly one of the most critical aspects of research, particularly into alternative philosophical foundations, and should be considered as one of the required elements of the epistemology.

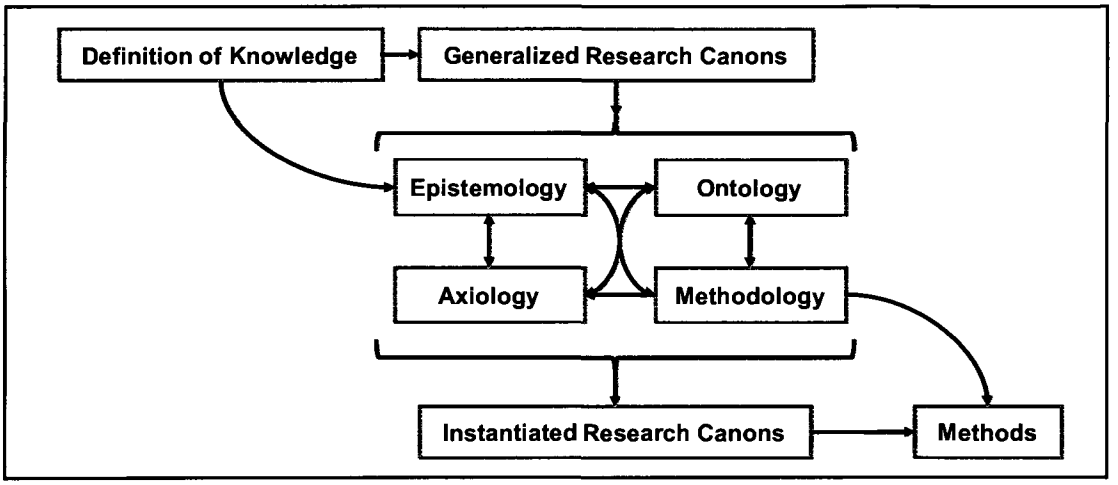

Figure 5. Revised Relationships between Methodology, Canons and Methods

Research Methodology

In accordance with the axiological principle of justification, the research methodology builds JTB(+) knowledge using the generalized JTB(+) canons. In this instance, the research itself develops an internally consistent philosophical foundation for decision making in complex situations; hence the methodology itself evolves in concert with the research. This does not imply that there is no methodology; to the contrary strict accountability to research canons is required. Further, there is a defined starting point for this research (pragmatic idealism). As such, it is possible to discuss the research methodology that will provide this level of strict accountability within the context of the broad philosophical foundation of pragmatic idealism; however, this discussion must be tempered by the knowledge that the ultimate test of justification will be to satisfy the generalized JTB(+) canons as instantiated for the particular philosophical foundation.

In this instance, the start point (pragmatic idealism) is essentially a set of conclusions derived from a set of premises – a rational deductive approach. Based on consistent application of ontological and epistemological foundations, these conclusions can be considered as rearranging knowledge – a form of learning where new applications

are found for existing knowledge. To further justify these conclusions as a true belief, continued use of rational deductive methods would only extend the body of premises and conclusions. Ultimately, the external validity must be established by the acceptance of the body of premises and conclusions as sufficient for consistency of the argument.

Further, research in complex situations is confronted by an inherent limitation: correspondence between theory and reality, for a particular situation, does not exist – the situation itself is unpredictable. Once the step has been made to adopt coherence, a rational approach is indicated (by the need to demonstrate consistency with a body of propositions) as opposed to an empirical approach – or, per Simon (1973), a *Logic of Scientific Discovery*. Also, while correspondence theories of truth have their own detractors (particularly in the regress problem which essentially translates to a recursive coherence theory of truth), correspondence tends to be emphasized in traditional management and engineering research methods reflecting an overall tendency towards positivist empirical approaches. Correspondence is seen as providing a high degree of external validity for theory, providing an additional measure of risk mitigation in the definition of the domain of applicability characterizing the generalizability and/or transferability of research.

Research methods based on coherence theory of truth must deal with the challenges of that stance, including the adoption of a rational approach and the establishment of external validity. It is not necessary to completely abandon one theory of truth for another – see for example, the idea of Foundherentism (Haack, 1993) – in dealing with complex situations it may be possible to construct a body of propositions using empirical methods and a correspondence theory of truth, then use that body of propositions as the basis for a rational method using a coherence theory of truth. In doing so, the constraints, limitations

and assumptions of the body of propositions are empirically rooted, but can then serve to define the domain of applicability for external validity via coherence.

Analysis

The analysis of results must conform to the instantiated canons, resulting in a rational deductive approach for both the construct and the analysis of the construct. The method includes a comparative analysis against decision-making constructs for alternative philosophical foundations (for example, deterministic and probabilistic decision-making approaches) as a part of the reliable context. The synthesis of conclusions is as critical as the analysis itself, and must address two distinct levels of synthesis: conclusions within the proposed construct and comparison across constructs. The former includes the comparative analysis across the elements of the proposed foundation, focusing on the requirement for internal consistency but also developing insights on the relationships and interdependencies. The latter will compare and contrast key elements of the differing philosophical foundations in order to gain contextual insights on the decision-making construct.

Products & Contributions

The products of this research are an internally consistent philosophical foundation for complex situations; a decision making construct for that foundation; instantiated canons, based on the generalized canons, for that foundation, and a research methodology for that foundation, applied to build knowledge consistent with that foundation.

The philosophical foundation extends the assertions of pragmatic idealism to incorporate all of the elements of a paradigm, particularly the axiological and

methodological components, and demonstrates both internal consistency and applicability to complex situations. The decision making construct provides a viable means for application of the construct, and provides guidance for further research into application of the construct. The generalized JTB(+) canons and the instantiation of those canons for the philosophical foundation provide sufficient guidance to justify both internal consistency and assessment.

Finally, the execution of this research exploring the area of rational research methodologies represents a product in and of itself. In areas where empirical methodologies and canons are inappropriate and potentially even dangerous (such as complex situations) there is a pressing need for research methodologies that can rigorously generate and assert knowledge claims – even though this may necessarily entail acceptance of significant constraints, limitations and/or assumptions. The particular instantiation of the research methodology for the CSP must be capable of defending knowledge claims with an acceptable level of rigor and a clear context.

CHAPTER IV: RESULTS

Introduction

The results of the literature review, guided by the principles provided in the research methodology, provide a good deal of guidance both in how and how not to develop the desired construct, including:

- Complexity is "the probability of making an erroneous knowledge claim about a situation" and is fundamentally "a construct associated with the fallibility of understanding" (Sousa-Poza & Correa-Martinez, 2005, section 3, para. 2).
- Understanding is about a means-consequence relationship involving both the observer and reality; and therefore consideration of complexity must rest on a consistent foundation of ontology, epistemology and associated methodology and axiology.
- These foundations must be internally consistent; and purely rational or empirical perspectives have limitations that prevent consistency given the characteristics of complexity.
- Complexity contradicts the assertion that more knowledge results in more understanding; it challenges the notion that reality is comprehensible (e.g. capable of being understood).
- This raises issues with bounding and framing from a systems perspective; in essence a systems perspective (as one of infinitely many possible perspectives) is seen to be a potential source of complexity as opposed to a resolver of complexity.

- In general, perspectives of extreme do little to aid the systems analyst or decision maker confronted with uncertainty but accordingly the middle ground of pragmatism includes elements of both extremes in philosophical perspectives.
- Pragmatic idealism further incorporates an explicit axiological principle (the existence of a value premise) to reject inaction as an inevitable consequence of fallabalism.

While the detailed argument draws on correspondingly more material, these ideas highlight the general foundation and direction for development, namely beginning with the philosophical foundations and deriving a basic set of principles that are consistent with complexity. More generally, it is desired that the argument be semantically complete, and therefore these principles should be tautologies. In this regard, the derivation of consequences or conclusions from these principles consistent with associated philosophical considerations may then be taken to constitute theorems as they are only asserted to be valid within the relevant philosophical framework (e.g. the philosophical perspective forms a coherent body of propositions validating the principle). The derivation of conclusions should therefore be sound within this semantically complete structure; essentially accomodating the axiological principle of internal justification.

It should be noted that, though this discussion provides the ontology, epistemology, axiology and methodology in that order, in development they are nearly inseparable and require multiple iterations to arrive at this early level of maturity. The initial development was framed around ontology, which culminated in a difficulty to resolve epistemology. Likewise, a subsequent effort to frame the effort around epistemology led to challenges in ontology and a difficulty in resolving a methodology. Ultimately, all perspectives are

unique and can only be re-solved through a shift to another paradigm or worldview – and though the following discussion is necessarily linear, the end result is necessarily a holistic product as threads of ontology, epistemology, axiology and methodology are woven into a Complex Situations Paradigm.

Ontology

The basic ontological principle is the existence of a "mind-independent reality" (Rescher, 1994):

O_1: Reality is (that which exists). (Reality Principle)

This is consistent with Sousa-Poza & Correa-Martinez (2005), which asserts that "a reality exists as a construct, which is both separate and part of the observer, and is beyond the observer's full understanding" (section 5.1), which brings an essential clarification to Rescher's statement as reality is framed as mind-independent and yet mind-inclusive. In this construction, reality (that which exists) exists and, in and of itself, is irreducible and cannot be subdivided or simplified – any division would establish another reality, the existence of which would extend reality. Here, irreducible is used in the sense of "... cannot be reduced to a simpler or more intelligible form; incapable of being resolved into elements, or of being brought under any recognized law or principle" (OED, 2008). As such, it speaks solely to the subject of existence, and does not prohibit or require reducibility in other senses (e.g. it is possible to posit the existence of something "beyond reality," including such individually and culturally significant aspects as the theological). Rescher (2000) presents the essential nature of this principle as presented earlier in the literature review for ontology.

The Reality Principle seems to abandon rationalism at the outset. Having already established the potential inconsistencies of rationalism with complexity this should not be disquieting in and of itself, but as it foreshadows a potential bias towards empiricism it is appropriate to acknowledge that bias early in the discussion. In essence, this apparent bias is a consequence of beginning with an ontological perspective as rationalism inherently begins with epistemology. Indeed, since the Reality Principle (among myriad other implications) essentially establishes an ontological priority over epistemology, a segue is necessary to introduce the notions of knowledge. This is in consonance with Rescher (2001) who noted that "an objective domain of impersonally real existence is not a product of but a precondition for empirical inquiry" (pg. 113). This is established through the assertion of a second principle:

O_2: *Self-awareness defines a unique existence within reality. (Self-awareness Principle)*

With appropriate homage to long-standing discourse related to being, cognition and similar topics, the critical contribution of this principle (in this regard) is the introduction of a unique perspective embedded within the whole. This principle is necessarily tautological in nature and therefore does not constitute a *de facto* Descartian pronouncement (*Cogito, ergo sum*). Descartes spoke to existence as a consequence of cognition while the self-awareness principle speaks to the inevitable consequence of acknowledging self – the delineation of other-than-self (with the acknowledged acceptance of the principle of the excluded middle within this rational context). This is essentially an ontological assertion defining the existence of an epistemology, not an epistemological assertion. From the Reality Principle, both self and other-than-self are contained within reality and this critical

disassociation of self from whole-containing-self creates the *foundational duality of cognition* – awareness of distinct existence within a reality otherwise free from such distinction (in this perspective). The unity subsumes all, but the duality is inescapable. For this discussion, self-awareness is only of a unique existence; a corollary notion of awareness will be developed in the epistemology section.

From the introduction of this disassociation it is possible to infer creation and causality – something that was not previously in existence – so that the notions of principal spatial and temporal dimensions are resident within this ontology. However, this is an inference, not an implication – it is possible to posit that awareness precedes self awareness, the converse, or to assert that they are mutually generative and therefore equivalent in some nature. The argument to this point is not a causal argument, but a tautological one that seeks to define and deduce consequences of definitions – it is sufficient that the Self-Awareness Principle and the concomitant foundational duality of cogitation can be asserted to exist. The principal spatio-temporal dimensions will be formally introduced as the argument matures.

A final ontological consideration also foreshadows the epistemological discussion by introducing limitations:

O_3: *Everything cannot be contained within less than everything. (Incompleteness Principle)*

This is essentially a restatement of the first principle within the conditions of the second principle. Since reality, as that which exists, is irreducible and self awareness defines an existence within reality, reality *in toto* cannot exist within self awareness; hence the disassociation of self from other-than-self must constitute a limited awareness of reality.

Using the Kantian formulation of *noumena* being the "thing in itself" (Kant, 1901, pg. 248), or "Ding an sich," the *noumena* of other-than-self are not the *noumena* of self and cannot therefore be resident within the self; only *phenomena* can influence the awareness of other-than-self. This is a stronger argument than appealing to the self-imposed bounded nature of self-awareness; it explicitly acknowledges that which is excluded by any bounds that may be established. From a different perspective, this is the negation of the law of identity: that which is not-self is not self, and cannot contain "ding an sich" within self. Further discussions on the fundamental limits of knowledge are found in Rescher (2009b).

An alternate perspective is to assert the primacy of awareness:

O_2: Awareness of other-than-self defines a unique existence within reality.*

(Awareness Principle)

This also supports the argument of necessarily limited awareness, but would permit awareness of self preceding awareness of other-than-self (Descartian), or awareness of other-than-self preceding awareness of self. This returns to the illusory nature of a snapshot in a dynamical consideration, reiterating notions of causality that imply a reduction not yet discussed. However, this perspective facilitates discussions of facets of awareness resident within reality prior to awareness itself – but the disassociation is still established from the perspective of self (e.g. self and other-than-self still remain within reality).

Finally, the notion of change introduces temporal structure – that reality includes time and change. Ascribing these properties to reality is tantamount to asserting a positivist quality of something that exists within reality (either derivative of or foundational to other things that exist); likewise to ascribe as derivative of awareness risks asserting a

constructivist quality. This question is set aside for this discussion as the essential element for the argument is that time and change are common to awareness, whether its source is foundational to reality or foundational to awareness. A similar discussion holds for the principal spatial dimensions. Hence, the temporal-spatial characteristic asserts that:

O_4: Awareness incorporates the principal temporal and spatial dimensions.

