Sideways Look at Systems: Identifying Sub-Systemic Dimensions as a Technique for Avoiding an Hierarchical Perspective

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Abstract

Many observers view organizations in terms of their components. We might say, for example, that the ISSS is an organization comprised primarily of SIGs, and individuals. Such a view, however, might be considered "atomistic" or "hierarchical." This paper suggests that such views may distract organizational theorists from developing new insights into the nature of systems.

The technique developed and used in a case study for this paper is called Reflexive Dimensional Analysis (RDA). RDA uses what might be called a "reflexive" process of theory re-creation, rather than the more traditional categories that we might call priori (intuitive) and posteriori (empirical).

A case study is presented where RDA is used to analyze a body of Complex Adaptive Systems (CAS) theory that has been developed by scholar-practitioners. The RDA method results in a description of CAS that consists of sub-systemic and co-emergent dimensions. This method suggests the opportunity to understand organizational and systems through a new perspective.

Keywords: Robust; Reflexive Dimensional Analysis; Complex Adaptive Systems; organizational theory; theory of theory.

Introduction - a Reflexive Point of View

Despite our attempts to understand, communicate, and use concepts of complexity theory, it is not uncommon to fall back on an atomistic point of view. Such a view might be seen, for example, when a team is described as a system, nested in an organizational system, and comprised of individual human systems. This paper will draw on the literature of dimensional analysis and grounded theory to suggest a form of analysis that might be used to gain a non-atomistic, or "sideways" understanding of systems (in general), and CAS theory (in particular). This shift, from one perspective of analysis to another, may be seen as a reflection of the broader shift in the literature of the social sciences.

This shift is described by Clarke (2003) who notes that postmodern forms of analysis seem to lend themselves to understanding, "…social worlds seen as mutually constitutive/co-produced through negotiations taking place in arenas…" In a similar vein, Goulding (1998) differentiates between a "positivist" epistemology (described as one with an emphasis on mechanical objectivity) and an "interpretivist" methodology (e.g. grounded theory), which she describes as including, "…methodological philosophies such as phenomenology, semiotics, critical relativism, researcher introspection, critical theory, hermeneutics, discourse analysis and postmodern perspectives…" Shifts of this sort may be seen in many areas of the social sciences. For example, there is a call for a more, "reflexive sociology" (Sweet, 2003) and in the study of history (Berkhofer, 1997). Then too, there is "reflexive ethnography;" described by Davies (2001) as an observer who reflects on his or her own reactions to the society under study. With this method, rather than striving for unachievable objectivity, biases are surfaced for the reader to see and understand. Additionally, Davies notes that these interactions generate knowledge and insight. In a sense, it may be imagined that this form of generativity could be considered as a form of dialectic, where the observer (seen as the thesis) and the observed (seen as the antithesis) interact; and, the insights emerge (as the synthesis).

Hall (1999) describes these forms of inquiry as a "third path" of inquiry that is primarily neither objective, nor subjective, rather it is essentially reflexive, where meaning is created in a socially constructed sense. Weick (1999) writes about theory creation as "disciplined reflexivity" which he sees as a change from theory creation as "disciplined imagination" only ten years before (Weick, 1989). In comparison to more formal techniques of theory creation, van Eijnatten, van Galen, & Fitzgerald (2003) call for a dialogic processes of organizational change. Such a dialogic process might be seen as similar to the understanding suggested by Shotter (e.g. 2000) where the change process is not so much