(Temporal-Spatial Characteristic)

Epistemology

The result of awareness is generically designated as a cognitive representation of reality (CRR, or "reality as cognitively re-presented", $\mathfrak{R}_{cr}$):

E_1: The result of awareness is a cognitive representation of reality.

(CRR Principle)

Cognitive is used in the sense of "... pertaining to cognition ..." where cognition is "the action or faculty of knowing taken in its widest sense ..." (OED, 2008). As a defined term, the CRR is quite literally a re-presention of reality in the cognitive domain that acknowledges *knowing* refers to something *known*. In this sense, cognition is the process (or processes) that generate the CRR. This yields the relationships indicated in Figure 6, where $\mathfrak{R}_{cr} \in \mathfrak{A} \in \mathfrak{R}$. A critical distinction here is that the boundary between $\mathfrak{R}$ and $\mathfrak{A}$ is defined by $\mathfrak{A}$ given the earlier Self-Awareness Principle; alternatively if the Awareness Principle is accepted then the boundary is mutually generative by interactions within $\mathfrak{R}$. In either case, it is possible to delineate from the perspective of the aware or self-aware entity that there exists self ($\mathfrak{A}$) and other than self ($\neg\mathfrak{A}$) such that ($\mathfrak{R} = \mathfrak{A} \cup (\neg\mathfrak{A})$). The assertion of ($\mathfrak{R}_{cr} \in \mathfrak{A}$) is made without additional stipulation such that $\mathfrak{A}$ may also include elements other than $\mathfrak{R}_{cr}$; however, since the CRR is defined as that of which the entity is

aware, it is asserted to be wholly contained within the self-aware entity. The domain of awareness $\mathfrak{D}_a$ – that portion of reality that is accessible to the self-aware entity, or in the case of the aware entity that portion which is mutually generative of awareness – is likewise asserted to wholly contain $\mathfrak{A}$, without prejudice to perspectives that consider more detailed aspects of the CRR (note that the domain of awareness is introduced here to facilitate a subsequent discussion on shared domains of awareness). This caveat is relevant as subsequent discussions may touch upon the ideas of explicit vs. tacit knowledge, or conscious vs. unconscious aspects of cognition, wherein the self-aware entity may not explicitly acknowledge some aspect of reality that is accessible to the entity. Under this definition, all that which is accessible to the entity is contained within the domain of awareness; a further delineation of a domain of conscious awareness is a trivial extension to clarify such points if required. Ultimately, the CRR exists because of and reflects the foundational duality of cognition; it exists as part of reality because of the delimitation of a unique existence within reality.

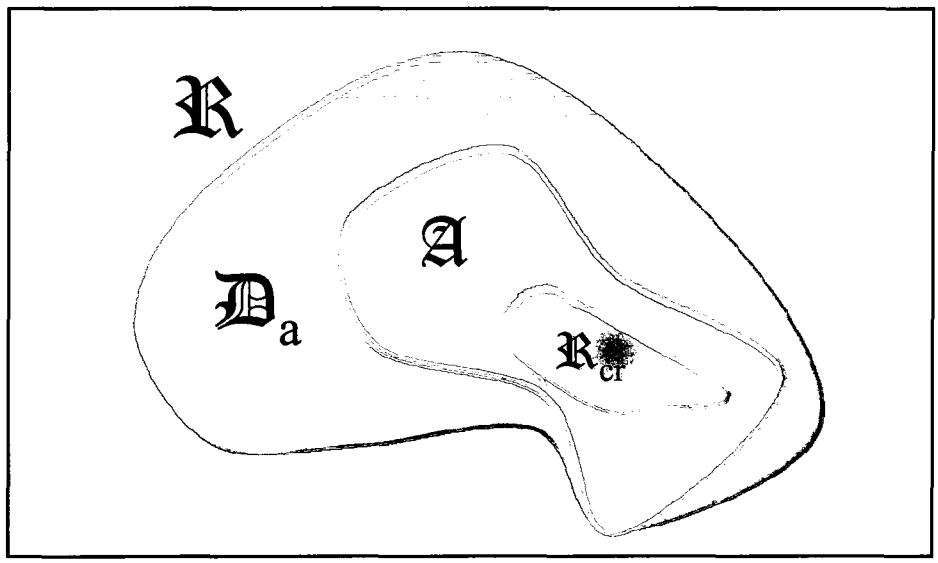

Figure 6. Relationships Between Reality, Entity and CRR

The definition of the CRR is intentionally conceptual and broad; the actual structure of the CRR delves into theory of mind (Baars, 1988, 1997) and other schools of thought (e.g. Churchland, 1986; Eliasmith, 2003; Kukla, 1992; Lyon, 2006) and is beyond the scope of this discussion.

There are, however, some fundamental characteristics that can be discussed relating to generation, scope and structure. Fundamentally, the CRR is defined as reflective of reality and is therefore reactive to changes in reality – the first introduction of a causal relationship in this argument. It therefore must have some generative processes which modify the CRR to reflect changes in reality. As the domain of awareness is limited, the CRR is limited and therefore fallible. Also, the CRR is defined relative to the self-aware entity; as described above the domain of awareness includes the cognitive (reality includes self and other-than-self) there are what would be designated rational (internal to the self-aware entity) and empirical (external to the self-aware entity) aspects to cognitive representations. As a limited portion of reality is accessible to awareness, it is possible to adopt a more precise Kantian formulation where *phenomena* are accessible to the domain of awareness and *noumena* are not. In this formulation, the phenomena is that which forms the stimulus for generating the CRR (though the CRR, since it exists, is comprised of noumena and thus is noumenalogically influenced as well).

Acknowledging that the CRR is the product of some generative process does not in itself define the CRR. However, the generative process implies a causal relationship and therefore some type of resulting structure for the CRR – a structure that will be reflective of the generative process. This gives rise to the CRR principle:

E_2: Cognitive representations of reality are characterized by a structure reflective of its generative processes. (Structure Principle)

This principle asserts only that the CRR is generated, and consequently has a structure. The CRR structure is inherently a functional representation of the domain of awareness; since there is a causally generated structure, generative processes must extract, classify and organize within the CRR in some form. An illustrative example of such a structure (though the particular definition is not critical to the discussion at this level) can be considered as a process that executes fundamental levels of generating structure; namely the establishment of differences, similarities and relationships. This can be generally described as abstraction, generalization and organization:

- Abstraction, "The act or process of separating in thought, of considering a thing independently of its associations; or a substance independently of its attributes; or an attribute or quality independently of the substance to which it belongs" (OED 2008), speaks to separation and differences.
- Generalization, "... general notions or propositions obtained from the observation and comparison of individual facts or appearances ..." (OED, 2008) speaks to combination and similarities.
- Organization, "the action or process of organizing, ordering, or putting into systematic form; the arrangement and coordination of parts into a systematic whole..." (OED, 2008) speaks to structures and patterns.

These particular designations are not critical for this discussion – in fact, even no structure at all defines structure by its absence. The notions of a formulation of a CRR that is functionally representative of the domain of awareness simply implies there are entities

within the CRR, and there are relationships between those entities. This is not without consequence, as it results in cognitive representations that have systemic characteristics, with systems being used in the sense of "a set or assemblage of things connected, associated, or interdependent, so as to form a complex unity; a whole composed of parts in orderly arrangement according to some scheme or plan" (OED, 2008). The notion of abstracting entities within the CRR from the domain of awareness, generalizing aspects across those entities, and instantiating some organization based on this abstraction and generalization results in an assemblage of things (rational and/or empirical in origin) with some relationship, or structure, between those things. However, the presence of systemic characteristics does not necessarily imply a system as the latter requires a comprehensible relationship between the holistic and the particular.

The CRR is therefore broadly asserted to have an associated generative process and a structure, illustrated by the systemically framed set of entities, boundaries and relationships. In order to facilitate discussions relative to the CRR, these may be further assessed relative to their scope and functionality specifically comparing the generative process to worldview (Weltanschauung) and asserting that the structure of the CRR can be conceptually represented as having a *perspective* and *resolution*.

Worldview is a richly debated notion centering on a fundamental orientation reflecting core beliefs, typically discussed as common to a culture or society. In this instance, when examining the notion of a generative process for a CRR, it is apparent that the functionality of that generative process encompasses the broad notion of worldview – that is, how the CRR is generated will be guided by some process that therefore defines the predilections inherent to a particular self-aware entity. In particular, discussions regarding

ongoing research (Kovacic, 2009) explore the idea of "dimensions" of worldviews – the idea that a worldview could be characterized by a set of dimensions, and the interpretation of reality influenced by the degree of the various characteristics. Jones (1972) presents elements of a worldview vector, providing illustrative elements of those characteristics which impact the perception of reality (Figure 7). The work of Bozkurt (2009) further explores the idea that there is a philosophical profile for an individual which impacts the framing of reality. The relevance to the argument at hand is simply that there is a body of research discussing the characteristics of precisely such a generative process as is asserted for the CRR, and notions of worldview and philosophical profiles treat sufficiently similar ideas to frame a shared understanding of this generative process. The generative process can be considered to have characteristics, and the degree to which these characteristics are present will be reflected in the CRR itself.

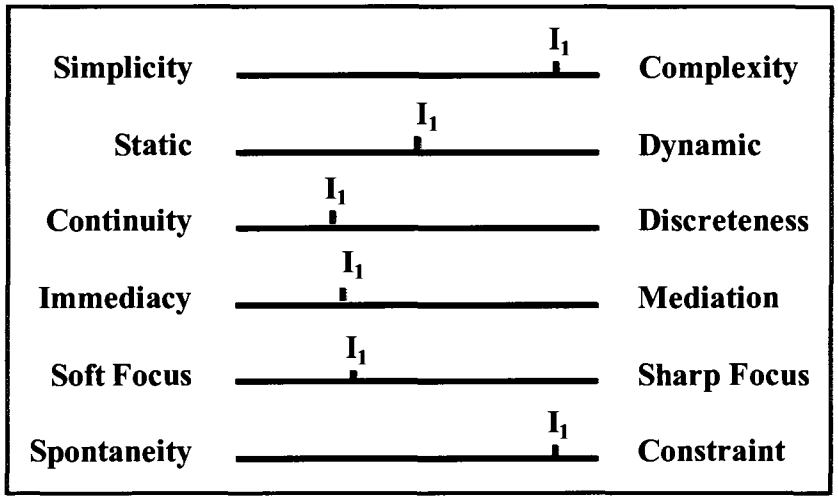

Figure 7. Elements of an Illustrative Worldview Vector from (Jones, 1972, pg. 86)

Having discussed the generative process, the structure of the CRR can be further discussed. First, the degree of abstraction and generalization in the CRR is defined as inversely proportional to the resolution of the CRR. A high degree of abstraction and generalization will result in a distinctly different CRR than a low degree; the organization will necessarily vary accordingly. Inversely proportional is used to employ resolution in a sense analogous to granularity; e.g. a high degree of abstraction and generalization will result in a low degree of detail. Since the resolution will impact the form of organization or structure of the CRR, it characterizes the relationship between the CRR and the domain of awareness (and therefore reality).

It should be noted that this illustrative example is helpful, but overly restrictive. Returning to the CRR principle, the fundamental issue is that there is a structure. Generalizing the example above, it is sufficient to say that the structure of the CRR has characteristics that will inherently differ when compared relative to some metric. The metric itself, as a characteristic of a generated structure, will be subject to the generative process; but given a structure there will likewise be characteristics, and given characteristics there will be degrees of those characteristics. When treated in these terms, the notion of resolution (or its inverse, granularity) can be held to be generally applicable to the CRR.

As an illustration of this notion of resolution, consider the typical case of strategic planning for an enterprise. The start point is often taken to be a *Strategic Vision* that expresses a high-level approach to attain a goal. In order to be translated into action, this must be expressed in a fundamentally different form through the expansion via myriad additional details and relationships. This translation echoes a move from the holistic to the

particular, and examples abound where the representation of reality at the operational level is different from that at the strategic level. Resolution itself is clearly an essential element to gaining understanding in a limited and fallible CRR; it is related to the essential vagueness of knowledge discussed in (Rescher 2009).

However, given that there is a granularity to the structure – a metric of scale or scope characteristic of the CRR – it is also necessary to acknowledge the differences inherent between various CRRs. A CRR can be considered to be subject to its location, both spatially (in accordance with the spatial aspect of the Temporal-Spatial Characteristic) and functionally (in accordance with its generative process or worldview). This is expressed via the notion of "perspective," capturing the relative functional or spatial orientation of the self-aware entity with respect to the domain of awareness. As an example, a probabilistic perspective represents one that neglects a dimension to look at behavior over that dimension. Given a process that may have random behaviors over time, a probabilistic perspective neglects time to consider the cumulative behavior as characterized by various statistics. This is an interesting classification as complex behaviors are often plotted on a continuum including deterministic to probabilistic; by this methodology both would represent CRRs with different perspectives. These perspectives are generally intended to provide understanding of the subject events - though not necessarily so; complexity could still be found in either perspective.

Finally, with respect to the Temporal-Spatial Characteristic, the CRR will include change and time. To visit the CRR at any fixed point in time is as illusory as a photograph, but it is a requisite price of analysis in any dynamical arrangement. These "snapshots" of

CRRs provide a useful additional concept as CRRs may be considered for multiple temporal instantiations (e.g. the temporal association of the CRR). Examples include:

- Descriptive: The *running CRR*, based on phenomena but presumed to lag reality
- Potential: A projection of what the CRR could become
- Historical: A prior CRR
- Desired: A projection of what the CRR is desired to be

In sum, the CRR is the product of a generative process (broadly aligned with worldview) and subject to that generative process, is characterized by a structure possessing characteristics including analogs to both perspective and resolution.

The Temporal-Spatial Characteristic asserts that the CRR must change as reality changes. The individual, as part of reality, will change and therefore changes in the individual (specifically, the noumena of the individual) will change the CRR itself (since the CRR is wholly contained within the self-aware individual). This can be considered in terms of changes in the generative process for the CRR, or in changes to the structural characteristics of the CRR. In general terms, changes to the structural characteristics may be considered more amenable than changes to generative processes – it is easier to choose, for example, a different perspective and resolution than to change the fundamental parameters of worldview. The critical point is that the CRR can implicitly be influenced, and can be influenced by a matter of cognitive processes. In practice, these cognitive processes may be further subdivided, for example, into conscious and unconscious processes for modifying the CRR.

These elements provide sufficient structure to assert a definition of a "situation" for this research; specifically that a construct to frame discussions of complexity relative to

reality, or a portion thereof; a self-aware individual (one or more), and the individual's CRR. This is analogous to Sousa-Poza and Correa-Martinez (2005), which frames the discussion using entity (reality or portion thereof); observer (self-aware individual), and solution form (CRR). The asserted equivalence of the CRR with the solution form may seem incongruous, but the differences can be illuminated by considering the work of Maturana (1988) where observation is used to capture not simply gathering data, but the active process of interaction across boundaries – of observer with environment, observer with entity and observer with solution form – capturing the essence of continuous processes relating learning, planning and implementation. This perspective tends to emphasize the Awareness Principle where the environment defines the observer as the observer defines the environment. Since the CRR is simply a label for that which is inherently part of this dynamic process, the apparent differences between the construct are a result of the snapshot illusion – as time progresses, the functionality and interaction of reality, the self-aware entity and the CRR will be equivalent to that of the entity, observer and solution form.

Finally, experience compels recognition that multiple individuals exist within the domain of awareness; so multiple representations of reality may exist across individuals (to be addressed in a subsequent section).

Knowledge and Understanding

Knowledge, as used here, is defined as a justified true belief with a reliable context and method for justification (to account for Gettier 1963), or JTB(+). Knowledge is resident within awareness and further refers to the domain of awareness – the individual establishes (is aware of) a JTB(+) for some portion of the domain of awareness. Extending this to more than one individual thus requires establishing mutually intersecting domains of

awareness, essentially generating respective representations of reality that are sufficiently congruent to establish a shared context. From this definition, a classification scheme for levels of the CRR follows the lexicon presented earlier for the generalized JTB(+) canons:

- Ideas: Elements of the CRR (not necessarily held to be justified or true)
- Beliefs: Elements of the CRR held to be true
- True Belief: A belief held to be reflective of reality.
- JTB: The assertion that a true belief can be communicated (externally justified).
- Knowledge Claim: Elements of the CRR held to be justified and true with a reliable method and context for justification within the domain of awareness
- Knowledge: Elements of the CRR held to be justified and true with a reliable method and context for justification within intersections of domains of awareness

As presented earlier, within this framework a knowledge claim is internally defined and knowledge is mutually defined.

Recalling the earlier descriptions of understanding from (OED, 2008) and (Dewey, 1933), the CRR construct presents understanding as a reflection of the relationships between entities (temporal or spatial) within the CRR – the organization of abstracted and generalized information constituting the means-consequence relationship. This organization is essentially the conceptual context for understanding, varying in degree and completeness (e.g. Nickerson, 1985).

Shared Domains of Awareness

The construct for knowledge requires mutually intersecting domains of awareness, essentially generating respective representations of reality that are sufficiently congruent to

establish a shared context. An individual's knowledge is some abstracted and generalized representation of reality that is held to be reflective of external reality meeting the JTB(+) condition. This knowledge is asserted to be a function of the degree of the structural characteristics and generative processes of the CRR. In order to build knowledge, there must exist some means to establish across individuals: an individual's CRR; the individual's generative processes for the CRR; the individual's structural characteristics of the CRR, and a reliable method and context to assert it is reflective of reality.

Based on the principles presented earlier, there is but one reality and there is existence within that reality. There can be multiple self-aware individuals within that reality, and there can be change. From the earlier discussion, as awareness is contained within reality, *a change in awareness is a change in reality*. Hence, a change within an individual's awareness is a change in reality that may then be accessible to another self-aware individual if and only if it is phenomenological in nature and accessible to their domain of awareness. Since the domain of awareness is only that which is accessible to awareness, this may also require adaptation of awareness within the domain.

This discussion speaks to bridging across the disassociation from the perspective of the individual: an individual's action is change in reality sourced in the individual's awareness. Within reality there is no bridge required. But, with the acknowledgement of multiple self-aware individuals it is possible to associate a change in reality with a self-aware entity – a phenomena carrying the characteristic of being associated with another unique disassociation. As a result, shared context can be defined by an individual's action: specifically, a change in reality, sourced in one individual's awareness, that is phenomenological in nature and within another individual's domain of awareness. This

directly implies that shared context can just happen but can be purposefully constructed and can therefore be located. This brings to mind the notion of action science (Argyris, Putnam, & Smith, 1985), and it is directly apparent that individual action of any kind has the potential to build shared context and facilitate mutual knowledge.

Individual actions that are executed with the purpose of establishing across individuals: respective CRR's; respective generative processes for CRRs; respective structural characteristics of CRRs, and reliable method and context asserting they are reflective of reality may be broadly grouped within the general notion of communication. A key point here is that a phenomenon must perceived as being associated with the action of self-aware individual in order to establish communication – the characteristic referred to above conveys a distinction from actions perceived to be otherwise sourced. This line of reasoning returns again to Rescher (2000): "The assumption of a mind-independent reality is essential to the whole of our standard conceptual scheme relating to inquiry and communications" (pg. 97) again recalling the caveat that mind-independent is not mind-exclusive.

With the introduction of action and communication, this begins to approach the notion of the observer as "a cognitive system capable of linguistic behavior" (EA, 2008). Varela (1976) asserts at least three main properties characterizing an observer: "(i) capacity for indication: to decide boundaries, to come up with nodes, systems, to have criteria for stability; (ii) capacity for time: to chop a net and start a sequence, to compute through a process, to approximate the stability of a whole; and (iii) capacity for agreement: to externalize, to synchronize with other observers, to re-produce other's distinctions and follow corresponding time patterns" (pg. 65).

The distinctions asserted for the CRR and communications between individuals speaks to the bridge across the disassociation – the interaction of self with other-than-self that mutually defines awareness. In Sousa-Poza and Correa-Martinez (2005) this ultimately resulted in the *solution form*, which encapsulates the bridge across the disassociation. The notions of action discussed above – where phenomena originate with action sourced in the individual's awareness – is reflective of this train of thought; in this instance the bridge is seen more from the perspective of the individual. The two approaches are not incompatible, but provide additional perspective on how various principles within a paradigm can emphasize different aspects within it, ultimately contributing to a richer understanding of the paradigm.

Axiology

The area of axiology introduces a critical component for a philosophical foundation: to discuss the nature of being and knowing is essential, but to choose in a meaningful manner requires a basis for choice and therefore some foundation of value. The axiological component of the philosophical foundation presents the meta-foundations of choice and value – a selection of principles to make explicit the often implicit underpinnings of profound and trivial selections. Specifically, two principles are presented – asserting implications of a particular value and the existence of value itself – that are essential to the development of the objective construct.

The review of decision theory introduced the general notion of a justification principle. Essentially, this introduced the notion of consistency as a principle, where consistency is a clear proxy for logically sound, semantically complete or various other expressions that imply a clear rational coherence to a basic set of principles:

A_1: *An operation is justifiable if it is internally consistent with philosophical foundations.(Justification Principle)*

The tautology is present in the equivalence of the term *justification* and *internally consistent* following the definition presented above. This principle is a coherent extension of the law of non-contradiction which is itself an axiomatic statement.

This principle was explicitly applied during the definition of the research methodology, which applied the principle internally in the form of constructing internally justified canons referenced to the definition of knowledge, but also when instantiated with respect to a particular philosophical foundation. However, there are direct ramifications when this is placed in the context of the ontological and epistemological principles above; in essence it holds that actions can be justified within the CRR if they are consistent with these foundations. This echoes the debate about the evolution of knowledge; and would for example deem Newtonian physics as knowledge (for earlier times) and would likewise deem relativistic physics as knowledge (for current times). In this instance, new knowledge modified old knowledge, but in some cases it may obviate that knowledge –for example, the notion of æther was accepted and subsequently rejected within essentially the same philosophical foundation (logical positivism). The differentiation serves to clarify the difference between a change in the CRR (e.g. additional content or a revision in perspective and resolution) and a Kuhnian paradigm shift in the underlying philosophical foundations.

Having asserted the Justification Principle, it is necessary to introduce a principle essential to decision-making: that of value. The discussion on decision making presented the necessity of value, and when placed in the context of the Justification Principle the necessity becomes paramount. In order to make a justified decision, there must exist a

reason, however it be expressed – a preference or valuation that guides the choice. This valuation must be expressed consistent with the above ontological and epistemological principles. To clearly state an implicit assumption regarding the valuing entity, the decision in question is being made by a self-aware entity (decisions made elsewhere in reality, such as those by another entity, will be discussed at a later point). Since the valuation must express a preference, the preference must be one of things that exist and are therefore in the mind-independent objective reality (Reality Principle). As a result, the preference is, insofar as awareness is concerned, expressed wholly within the entity's awareness. This preference must be expressed relative to a CRR – a preference between projected futures, for example, is a preference between projected CRRs. This is asserted in the Value Principle by defining the notion of a value premise as that premise which establishes the ability to express preference:

A_2: A value premise establishes a preference between CRRs. (Value Principle)

Defining a value premise does not create a value premise; however, it is an essential assumption that a value premise is required in order to make a meaningful decision. Moreover, using the rational methodology for this philosophical foundation, a value premise is essential to justify a decision as it establishes the premises from which conclusions can be drawn.

Since the CRR is limited and fallible (by the Incompleteness Principle), the preference established from the value premise may also be fallible. Taking this to the extreme leads to the perspective of fallabalism, in which case no decision is justified. Sousa-Poza and Correa-Martinez (2005) reject this perspective and asserts the value premise can demand a decision on the part of the self-aware entity, as captured by

pragmatic idealism. As an example, the value premise for a self-aware entity may be defining in nature, to the extent of being mutually generative. As an extreme case, life itself – as a self-sustaining biological process – must sustain life or cease to be. A more commonplace example could be in an official of a government making a decision in the course of his or her duties – in the case of the United States government, such officials swear to "support and defend the Constitution of the United States of America" (U.S. Army, 2006, pg. 2-2). This can be considered a self- defining value premise; if a decision ceases to conform to this value premise then the official ceases to act as an agent of the government. For these cases, this type of self-defining value premise is defined as a final or ultimate value premise; e.g. one that would be invariant across all CRRs for justifiable decisions (or else it would not meet the criterion of a self-defining value premise). This places the ultimate value premise on a par with the generative process for the CRR – not necessarily a component of the generative process, but one that would impact the structure (perspective and resolution) of the CRR. This analogy parallels the notion of the generative process as worldview, and of that of a paradigm (including essential values) guiding not only perceptions of the world, but methods of investigation and observation.

The ultimate value premise is therefore independent of the structure of a given CRR, yet similar to the arguments that assert a structure for the CRR, it can be asserted that the ultimate value premise will be instantiated in a particular form for a given CRR. This instantiates a particular representation of the value premise concomitant with the representation of reality (e.g. incorporating perspective, resolution and other characteristics of the associated structure). The particular representation of an ultimate value premise within a given CRR is referred to as a penultimate value premise, designating its place as

next to final in the establishment of value. This does not exclude the establishment of any number of other, transient value premises; but the notion of an ultimate value premise has a particular significance and its representation within a given CRR will clearly have a central role in decision making, as these other value premises may not have alternative representations in different CRRs.

Methodology

A methodology is "the branch of knowledge that deals with method generally or with the methods of a particular discipline or field of study" (OED, 2008). Methods are particular to a circumstance while methodologies guide the development of specific methods. For a decision construct, a methodology must provide guidance for methods that lead from data to understanding and, ultimately, action towards a value premise. Based on the principles provided earlier, this evolution (dynamic and interrelated) will depend on the CRR.

Returning to the Justification Principle, the desired methodology will provide guidance for methods relating ontology to epistemology, consistent with axiology (Figure 8). Consequently, the methodology will be composed of conclusions derived from the associated principles. The task at hand, then, is to determine precisely what epistemological and ontological considerations are to be mapped. In this instance, they must be derived from the considerations relating to the CRR and complex situations. As complexity has been stated to fundamentally deal with understanding, and understanding has been expressed with respect to the CRR, the epistemological components are defined related to understanding; it remains to determine the appropriate ontological components. If the

ontological and epistemological components are consistent with the associated principles, then the construct as a whole will be internally consistent.

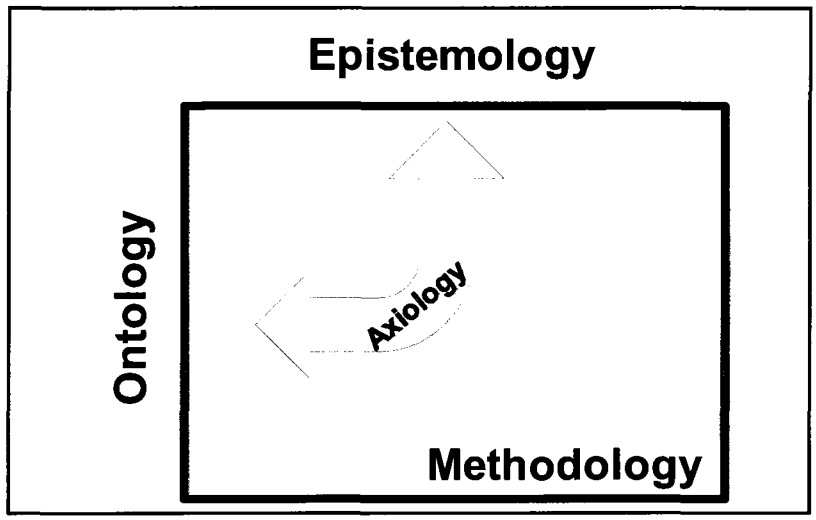

Figure 8. Initial Relationship of Epistemology, Ontology, Methodology and Axiology

Understanding, as presented earlier, stated in this manner involves the individual and CRR. By extension, it also involves the broader situation (e.g. the individual situated within reality); within which an individual may assert understanding or the lack thereof. However, given the reality principle and incompleteness principle, a distinct assumption can be asserted with respect to reality itself – namely, that reality may comprehensible, meaning "that which may be grasped" (OED, 2008) or incomprehensible, meaning "that cannot be grasped by the understanding; beyond the reach of intellect or research; unfathomable by the mind" (OED, 2008). This implicitly reflects the nature of a complex situation; the situation of comprehensibility (or lack thereof) exists in reality only as a consequence of the existence of a self-aware entity and the associated CRR. Yet, it is clearly an ontological condition; albeit an ontological consideration that is the result of an epistemic consideration. This matures the illustration of the methodology (see Figure 9) to

incorporate understanding as the epistemological component and comprehensibility as the ontological component. Each of the quadrants can be considered individually; however, it should be noted that in making these designations no precedence has been asserted – these are simply epistemological and ontological conditions at this point.

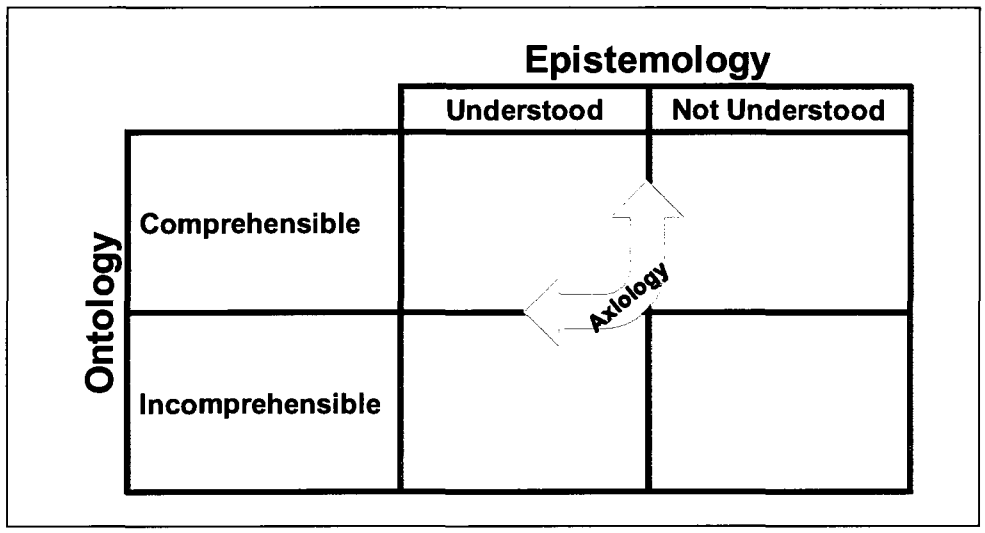

Figure 9. Revised Relationship of Epistemology, Ontology, Methodology and Axiology

The first situation to discuss is that where the CRR asserts understanding of a comprehensible reality. This situation is bounded by the domain of awareness since the epistemic determinant does not extend past that point (which recalls the inherent fallabilism of the CRR, now extended to the definition of comprehensibility). With respect to complexity, the sources for *error* in knowledge claims can either rest within the CRR (if reality is comprehensible) or within an incomprehensible reality external (from the perspective of the individual) to the CRR. These are rational designations; under the earlier principles the CRR is established as limited and unique to the individual. Similar to the

precepts of fallibilism, the CRR is developed from a limited subset of reality (phenomena) and all the CRR of noumena is induced. Kant (1901) summarizes this as:

> Nay, further, this conception is necessary to restrain sensuous intuition within the bounds of phenomena, and thus to limit the objective validity of sensuous cognition; for things in themselves, which lie beyond its province, are called noumena, for the very purpose of indicating that this cognition does not extend its application to all that the understanding thinks. But, after all, the possibility of such noumena is quite incomprehensible, and beyond the sphere of phenomena, all for us is a mere void; that is to say, we possess an understanding whose province does *problematically* extend beyond this sphere, but we do not possess an intuition, indeed, not even the conception of a possible intuition, by means of which objects beyond the region of sensibility could be given us, and in reference to which the understanding might be employed *assertorically* (pg. 248).

As it is not possible to prove within the CRR using inductive reasoning, the source of complexity cannot be proven, in general, to reside in the CRR or in reality. Such proofs are necessarily *a posteriori* (again, derivative of the inability to prove comprehensibility in general), and are subject to all of the individual, unique, limited and resolution aspects for the CRR. Consequently, even inferred causality is individual, unique, limited and has an associated resolution. Counterexamples to comprehensibility in reality external to the CRR include any non-causal event inferred in reality (such as beyond the Plank scale, or creation itself) and counterexamples to comprehensibility within the CRR can be found in complexity, paradox and duality (e.g. Goedel's theorem). In a different but related vein, Rescher (2009b) presents a rational argument for the infinity of facts vs. the finitude of truths which reiterates the limits of comprehensibility for a given CRR.

Previous arguments established (under the tenets of the associated principles and derivative conclusions) that, for a given CRR, comprehension can be established *a posteriori*. This walks a fine bridge across the disassociation; for this argument understanding is used as the means-consequence relationship within the CRR, but here

there is an assertion, within a CRR, the prior comprehensibility of reality. Comprehension cannot be predicted within a given CRR *a priori* – which would leave no apparent basis for action. However, with the necessary assertion that asserted comprehensibility of a given situation will remain constant within the established resolution a *justifiable* basis for action can be asserted:

> M_1: *Within a CRR, establishing comprehension a posteriori defines a justifiable basis for action a priori. (Action Theorem)*

The basis for action is assumed to be movement from the descriptive CRR to a desired CRR; this is used in the sense of direct action towards a value premise as opposed to indirect action such as learning and adaptation including, for example, concepts such as Action Research (Argyris et al., 1985). With the assumption that establishment of comprehensibility can be justifiably projected forward in time, the temporal scale of resolution defines the appropriate transience for action and the spatial scale of resolution defines the appropriate scope for action. This assumption implicitly assumes *status quo* relative to that CRR, an assumption clearly valid for much of human experience, but still an assumption based on the stated ontological and epistemological foundations. To reiterate, assertions of comprehensibility a priori can be *justified within the CRR* but cannot be *proven for reality.* As comprehensibility implicitly refers to phenomena and noumena, comprehensibility can be justified inductively but not proven a priori.

The second quadrant presents a situation where the CRR does not assert understanding, but the situation is comprehensible. Again, this situation is bounded by the domain of awareness. Since the situation is comprehensible, understanding can be achieved and therefore the means-consequence relationship must be attainable. This is an

expression of the classical empirical philosophy whereby more information can resolve the lack of understanding. If a CRR does not achieve understanding, a justifiable approach is to attain understanding through learning, through the different application of existing knowledge as well as the acquisition of new knowledge:

M_2: Within a CRR, lack of understanding justifies learning. (Learning Theorem)

The third quadrant considers the situation where the CRR does not assert understanding and the situation is incomprehensible. Since comprehensibility is related to a given CRR, if reality is incomprehensible for a given CRR, then the CRR itself must adapt whether through generative processes or characteristics of structure such as perspective and resolution. Though the notion of incomprehensibility is purely a rational assertion, if the situation is incomprehensible, the CRR cannot reflect reality, is in error, and must adapt:

M_3: Error between understanding and comprehensibility justifies adaption of the CRR. (Adaptation Theorem)

This requirement to adapt the CRR is significant; once adapted, actions must be justified within the adapted CRR (for example, at a different perspective and resolution). Essentially, all basis for action under the prior CRR are obviated – there is no assurance that value premises valid within the earlier CRR will be valid within the adapted CRR. Here, the potential of an ultimate value premise may permit the instantiation of a new penultimate value premise.

The final quadrant presents the situation where the CRR asserts understanding of an incomprehensible situation. In this instance, the source of complexity is clear – the error rests with asserting a false understanding. The justifiable action in this situation is to assess the comprehensibility of reality – whether challenging assumptions, models, conclusions,

perspective, or resolution. No principle is asserted for this situation as the need to assert comprehensibility by establishing understanding has already occurred; it is simply in error. This implicitly recognizes the limited and fallible nature of the CRR.

From the earlier discussion, it is not possible to determine the comprehensibility of reality *a priori*. Experience compels acknowledgement that comprehension can be safely asserted within much of the scope of human experience, but this remains an assertion based on the assumption of status quo and subject to the constraints of the CRR. As in the last situation considered, it is typical to operate on the basis of understanding – but in cases of complexity, it is essential to abstract not only relative to understanding but relative to the generation of understanding. As a result, there is a consequence of using the natural tendency to consider the ontological-epistemological relationship matrix as one composed of quadrants; this rational distinction created to facilitate understanding presents these distinctions as having an unwarranted clarity. To remove this illusion of clarity, each of these quadrants is referred to as a *situation*, the totality of them representing *complex situations*. With this distinction, the equivalent relevance of these fundamental situations is asserted as the Situations Theorem":

> M_4: *Absent additional information, each fundamental situation related to comprehensibility and understanding is equally relevant at any given time. (Situations Theorum)*

These four situations related to understanding and comprehensibility including an examination of complexity and the dominant appropriate options for the individual are presented in Table 5. In situations where understanding and comprehension are inconsistent, the appropriate option is to learn – to build knowledge and context for

understanding enabling the establishment of a means-consequence relationship. In any situation of high complexity the appropriate option is to adapt the CRR either through a change in resolution or adapting the parameters of abstraction, generalization and organization (worldview). Finally, consistent with the Justification Principle, the appropriate option is to act within the appropriate resolution whenever comprehensibility is established for that perspective, resolution and situation.

Table 5. Matrix of Situations

CRR asserts: / Reality is:	**Not Understood**	**Understood**
Comprehensible	High Complexity Justifiable Option: Learn	Low Complexity Justifiable Option: Action within justified CRR
Incomprehensible	High Complexity Justifiable Option: Adapt CRR	High Complexity Justifiable Option: Assess CRR

Per earlier principles, it is not possible for the individual to prove the currently applicable situation this matrix – absent additional information, each situation is equally relevant at any given time and appropriate options must be executed simultaneously and continuously. Therefore, the justifiable options for an individual at any given time are to:

- Act when within justifiable perspective and resolution;
- Learn when understanding is needed;
- Adapt CRR when complexity is present, and
- Assess assertions of comprehensibility.

These can be summarized as assessment, action, learning and adaptation (noting the risk in providing equally relevant options in any order). These options will be subject to several

challenges in practice – the justifiable perspective and resolution for action may be incompatible with the individual's value premise, learning presents its own suite of challenges, and adapting the CRR through generative processes or structural characteristics may require extended effort and time. However, adapting resolution is common – it is typical, for example, to consider strategic, operational, and tactical levels of detail – and so provides an amenable option for attaining understanding consistent with comprehensibility.

In all of these situations, these justifiable actions are those that are deemed to have primacy of purpose – for example, adaptation and assessment will certainly require learning. These justifiable actions provide a characterization of the situation and are not exclusive. Learning, as a justifiable action, is *learning to gain understanding*, and does not restrict learning to operations within that situation alone (which cannot be clearly separated). In a more general form, the above matrix would guide the individual to learn and adapt when paradox or conflict is seen in conclusions, and act and assess when not. Similarly, when complexity is likely, additional emphasis would be given to learning, assessment and adaptation. Recalling the potential for a penultimate value premise (the instantiation of the invariant ultimate value premise for a particular CRR), each of these justifiable actions represent an antepenultimate value premise – a clear assignation of value for that particular situation – that asserts value based solely on these theorems, derivative of the Justification Principle. This antepenultimate value premise is predicated on the existence of a penultimate value premise – there must exist a reason, instantiated within the given CRR, to act, assess, adapt and learn – as an essential consequence of the Value Principle. In the context of the Situations Methodology, it is also interesting to compare

this to the notion from Keeney (1992) where value-focused thinking leads to decision-making opportunities.

An immediate (and inaccurate) comparison can be made to various temporally oriented decision cycles, such as the *Observe-Orient-Decide-Act* (OODA) loop (Boyd, 1986, 1987). A decision cycle is fundamentally a temporal process whereas the situations methodology represents justifiable situations at a point in time. This, however, does frame a problem for reduction to practice: if all situations are equally relevant absent additional information, what is the guidance for the practitioner? This issue must be guided by the Justifications Principle, which will allow operations in any one of the situations when canons for truth, justification, method and context are fulfilled. In particular, the method must be consistent with the situations methodology. Since this is a continuous situation, the probability of precisely equal justification for all four situations is theoretically zero (though they may be approximately equal within a given resolution). In the theoretical case, there will always exist a preference to operate in one of the four situations; and in the practical case a decision to assert primacy of any one of them is justifiable. Finally, experience compels that there is often sufficient additional information to assert primacy of one of the four quadrants. The asserted primacy of a given situation may leverage, for example, the initial consideration of the nature of the situation at hand – if it is a situation where one may rationally assert comprehensibility given the likely CRR (for example, a well-framed optimization problem) then one would be guided to emphasize learning and action (the options associated with a comprehensible domain of awareness). Since it is necessary to gain (or at least confirm) understanding to justify action, primacy would be granted towards learning as the initial situation- though, per the Situations Theorem, this

learning should still contextually account for assessment, adaptation and action. Alternatively, the situation at hand may be one where there is a higher probability of an incomprehensible domain of awareness given the likely CRR – namely, any of the conditions known to give rise to complexity. In those instances, primacy of operations would be granted towards assessment and adaptation.

Having therefore asserted that it will be practical to assert primacy of a quadrant within the situations methodology, and therefore asserted guidance for selection of a justifiably reliable method, the issue of a justifiably reliable context can be formally considered. At a minimum, the context must be sufficient to satisfy the requirements of communication established earlier. Similar arguments to the one that determined the primacy of a situation can also be established to assert the relevance of the other situations. Disregarding the other potential situations leads to a necessarily incomplete representation, leading to the Contextual Corollary:

> M_5: *Justifiable operations within a given situation must include all other situations as relevant context. (Contextual Corollary)*

The Contextual Corollary is therefore a necessary condition for cognitive operations within a complex situation. There is no assertion of sufficiency as other factors must inherently be considered – for example, the acquisition of knowledge, consideration of value, etc. must still be present.

The exploration of these theorems, consistent with principles of pragmatic idealism, illustrate the potential of a dialog within a philosophical framework – the clarity of expression for the Structure Principle enables the discussion of justifiable resolution for action, and frames the situations methodology.

Reconciliation with Canons

This section instantiates the canons of research for this particular philosophical foundation and assessed the results with respect to the instantiated canons. The philosophical foundation established to this point is summarized as Pragmatic Idealism (Sousa-Poza & Correa-Martinez, 2005) founded on the premises of a mind-independent objective reality (Rescher, 2000) containing self-aware individuals with necessarily fallible representations of reality (the *Idealism* speaks to a rejection of inaction based on fallabalism). As such, a belief is one or more propositions (themselves constructs within the individual's representation of reality) that constitute a set of conclusions, from phenomenological sources, that generate understanding – an assertion of comprehensibility. Therefore, an internally consistent canon for truth is demonstration of the internally consistent coherence of the asserted truth with a set of conclusions through an assertion of comprehensibility based on phenomena. This implicitly carries the constraints and limitations of the individual's representation of reality – fallible, limited, and subject to the resolution, generation and structure of the representation of reality – but carries with it a specific tie to the objective reality. Given a self aware individual as a component of an objective reality, the interactions of that individual with reality are similarly a component of the objective reality and create phenomena subject to incidence on other individual's domains of awareness. Though this definition of a truth canon is internal to an individual's representation of reality, it is a definition permitting the extension of the asserted truth to others.

The generalized canon of justification asserts that research must establish that truth external to the individual. This introduces the notion of an external representation of reality

(one or more), and requires the individual to assert the justification as accessible to another representation of reality. The elements of the representation of reality asserting truth must be representable through phenomenological action, consistent with the criteria for communication. Specifically, this must include the ability to communicate the philosophical foundations, the set of propositions against which the truth establishes coherence, and the phenomenological sources that generate those conclusions (with the concomitant assertion of comprehensibility). As a practical example, an individual may hold some data set to constitute justification for a truth – the data set represents the phenomenological sources, and the analysis of that data set represents a set of propositions against which the truth is justified. The individual then must believe the sources, data, analysis and resulting propositions can be established in a shared domain of awareness with some other individual(s). This does not guarantee that another individual or individual(s) will accept this truth, but a necessary condition for justification is that the individual asserting the JTB(+) believes this to be possible.

The remaining two generalized canons, method and context, being the ways and means of justification, can be taken to represent a process and substantive perspective on the actual establishment of a shared domain of awareness. A shared domain of awareness must incorporate two or more representations of reality; by direct implication there must be phenomenological action sourced in the respective representations of reality that is within the respective domains of awareness – e.g. there must be communication involving, and active effort for, both. Returning to the critical point of communication, if phenomena are not perceived as sourced in another representation of reality (purposively or neglectfully) then the essential characteristic of sourcing within a self-aware individual is not present and

the ability to purposefully construct a shared domain does not exist. The definition of shared ways and means within the shared domain of awareness requires multiple representations of reality to participate – quite common in practice as numerous references on research methodology are available, providing specific ways and means to establish a shared representation of reality within specific philosophical foundations.

Under the philosophical foundations in question (pragmatic idealism and associated derivative principles), the generalized canons of method and context are asserted to be a shared ways and means by which a shared domain of awareness is constructed. A reliable method and context must be one which is held to be justified across multiple representations of reality. The method and context itself becomes a JTB(+) requiring a method and context; ultimately this infinite regress must terminate in the philosophical foundations which here require acknowledgement of an (limited, fallible and unique) assertion of comprehensibility based on phenomenological sources. As these sources are held to be derived from an objective reality, they are potentially accessible to multiple representations of reality and therefore permit this assertion to be shared. Those elements of reality accessible and accessed by relevant representations of reality then constitute the means by which the shared domain of awareness is constructed (though this can clearly be constrained to those relevant to the JTB(+) assertion at hand). These elements are both objectively and mutually defined; hence the shared domain is immediately seen to be dynamic in nature – it is defined by reality and by the relevant representations of reality. Context for justification will necessarily be dynamic as well. The ways by which the shared domain of awareness is constructed are then those elements of communication which enable the establishment of the domain; a method ultimately speaks to enabling

communication via the instantiation of a body of concepts in a manner accepted by multiple individuals.

To summarize the generalized JTB(+) canons as instantiated for pragmatic idealism:

- The definition of the generalized canon of truth is the demonstration of the internally consistent coherence of the asserted truth with the conclusions through an assertion of comprehensibility based on phenomena.
- The generalized canon of justification is the assertion of an ability to communicate foundations, propositions, conclusions, and sources which permit the assertion of comprehensibility for the truth at hand.
    - Foundations: the philosophical foundations and the rational derivation justified through a rational deductive argument;
    - Propositions: the characteristics of the domain of applicability for the validation;
    - Conclusions: a deductive argument that equates the behavior of the research domain to be consistent with the propositions, hence allowing the assertion of comprehensibility that the research domain will possess the characteristics proposed, and
    - Sources: specific components of the research domain themselves; in a general sense the ability to create a model with the above characteristics.
- The generalized canon of method is the definition of those elements of communication which enable the establishment of a shared domain of awareness.

- The generalized canon of context is the establishment of those elements of reality accessible and accessed by the relevant representations of reality that constitute the means by which the shared domain of awareness is constructed.

The philosophical foundation derived above can now be for each of these instantiated canons will be considered in turn. In essence, this serves as a final confirmation of internal consistency – the consideration of a philosophical foundation against canons instantiated for that philosophical foundation – while framing the evaluation against the specific definition of knowledge as justified true belief with a reliable method and context for justification.

Truth is asserted through acceptance of ontological, epistemological, and axiological principles. Justification is asserted through internal consistency of those principles. The foundational principles are explicitly presented and founded on a well-established philosophical basis. The propositions (theorems) are rationally derived from the principles, and conclusions and sources are justified relative to the specified domain (a general consideration of philosophical foundations for complex situations).

Reliability of method is provided by adhering to accepted practices for rational derivations. The principles are semantically complete (e.g. expressed as tautologies) and the theorems are sound (e.g. derived from the principles). The notable exception is the introduction of an essential characteristic; however, this is such a fundamental characteristic that the likelihood of rejection in the shared domain is held to be trivial. Reliability of context is provided by basing principles and conclusions on established definitions common to the literature, and on explicit rational derivations where extended beyond the literature.

In total, the above canons are held to be satisfied in that a shared domain of awareness can be constructed via explicit rational derivations based on principles available in extant literature. The philosophical foundation is therefore a valid JTB(+) knowledge claim.

A Complex Situations Paradigm

A paradigm is "a philosophical and theoretical framework of a scientific school or discipline within which theories, laws, and generalizations and the experiments performed in support of them are formulated; broadly: a philosophical or theoretical framework of any kind" (MW, 2008). In a general sense, this research uses the establishment of epistemology, ontology and methodology to represent core elements of a paradigm (with acknowledgement that axiology must be present in a contextually dependent manner). Given this assertion, this philosophical foundation can be asserted to constitute a Complex Situations Paradigm summarized as:

Ontology: Pragmatic

O_1: *Reality is (that which exists). (Reality Principle)*

O_2: *Self-awareness defines a unique existence within reality. (Self-awareness Principle)*

O_2*: *Awareness of other-than-self defines a unique existence within reality. (Awareness Principle)*

O_3: *Everything cannot be contained within less than everything. (Incompleteness Principle)*

O_4: *Awareness incorporates the principal temporal and spatial dimensions. (Temporal-Spatial Characteristic)*

Epistemology: Rational

E_1: *The result of awareness is a cognitive representation of reality.(CRR Principle)*

E_2: *Cognitive representations of reality are characterized by a structure reflective of its generative processes. (Structure Principle)*

Axiology: Idealist

A_1: *An operation is justifiable if it is internally consistent with philosophical foundations.(Justification Principle)*

A_2: *A value premise establishes a preference between CRRs. (Value Principle)*

Methodology: Situational

M_1: *Within a CRR, establishing comprehension a posteriori defines a justifiable basis for action a priori. (Action Theorem)*

M_2: *Within a CRR, lack of understanding justifies learning. (Learning Theorem)*

M_3: *Error between understanding and comprehensibility (complexity) justifies adaption of the CRR. (Adaptation Theorem)*

M_4: *Absent additional information, each fundamental situation related to comprehensibility and understanding is equally relevant at any given time. (Situations Theorem)*

M_5: *Justifiable operations within a given situation must include all other situations as relevant context. (Contextual Corollary)*

The assertion of Complex Situations Paradigm in no way obviates a "systems paradigm" – generally positivist and empirical, with a suite of systems methodologies. Systems theory is relevant within the context of the CRR, but the Complex Situations Paradigm implicitly

incorporates complexity whereas for systems theory it is incorporated in general (see discussion in the review of the literature). Based on the principles espoused for the CRR, systems approaches are a method of learning and action consistent with perceptions of reality – but applying them to the incomprehensible or in the face of paradox is fallacious.

A Decision-Making Construct for Complex Situations

The Complex Situations Paradigm provides an internally consistent philosophical foundation for complex situations. Recalling that complexity creates a situation where decision making must deal not with the situation, as no basis for valuation can be justifiably postulated, but with the nature of the situation, the CSP itself becomes the core decision making construct. More specifically, the situations methodology provides a meta-framework for *deciding about decisions* that is appropriate for complex situations. As has been briefly discussed earlier, this methodology provides guidance for the decision maker on where to start and how to structure specific decision-making methods. Additional discussion is provided on the nature of value premises, and how they can further aid in the meta-decision process and specific decision-making methods.

The meta-decision process begins with the introduction into a particular situation; as earlier discussed it may be possible to assert an initial estimate of primacy for a particular set of situations based on the anticipated comprehensibility given the likely CRR. If the situation is anticipated to have low complexity, the methodology would guide the decision-making process to incorporate assessment and adaptation into learning and action in a contextual manner (the analogies to the "learning organization" [Senge, 1994] are clear and will be discussed in the final section). Given high confidence of comprehensibility for a given CRR, primacy would initially be assigned to learning. The methodology would

guide learning to focus on the perspective and resolution for the CRR that is anticipated to yield comprehensibility, with the antepenultimate value premise of attaining understanding to enable action towards the penultimate value premise.

For situations anticipated to have high complexity, the initial development of the CRR would place a greater emphasis on assessment of comprehensibility as various perspectives and resolutions can be evaluated for the representation of reality. Certainly learning still occurs, but here the antepenultimate value premises are to assess comprehensibility and adapt the CRR to attain the ability to assert comprehensibility, leading to the focus on structural characteristics of the CRR (such as perspective and resolution) and possibly even to generative processes. In these cases, the goal would still be to attain the ability to assert comprehensibility given the adapted CRR.

In the later cases, where the CRR is adapted, value premises expressed relative to the original CRR are no longer internally consistent, and decision-making using those premises is not justified via the Justification Principle. The adaptation of the CRR to attain an assertion of comprehensibility obviates complexity; it is rendered irrelevant as it is no longer within the internally consistent framework. This may require abandonment of value premises (goals and objectives) expressed within the original CRR. If there is an ultimate premise with an expression as a penultimate value premise within the original and adapted CRRs, it may be possible to transform the valuing principle but this is not assured.

This condition – of relating value premises across CRRs – warrants additional discussion. Suppose a value premise is expressed in one CRR, and is desired to be related to a value premise in another CRR – perhaps at a different resolution, such that, for example, a value premise expressed within a comprehensible CRR at a strategic resolution

would be mapped to a value premise expressed within a comprehensible CRR at an operational resolution. This is not quite devolution or inheritance of the value premise, as any CRR that permits justifiable assertion of comprehensibility is equally valid as any other, but does represent a common circumstance and therefore the ability to frame a relationship within the CSP is desirable. There are two apparent observations relative to this relationship: the existence and scope of justification. There must exist a justifiable relationship between the two CRRs; in essence this creates conditions described above for communication where it must be possible to create a shared domain of awareness that encompasses generative processes, structural characteristics, methods and contexts. The establishment of this shared domain is essential to allow the transformation of the value premise for one CRR to the other, and speaks to the essential nature of a greater proportion of energy devoted to communication – the interactions are fundamental to a justifiable transformation of value premises.

Having transformed the value premise, there is a tendency to then revert to operations within the respective CRRs – but based on the CSP there are cautions to this mode of operation. CRRs are dynamic, limited and fallible and therefore the comprehensibility asserted when transforming the value premise may well be transient. The need for assessment continues notwithstanding the single mapping of the value premise; indeed applying the methodology across two CRRs imposes respective requirements for adaptation, learning, etc. Also, operations within a CRR are still restricted to be justifiable within the perspective and resolution at which comprehensibility and understanding is asserted. If, for example, a value premise established at a strategic resolution is carefully transformed to a value premise at an operational resolution, operations within that

resolution towards this transformed value premise must still be justified within the operational resolution. This fundamental requirement translates to a quite practical guideline: uninformed micromanagement cannot be justified within the CSP. Informed micromanagement, however, may serve as a way to establish the shared domain between two resolutions. Further, the whole idea of empowerment reflects that, given a transformed value premise to a given CRR, justifiable operations must occur within that CRR and interventions based on a different CRR (one that does not share a domain of awareness) are not justifiable.

Operations within each situation will employ specific methods – indeed, the entire purpose of a methodology is to guide the selection of methods. For the situations methodology, it is readily apparent that the antepenultimate value premise coupled with the principles and theorems of the CSP provide specific guidance on selection of methods. For each situation, methods should operate at the same structural characteristics (e.g. perspective and resolution) as the CRR. Learning methods should contribute towards building understanding for the CRR; and adaptation should seek different perspectives and resolutions from the current CRR. Assessment should determine if *a posteriori* assertions of comprehensibility are valid, and action should be causally linked (given the asserted understanding and assertion of comprehensibility for the CRR) to the value premise (or penultimate value premise if available).

Finally, it is clear that, for complex situations, the decision-maker must have the flexibility to operate within all possible situations. Proscribing operations in only one of the situations immediately restricts the justifiability of action to those instances where serendipity has aligned comprehensibility and understanding. Placing an entity in a

complex situation where learning, adaptation and assessment are constrained is fundamentally inconsistent with the CSP. Though this is obvious from the standpoint of this argument, a bias towards action tends to predominate – if for no other reason than a false application of the principle of economy of force. However, application of energy towards a value premise, without a justifiable assertion of comprehensibility, is in itself a violation of this principle as the attainment of the value premise cannot be rationally justified.

Summary

This research purposed to develop a decision-making construct for complex situations. Noting that no complete expression of an internally consistent philosophical foundation for such a construct existed, the research built on the work of (Sousa-Poza & Correa-Martinez, 2005) to generate such a foundation, designated as a Complex Situations Paradigm. The philosophical foundation extends the assertions of pragmatic idealism to incorporate all of the elements of a paradigm, particularly the axiological and methodological components, and demonstrates both internal consistency and applicability to complex situations. In order to develop the CSP using a rational research methodology, the research developed generalized canons based on the JTB(+) definition of knowledge, and instantiated these for the CSP. The instantiation of those canons for the CSP provide sufficient guidance to justify internal consistency. The situations methodology for the CSP then directly formed the meta-construct for decision-making in complex situations. The decision making construct provides a viable means for application as well as guidance for further research into application of the construct.

CHAPTER V: CONCLUSION

The assertion of a paradigm is not without risk; even the definition of a paradigm remains the subject of discussion in the literature. Having made such an assertion, it is appropriate to consider the relative significance of this paradigm (and derivative decision making construct) with respect to the body of literature and theory as well as the potential contributions to practice. In particular, since various methodologies, approaches and methods for operations in complex situations already exist, a putative methodology warrants a brief discussion with respect to an illustrative sample – though principally for illustration of the paradigm, this also serves to extend the shared context for communication that constitutes one of the generalized JTB(+) canons. This section closes with a discussion of potential areas for further research, focusing on the areas of validation, cognition, the development of methods, tools for analysis and synthesis, and considerations for reduction to practice.

Significance

Contribution to the Literature

Sousa-Poza and Correa-Martinez (2005) provide the initial discussion (for the purposes of this research) of alternative philosophical foundations for complexity and systems, introducing the concept of a complex situation. This research furthers that discussion, extending the initial philosophical foundation to include epistemological, ontological, axiological and methodological underpinnings – a Complex Situations Paradigm. The difference between the solution form and the CRR has already been discussed, principally arising from a slight shift in precedence for ontology and

epistemology. As both approaches are based on the same ontological and epistemological foundations, the two should be reconcilable, and indeed it is noted that the CSP explicitly formulates several requirements from (Sousa-Poza & Correa-Martinez 2005): the disassociation of systemic perception, the disassociation of the concepts of analysis, design and transformation, and the need to address the unknown. In the first case, the CSP presents systemic perception as one potential form of the CRR – indeed, one that the CRR may present as a necessary bias of generalization, abstraction and organization – but it is inherently a property of the self-aware entity and exists across the disassociation bridge between self and other-than-self. The situations methodology likewise disassociates concepts of learning, adaptation, assessment and action as each is seen as operations within one of the complex situations that are inherently a product of the generation of the CRR. Finally, the basic notion of an incomprehensible reality that is in essence mutually generative with the CRR incorporates the core characteristics of complexity (whether they are expressed as emergence, context or non-ergodicity).

Additionally, this research is aligned with a small number of works (Sousa-Poza and Correa-Martinez, 2005; Kovacic, 2005; Kovacic, Sousa-Poza, & Keating, 2008) that seek to redefine the basic foundations for regarding complexity, and further builds a structure that can guide operations within or research regarding complex situations. This represents a fundamental contribution to the literature as the discussion is extended beyond adapting traditional approaches to re-examining paradigms themselves.

The contribution to theory is the internally consistent philosophical foundation for complex situations – the express purpose for the research – as well as the associated discussion of generalized JTB(+) canons. The product of the research is in itself a theory

built on semantically complete diverse topics related to complex situations. The discussion of research canons principles and defined by sound theorems. Though this theory may be refined, extended or rejected, it presents a necessarily complete basis to enable robust discussion and investigation suitable for alternative philosophical foundations and provides a new perspective with the potential to enable multi-disciplinary research beyond this particular application.

The most readily apparent contribution to practice is the decision making construct itself. This represents a coherent framework for selection of methods through the antepenultimate value premise associated with each situation, along with constraints provided by the various principles and theorems of the CSP. Initial framing for asserting primacy of a given situation as well as the application of the Contextual Corollary provide broad but actionable guidance.

Beyond these specific contributions, there is the more nebulous contribution of continuing the dialog regarding complexity and its fundamental relationship to reality, being, cognition, and value. The earliest ontologies established perspectives at the extremes (rationalism and empiricism) that served to illuminate a discussion away from the extremes – pragmatism, post-modernism, and other later philosophical perspectives. The CSP rests within this body of work in rejecting the extremes – and though it attempts to obviate certain consequences of extreme philosophical perspectives, it does so at a cost of obviating certain perspectives (those that engender an incomprehensible domain of awareness). Further, the CSP itself carries its own bias by introducing the notion of idealism; it is not incongruent to relate that to the bias of identity originating in the field of engineering – a field that seeks to "being the art of directing the great sources of power in

Nature for the use and convenience of man" (ICE, 2009, pg. 3). In this simple statement, ontology, epistemology, and axiology are all present; this may be considered an ultimate value premise that consequently biases the CRRs oriented to support it – including this research. As such, the CSP presents a dialog borne of an engineering perspective and matured to confront engineering problems, inclusive of engineering management problems. Though the dialog regarding complexity is by no means complete, the CSP provides another basis to extend and continue the discussion.

Illustrative Comparisons

Soft Systems Methodology

Soft Systems Methodology (Checkland, 1999b) explicitly applies systems concepts to deal with complexity. The relationship between systems concepts and complexity has been noted in the review of the literature, especially in those cases where complexity is likely to arise. System-of-systems engineering, as an example, involves relationships between, essentially, CRRs of different structural characteristics and therefore faces the challenge of building multiple domains of shared awareness in order to assert comprehensibility. In a broader sense, systems approaches are typically applied in appropriate situations: hard systems techniques when comprehensible and understood, soft systems techniques when learning and adaptation is emphasized, and finally wicked problems such as the incomprehensible / not understood situation.

SSM is explicitly presented as a methodology referenced to the same problem area of complexity. The intent for methodology is similar (noting the SSM reference to methodology as the *logos of principles*) in that it is intended to guide methods. However, the SSM methodology is not explicitly derived from ontological and epistemological

principles (in contrast to the situations methodology). SSM does refer to a systems paradigm, but this is not expressly defined – instead, SSM relies on a presentation of systems concepts in concert with the methodology. The explicit systems approach, from a CSP perspective, represents a bias for the structure of the CRR that may already be inherent (from the earlier discussion on structure of the CRR). The caution for an explicit system perspective remains as discussed in the review of the literature, but can now be expressed relative to the CSP: a comprehensible systems perspective requires a shared domain of awareness between two comprehensible resolutions operating at the scale of the whole and at the particular. Absent causal relationships between the two, conclusions at one level cannot be applied relative to another.

SSM has evolved over time, moving through phases delineated by Checkland (1999a) ; namely *blocks and arrows*, *seven stages*, *two streams* and *four main activities*. In the latter and most recent form, the four main activities are (Checkland, 1999a): "finding out about a problem situation, including culturally/politically; formulating some relevant purposeful activity models; debating the situation, using the models, seeking from that debate both changes which would improve the situation and are regarded as both desirable and (culturally) feasible, and the accommodations between conflicting interests which will enable action-to-improve to be taken, and taking action in the situation to bring about improvement" (Section 3).

The first activity seems to assign primacy learning; not inappropriately, but from the CSP that would align with the assertion of a comprehensible reality (which is consistent with systems concepts). In more detail, the technique of developing a rich picture is a physical instantiation of developing a CRR – and to the extent it incorporates both holistic

and particular perspectives, it will support this systemic perspective in building a shared domain incorporating multiple structural characteristics. The second step is more explicitly oriented on the CRR, but introduces the value premise as "an expression of a purposeful activity as a transformation process" (Checkland, 1999a, Section 4). Ideas incorporating multiple perspectives (e.g. CATWOE and multi-level thinking) explicitly address the development of a shared domain of awareness. The third step addresses the issue of assessment and adaption, seeking to refine the model to (in essence) gain an assertion of comprehensibility. The final step is a direct analogy to the action situation.

Certainly the CSP does not currently possess the depth of discussion associated with a mature and refined approach such as SSM, but there is certainly a high degree of accommodation for SSM within the CSP. In doing so, additional considerations are available to the practitioner such as creating shared domains of awareness across CRRs with different structural characteristics. SSM is oriented on a maturing process (though iteration and feedback are specifically mentioned) and does not directly speak to the Situations Theorem or the Contextual Corollary. SSM asserts a methodology without an explicit expression of ontology or epistemology, though the systems paradigm is referenced as an underlying source. The absence of these explicit expressions creates the previously discussed potential for paradox in employing a systems perspective in a complex situation.

The Learning Organization

Senge (1999) provides a discussion of an overall management approach incorporating five disciplines: Systems Thinking, Personal Mastery, Mental Models, Shared Vision, and Team Learning. As can be noted from the subtitle ("The Art and Practice of the Learning Organization") the work is not expressly a product of academic

research, but does capture a set of management principles that had been discussed, assimilated and adopted within the community of practice. There is no explicit treatment of philosophical foundations or derivations of principles and theorems, but it does provide a basis of comparison against a product that evolved from a mixture of theoretical and practical perspectives. At the least, the subject matter of complex situations is common. Four of the disciplines are discussed below; the fifth (Personal Mastery) is not as directly relevant and is not discussed here.

The Systems Thinking discipline introduces systems concepts, with similar consequences as discussed in the SSM section. Systems concepts are currently more ubiquitous than at the time of this writing and a good deal of the material discusses the basic aspects of systems thinking. From the CSP perspective, this is a valid structure for the CRR but, to reiterate, the systems perspective carries the burden of creating a shared domain of awareness between CRRs with structural characteristics accommodating the holistic and particular perspective. Absent the additional explicit effort towards this type of communication, the risk for paradox remains where one or both CRRs result in an incomprehensible situation.

The Mental Models discipline is presented in a form with several characteristics of the CRR itself – for example, a mental model is stated to "affect what we *see*" (Senge, 1999, pg. 175). This discipline stresses the adoption of new worldviews (which in this context could be taken to be either the CRR or the generative process for the CRR) reflecting the situations demanding assessment and adaptation, including referencing action science (Argyris et al., 1985) as a means to facilitate this adaption. Action science itself is a useful illustration of the antepenultimate value premise as it seeks to learn through action

not necessarily directed towards the particular value premise. Senge (1999) also speaks of "planning as learning" (pg.187), which reflects at least an iterative (if not parallel) regard for operations in multiple situations. Similarly, explicit references to reflection and inquiry address the CSP notion of an ongoing assessment of comprehensibility. Finally, combining the Mental Models and Team Learning discipline speaks to establishing shared domains of awareness across the organization – by implication, including CRRs with multiple structural characteristics as different hierarchical levels are discussed in this context.

The initial perception of the Shared Vision discipline, from a CSP perspective, is likely to align with the area of communication and shared domains of awareness. However, it contains a good deal of discussion on the notion of devolution of value premises. The description of a shared vision as "a force in people's hearts" (Senge, 1999, pg. 206) speaks to an ultimate value premise – one that is essentially self-defining for the individual. This is closely tied to the learning organization ("You cannot have a learning organization without shared vision" [Senge, 1999, pg. 209]) and is therefore a close reflection of the Value Principle. This discipline also accommodates the relationship between visions (or value premises in this context) at the shared and personal level, so there is a treatment of establishing the shared domain between CRRs with differing structural characteristics (e.g. organizational and personal).

In summary, Senge (1999) does not voice specific ideas such as the Justification Principle, Value Principle, Situations Theorem and Contextual Corollary, and such would not be expected for this type of work. There are sufficient similarities to assert that the CSP accommodates the general concepts associated with *The Learning Organization*, even to the extent of aligning at least a set of the disciplines with the various CSP situations,

potentially enabling mapping them specifically as methods within the situational methodology.

Sense-Making

The body of work relating to sense-making bears a direct relevance to the CSP justifiable actions of assessment and adaptation. "Sense-Making is an approach to thinking about and implementing communication research and practice and the design of communication-based systems and activities" (Dervin, 2009, para 1). Sense-making traces a line of thought to Piaget's genetic epistemology (1970), which has impacted a number of areas of cognitive research in general but finds particular relevance with the notion of *making sense*. This is treated in a highly contextual manner; Dervin (2009) discusses an enactment perspective that specifically frames sense-making which "accommodates communications in building the shared domain" (para. 1), again expressing ideas and context that are accommodated within the CSP.

The overall evolution of sense-making has gravitated towards a sense of a methodology as opposed to a method – (Dervin, 1998), for example, treats "knowledge as a verb" (pg. 36) while (Dervin, 2009) explicitly states that sense-making should be treated as methodology. This methodology incorporates several cognitive aspects, including individual characteristics that impact sense-making (perception, bias, etc.) and communication. The former directly accounts for the individual, limited and fallible nature of an individual's cognitive representation of reality; the latter directly accounts for aspects relating to shared domains of awareness. Dervin (1988) further states that "... sense making and sense unmaking is a mandate of the human condition. Humans, sense making assumes, live in a world of gaps: a reality that changes across time and space and is at least

in part 'gappy' at a given time-space; a human society filled with difference manifested in madness, culture, personality, inventiveness, tentativeness and capriciousness; a self that is sometimes centered, sometimes muddled, and always becoming. In this view, the sense making and sense unmaking that is knowledge is a verb, always an activity, embedded in time and space, moving from a history toward a horizon, made at the juncture between self and culture, society, organization" (pg. 36). This eloquently captures the dynamic, limited and fallible nature of the CRR within the CSP. Further, the sense-making methodology "... consists of a set of philosophical assumptions, substantive propositions, methodological framings, and methods" (Devin, 2009, para. 2) and therefore has some basis for comparison (if not alignment) across different philosophical foundations and methods – indeed, it is asserted as applicable to multiple resolutions such as "intrapersonal, interpersonal, small group, organizational, mass, national, global" and multiple philosophical perspectives such as "constructivist, critical, cultural, feminist, postmodern, communitarian" (ibid, para. 2).

From the CSP perspective, sense-making is relatively well suited as a method for adaptation of the CRR to gain an assertion of comprehensibility. The treatment of sense-making as an individual activity influenced by the individual's environment (i.e. context to include social interactions and communications with others) can readily accommodate notions of the domain of awareness and operations within a unique, individual, limited and fallible CRR. The multidisciplinary nature of the area also permits application of the Situations Principle; action learning and other techniques can be considered, as can be the impact of the goal of sense-making on sense-making itself (e.g. devolution of value premise). Assessment and adaptation are certainly related; while the combination of these

under the general rubric of sense-making does not detract from the asserted primacy in certain situations, it does enable a clear picture of the Contextual Corollary where assessment, adaption, learning and action enjoy a robust contextual relationship.

Commander's Appreciation and Campaign Design

The *Commander's Appreciation and Campaign Design* (CACD) is a cognitive process "to create a systemic and shared understanding of a complex operational problem and to design a broad approach for its resolution" (U.S. Army, 2008, pg. 4). It is based on a complex situation expressed in the characteristics of a wicked problem (Rittel & Webber, 1973). The goal is to gain an *appreciation* of the situation as opposed to an understanding – within CACD, the term appreciation refers to the process of understanding a situation thus incorporating aspects of adaptation and learning. The appreciation emphasizes multiple perspectives and iterative discussions to form the commander's appreciation: *"Discourse* is the candid exchange of ideas without fear of retribution that results in a synthesis and a shared visualization of the operational problem. The goal of the commander, subordinate commanders, staff, and other stakeholders is to consider and synthesize many different perspectives and ideas" (U.S. Army, 2008, pg. 15). This directly addresses creation of a shared domain encompassing CRRs of multiple structural characteristics – one of the essential elements in a large organization that must inherently translate a value premise at one resolution (e.g. operational) to value premises at a lower level of resolution (e.g. tactical).

CACD emphasizes not only development of the appreciation, but specifically highlights assessment and reframing. It specifically includes the need to describe the requirements for reframing - "the factors that would change or obviate the current

understanding/framing of the problem" (pg. 29). This requires a continuous assessment of the situation – essentially a determination of comprehensibility – that leverages parameters for reframing to determine when the appreciation must be refined or rebuilt. This treatment is sufficiently explicit for CACD to frame the following questions as a basis for learning:

1. How to execute the planned course of action for a specific operation;
2. Whether another course of action needs to be adopted;
3. Whether the operational design based on the problem frame is producing results;
4. Whether the problem framing needs adjusting; and
5. Whether the learning mechanisms of the organization are tuned to the particular operational problem. (U.S. Army, 2008, pg. 18)

This approach also uses the term *design* as opposed to *engineering*; in this use "designing focuses on learning about an unfamiliar problem and exploits that understanding to create a broad approach to problem solving" (pg. 13). This choice of emphasis tends to introduce a contextual element to learning and adaptation enabling justifiable action.

CACD is based on a set of characteristics of complexity, not a rigorous definition. However, it is a robust set of characteristics enabling a fairly complete treatment – at the least arriving at the notion of the Commander's Appreciation (highly analogous to the CRR) incorporating multiple perspectives (at least a partial attempt to construct shared domains of awareness). The need for continuous assessment and adaptation is explicitly framed within the overall concept (by specifying triggers for re-framing), and the idea of design vs. engineering introduces a contextual element. However, the discussion on reframing does not rise to the level of emphasis indicated by the Situations Theorem and there is no explicit analog to the Contextual Corollary. The concept of explicitly examining structural characteristics of the CRR to enable assertions of comprehensibility

would potentially benefit both the appreciation and design phases. Overall, the mapping from CACD to CSP is not as clearly defined as in some of the other illustrative comparisons but in the same perspective the similarities in functionality remain clear.

Summary

This suite of illustrative comparisons provides multiple perspectives that are relevant to the CSP: a methodology, a method, and two approaches (with some broad liberties in interpretation). Though this certainly does not provide any form of rigorous validation (see discussion below), it does serve a purpose in demonstrating the CSP can provide a coherent framework to evaluate disparate approaches related to complexity. In each case, it is possible to recommend reasonable and feasible areas for additional emphasis within the particular methodology, method or approach. To the extent that it also provides an illustration against extant work, these comparisons also contribute to establishing a reliable context for justification under the instantiated generalized JTB(+) canons.

Potential Future Research

This section discusses potential areas for research, addressing several areas due to the necessarily broad nature of the Complex Situations Paradigm. This includes validation of the CSP, areas related to cognitive theory, shared domains of awareness, the selection and/or derivation of methods consistent with CSP principles and methodology, and a derivative concept designated *forensic complexity*. The discussion also addresses a related but distinct area concerning the concept and application of generalized research canons.

The section concludes with a discussion of potential research areas related to reduction to practice, including the derivative decision making construct.

Validation

The purpose of this research is essentially theory-generating, an overall inductive process that incorporated inductive selection of principles followed by a rational deductive generation of theorems, in composite forming the Complex Situations Paradigm. An immediate observation in terms of potential future research is the validation of the paradigm, beginning with the interpretation of what a validated paradigm actually is. In Kuhnian terms, a paradigm is reflective of the prevailing worldview and frames scientific investigation as a whole. Paradigms in this sense are generally not born whole from the half-shell, but are either the products of evolution or revolution within the community at large. The research has shown this derivation to be internally consistent and therefore complies with its own Justification Principle, and asserts a valid knowledge claim through the reliable method and context used for the justification. However, under its own definitions, the CSP is only a knowledge claim until it is accepted by another individual. The goal of attaining paradigm-hood in the Kuhnian sense is yet another order of magnitude (or several) removed from this level of justification. This semantic delineation does not obviate a search for the ways and means to broaden the method and context for justification.

A major impediment to validation is the assertion of adapting the CRR, which obviates the initial expression of the value premises within the CRR. As an example, if one CRR that is structured on a substantive basis is assessed to be generating an incomprehensible situation, another CRR may be asserted which is structured on a process

basis. In this instance, the ability to conduct longitudinal or comparative studies would be greatly constrained. However, it may be possible to use criteria of internal consistency – how well the extant value premise is supported – as a metric. Within these constraints and limitations, the CSP as a foundation for dealing with complex situations may be best suited for more targeted investigations of a qualitative nature – case studies, interviews and/or ethnographic approaches that are suited to more naturalistic/constructivist approaches.

For more quantitative approaches, research in complex situations is confronted by a limitation due to the lack of correspondence between theory and reality for a particular situation – the situation itself is unpredictable. This may be avoided by addressing stable characteristics of the emergent behavior such as emergence itself or limits of possible behavior. Agent-based models or cellular automata illustrate patterns or limits in emergent behavior; alternatively, for management of complex situations the investigation of reaction to emergence can be examined (versus specific emergent behavior). Even in these cases, research methods must abandon correspondence in exchange for coherence, illustrating consistency with a body of propositions (for example, characteristics of emergent situations).

Empirical inductive methods justify knowledge claims within rigorous bounds tied to reality – a correspondence theory of truth. Even for well-behaved problems, gaining a meaningful *p*-value is challenging (Cohen, 1994) – but for complex situations their inherently unpredictable nature of complex situations decreases the utility of the correspondence theory of truth. When outcomes are equiprobable, or logical complexity renders the next value incalculable, notions of predictive analysis are no longer relevant – all statistics generated essentially become a statement of comprehensibility at a different

resolution. Considering the limits of empirical approaches, the rational approach used to derive these conclusions points to a rational inductive approach as better suited to the research question. This does not assert that empirical approaches cannot be applied (e.g. Maani and Maharaj, 2004) but asserts such approaches will be constrained by the inherent characteristics of complexity – leading, in this example, to the conclusion "that the story is much more convoluted" (Maani & Maharaj, 2004, pg. 46).

A final potential contributor to validation regards the situations methodology specifically. As a methodology purposes to enable the development and/or selection of methods, the extent to which this can be accomplished using the CSP represents a substantive degree of validation (see section on Derivation of Methods).

Cognitive Applications

The Cognitive Representation of Reality introduces cognitive studies as a potential area for further research. Cognition is a multidisciplinary field, dealing with a subject of enormous complexity – the brain is estimated to have some 10^{13} to 10^{15} neuronal connections (Churchland, 1986). In general, cognitive models are classified as biogenic or anthropogenic (Lyon, 2006). Biogenic models are based in direct models of physical phenomena (e.g. Eliasmith, 2003; Taylor, 2004) and tend to deal with individual neurons or neuronal paths (Churchland, 1986). Anthropogenic models are constructed at a more aggregate level (e.g. Baars [1988] Global Workspace Theory) and tend to deal with gross characteristics that are difficult to apply to individual behaviors. Clearly, challenges exist for synergistic investigations of these two multidisciplinary fields.

Though the level of complexity is daunting, Brewer and Sousa-Poza (2007) illustrate how ideas from cognitive studies can inform operations in complex situations.

Drawing from (Baars, 1988), which presents the physiological stress associated with novel situations, and the general cognitive desire to habituate responses to situations, Brewer and Sousa-Poza (2007) state:

> In this framework, observer dynamics are illustrated in tension in complex situations, continuously seeking to form habituated responses and modify or build global contexts in the face of sustained novelty - the framework seeks to build habituated responses, or global contexts, specifically to transfer the cognitive load from the low-bandwidth distribution network to high-bandwidth parallel processing modules or framing constructs. Sustained novelty, generated by emergence, will consume the distribution network; requiring sustained attention to continually seek understanding where the limits of understanding may have already been reached - at the cost of increased physiological stress. In this sense, it is desirable to habituate novelty via developing a global context that abstracts to focus on the nature of novelty and not novelty itself. (pg. 57)

This is directly applicable to the CSP and the decision making construct – focusing on the nature of the problem as opposed to the novelty of the problem becomes a means to reduce physiological stress.

Brewer and Sousa-Poza (2007) further discuss the relationship between cognitive studies and complexity, concluding that: "Observer dynamics are inextricably linked to the evolution of a complex situation. Work in cognitive research may provide a means to incorporate observer dynamics into complex situations, and therefore assist in the understanding of the complex situation (vice [*sic*] the complex entity)" (pg. 59). Exploring general characteristics of cognition as a means to inform the concept of the CRR in particular (and by implication the CSP in general) is a natural extension of this research, and would involve a significant degree of multidisciplinary research (across two multidisciplinary fields). This would have the advantage of drawing on a significant extant body of work in the literature.

In addition to maturing the CSP and its application in the context of cognitive studies, there are within the various situations a number of additional cognitive aspects for further exploration. Sense-making, for example, presents an area that has matured into in-depth explorations of the cognitive aspects for assessment and adaptation, and there are entire fields related to the cognitive aspects of learning. The interaction of three multidisciplinary fields (complexity, cognition, and sense-making) provides opportunities to investigate specific cognitive aspects such as contextually informed learning, assessment and adaptation (as framed within the CSP). This would provide a basis to investigate reduction to practice for contextually informed operations within the various complex situations.

Shared Domains

The concept of shared domains of awareness is resident in multiple fields, including cognition, communications, and learning (among many). The breadth of the subject is illustrated by the evolution of sense-making into a Sense-Making Methodology as described above. This does not prohibit specific investigations into areas framed by the CSP, including defining, building and maintaining shared domains based on the general concept of the CRR, particularly with respect to generative processes and structural characteristics. In the case of establishing knowledge, the goal would be to communicate sufficiently compatible structural characteristics and generative processes to build the shared domain – essentially with a goal of transforming a knowledge claim into knowledge. In the case of devolution of value premises or aggregation of knowledge, the task would be to communicate diverse structural characteristics to enable generation of multiple CRRs (at least more than one) that can assert a comprehensible relationship

between the diverse structural characteristics. In sum, this equates to a *requirement* for meta-discussion to enable communications.

Since the CRR is a general concept, it should be noted that the shared domain does not have to exist across individuals – the case of determining a comprehensible relationship between an individual's current and desired CRR represents the general process of planning. The same issues of establishing a shared domain can be applied to this instance, requiring the establishment of a method and context to justify the causal relationship that may span CRRs of different structural characteristics. Potential for research exists in revisiting existing concepts from the perspective of generative and structural characteristics, assessing the means by which comprehensible relationships between diverse structural characteristics are developed, and the general areas of reliability of method and context with respect to the CRR.

Finally, the idea of shared awareness – a putative quality of organizations – is seen from the CSP perspective to represent several intersection domains of awareness across multiple CRRs. The accessible reality of the organization, however it is captured through policy, tradition or other means, represents potentially shared method and context; it then remains to generate sufficiently compatible domains of awareness across individuals. This approach would emphasize research into the desired structural characteristics of CRRs within the shared domain, including the representation of organizational value premises, in order to facilitate concerted action.

Derivation of Methods

The self-identifying value premise of a methodology is guiding the selection of methods. In the case of the situations methodology, areas for future research include the

classification of extant methods as well as the generation of new methods. The former allows consideration (as seen in the illustrative comparisons) of how existing methods may be adapted to operate under the CSP. For comprehensible situations, there are numerous existing methods that either frame learning (e.g. Action Science) or frame learning to gain understanding and transition to action (e.g. Hard Systems Engineering, Risk Analysis, Decision Theory, and analytical techniques in general). The learning organization approach also tends to emphasize the comprehensible. Methods devoted specifically towards action include such well-known approaches as Project Management, Configuration Control, and Process Control; for highly comprehensible and well understood situations this would include Lean Six Sigma or similar approaches. As the situations transition to high complexity, methods such as Soft Systems Methodology come into play – but it should be noted that this is somewhat sequential in practice, and SSM will transition from learn, to assess, to adapt, and possibly return before transitioning to action. This can be seen as a necessary shift of primacy given the situation, but can also be a by-product of an overly simplistic treatment of a methodology applied as a sequential method – Checkland (1999a) cautions against treating the methodology as a method. The technique of developing a rich picture is not restricted to SSM, and can be seen as either a learning approach or an adaptation approach (depending on the intent for the development of same). Sense-making, as described earlier, may be particularly well suited as a method for adaptation and assessment – but it represents a methodology in and of itself, implying that there may be a finer level of detail in leveraging this approach. Still, the general concepts of communications to enable individual assessment and adaptation are appropriate in any one of the situations where either there is a lack of understanding or of comprehensibility.

Finally, there are emerging environments such as the Complex Adaptive Situations Environment at Old Dominion University (Sousa-Poza, 2009) which are expressly founded on the philosophical foundations of Pragmatic Idealism and therefore have a high degree of applicability across all situations. Figure 10 presents a summary of these methods mapped to the situations methodology, illustrating the general area of applicability for each. Hard systems engineering is represented uniquely by an arrow as it represents a well-structured approach for dealing with extremely complicated problems in a manner that allows specification and attainment of well-defined requirements. However, in those cases where requirements are ill-defined, or the problems become complex, hard systems engineering can be severely challenged (as discussed in the review of the literature).

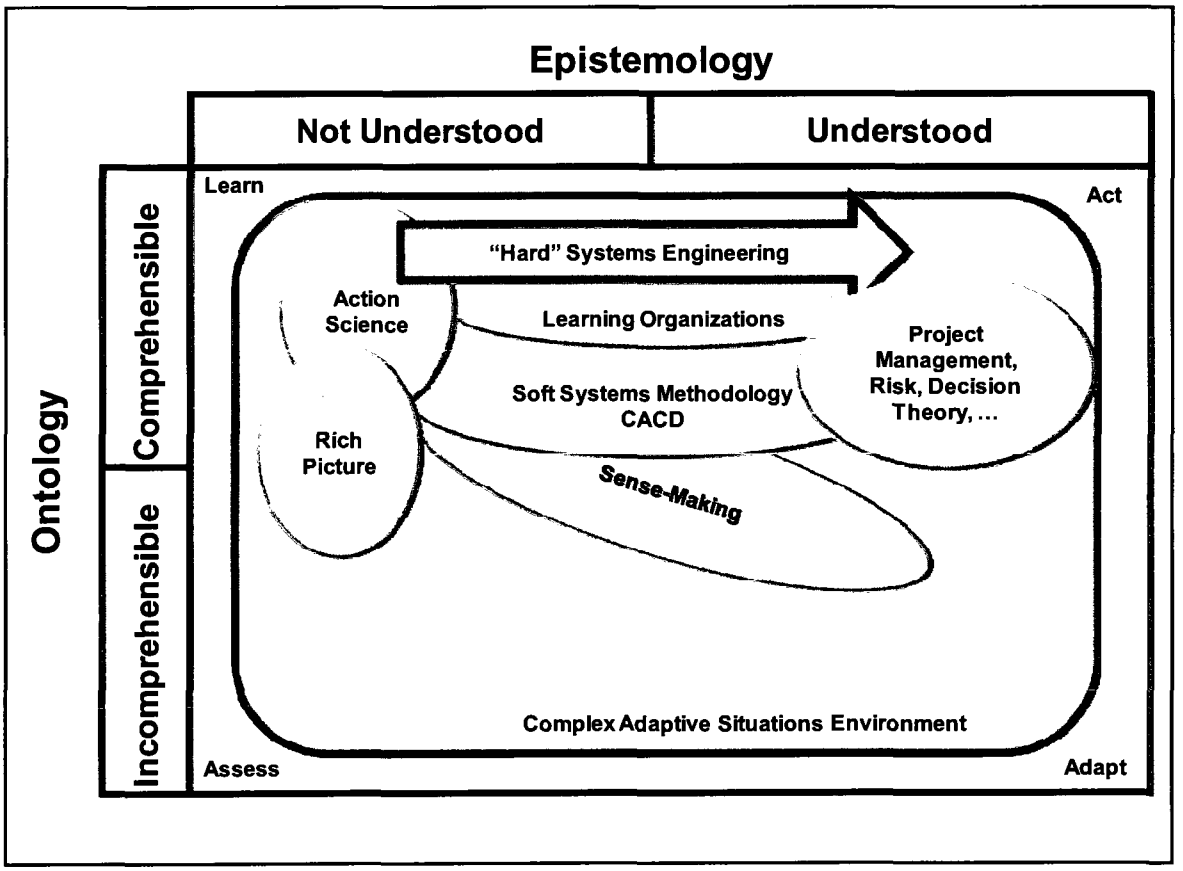

Figure 10. Illustration of Methods Within the Situations Methodology

The generation of methods for the various situations, based directly on the principles, theorems and corollaries presented by the CSP, is of particular interest as an area for further research – both since new methods are welcomed in this highly challenging areas, and because this serves as an additional measure of validation for the CSP as a whole and the situations methodology in specific. Though admittedly broad, there is a substantive level of guidance provided for methods, beginning with the antepenultimate value premise associated with each situation. The Justifications Principle provides guidance as to operations with respect to the generative processes and structural characteristics of the CRR; creating methods based on this concept as opposed to adapted to it may hold some promise. The Situations Principle provides guidance for transition between methods, and the Contextual Corollary provides additional guidance for structuring methods with respect to other situations – for example, how learning methods can also accommodate assessment of comprehensibility, how the assessment may potentially aid adapting structural characteristics of the CRR, or if there are there determinable bounds for justification for action (analogous to the criteria for reframing in CACD). Preliminary research is underway regarding an approach called Reverse Decision Making (RDM), which is based on the CSP (Kovacic, 2009). The initial research for RDM focuses on a process perspective that instantiates substantive perspectives in specific situations as warranted.

Forensic Complexity

As complexity cannot be predicted, recreating complex situations does not substantively contribute to attaining a value premise. It is possible, as illustrated by the CSP itself, to investigate characteristics of complexity in order to consider justifiable

operations within complex situations. Toward these ends, the concept of forensic complexity (Gheorghe, 2008) has been postulated as a potential future area of study, essentially studying past complex situations to assess the ways and means by which antepenultimate value premises were attained (or not attained, as the case may be). More precisely, a statistical analogy may be appropriate as forensic complexity would possess *descriptive* and *inferential* aspects. Descriptive forensic complexity addresses, for example, the generative processes and structural characteristics of comprehensible CRRs; mechanisms for assessment of comprehensibility; adaptation of CRRs, including the transformation or obviation of value premises; and approaches for embedding context for operations within the various situations. These may also include methods for the formation of comprehensible CRRs that were not necessarily understood at the time, as a means to inform or refine learning (or the transition from assessment/adaptation to learning). Inferential forensic complexity would then address the application of such meta-constructs to complex situations to aid in assessment and adaptation. This explicitly does not violate the Incompleteness Principle; such inferential statements are confined to cognitive operations in complex situations.

Generalized JTB(+) Canons

As noted in Brewer and Sousa-Poza (2009) there are several areas meriting additional research related to the generalized canons themselves. These include further refinement of the definition of JTB(+) knowledge and the development of generalized canons for other definitions of knowledge.

Application to Practice

The Structural Theorem presents opportunities to further explore complex systems within the CSP. As previously mentioned, resolution is commonly used to differentiate strategic, operational and tactical levels of resolution; issues of command and control follow by extension. Transitioning guidance or information across levels requires a means of bridging across disparate resolutions. This will require establishing causal linkage between levels of resolution – which will necessarily be inferred as this will involve noumena not accessible to the CRR at either level of resolution. This calls for further research into transitions across levels of resolution, particularly in the area of building a shared domain of awareness for value premises originating in CRRs of different structural characteristics.

The CRR as presented here is an abstract construct that raises issues of some form of physiological equivalence to establish a realized context for further investigation. As an example, the notion of adapting the CRR embodies diverse concepts such worldview, perspective, and resolution which may bear further exploration in a realized context. The principles provided here also provide a comparison – complementary and supplementary - with the principles of the observer set forth by Kovacic, Sousa-Poza, & Keating (2007) regarding the Type III Theory of the Observer. Additional aspects should explore the relative primacy of justifiable actions within the various situations, as well as incorporating other situations as context.

The Complex Situations Paradigm provides a basis for further dialog and investigation. Though even the definition of paradigm itself is a rich subject for debate, the

comparison of a systems paradigm and a situations paradigm holds the potential for illuminating perspectives in both theory and practice. The methodology of equally relevant situations challenges the dominant priority in practice, which is typically one of acting, learning when challenged in action, and adapting perspective as a last resort. Applying these actions continuously and simultaneously implies moving beyond inner / outer loop learning to a construct of action, assessment, learning and adapting, in concert, exploiting the balance of situations as context for cognitive operations in any given situation.

Summary

This research identified a gap in literature, theory and practice and posited a research subject that ultimately contributed to closing the gap in all three areas. System engineers, managers and other professionals continue to deal with complex situations that are sometimes of critical importance (Richardson, 1994) by extending and adopting existing approaches. From the review and analysis of the literature, the limitations and shortcomings of applying traditional system engineering or management practices to complex situations are apparent. These are traceable to the uncertainty inherently associated with complexity, indicating the need for a construct such as the CSP to enable or frame decision making in complex situations. This required development of a suitable, internally consistent philosophical foundation, which in turn dictated a rational research methodology. This approach is illustrated in the development of generalized JTB(+) canons to guide the research, effectively tying the foundations and the research back to a definition of knowledge. In sum, this research identified a knowledge gap, and demonstrated a contribution to close that gap. It requires accepting knowledge claims

within the philosophical foundation of the Complex Situations Paradigm, based on a research methodology that is consistent with the constraints imposed by the subject area.

With some latitude in perspective, this research could be described as creating an anticipatory paradigm – though, since a paradigm is supposed to reflect the prevailing mode of thought for scientific inquiry, it is not necessarily apparent that one may create a paradigm *a priori*. However, it is typically the unresolved problem that initiates a paradigm shift – certainly as opposed to solutions formulated within a different paradigm during the evolutionary phase of development. In both the subject matter area and the research methodology, this research holds potential to further dialog and discussion in the treatment of complex challenges.

The breadth of Complex Situations Paradigm itself holds the capacity for larger applications. If its utility shows promise, the dialog regarding the general class of areas dealing with the tension between certainty and uncertainty, constructivist and positivist, and other dialectics originating in philosophical differences may be enriched by this perspective. Engineering management, originally born of necessity, represents a field that must inherently embrace both analysis and synthesis, both as technology grows to attain levels of complexity previously not encountered and as the ability to separate technology from social aspects (and all the associated potential for complex behaviors) becomes increasingly difficult. As this field matures to a discipline (a point that can be richly debated), it is appropriate to challenge the underlying philosophical foundations – and the Complex Situations Paradigm may contribute to that dialog. Systems engineering, "hard" and "soft," can be enriched by considering the role of the observer, the generative and

structural characteristics of how reality is represented, and the basic notions of comprehensibility as a function of the observer.

The devotion of such effort to matters debated over millennia may seem far removed from the "fierce urgency of now." [1] Philosophical foundations are oft regarded as interesting diversions, overwhelmed by practical and pressing details. Yet, the earlier definition of engineering itself – "being the art of directing the great sources of power in Nature for the use and convenience of man" (ICE, 2009, pg. 3) – includes methodology (*directing*), ontology (*Nature*), axiology (*use and convenience*), and epistemology (*man*), so it would seem this is a topic area worthy of its due for engineers and philosophers alike. James (1995) provides a perspective that is appropriate for closing the discussion:

> There are some people – and I am one of them – who think that the most practical and important thing about a man is still his view of the universe. We think that for a landlady considering a lodger, it is important to know his income, but still more important to know his philosophy. We think that for a general about to fight an enemy, it is important to know the enemy's numbers, but still more important to know the enemy's philosophic. We think the question is not whether the theory of the cosmos affects matters, but whether, in the long run, anything else affects them. (pg. 1)

[1] From Dr. Martin Luther King's "I Have a Dream" speech, 28 August 1963.

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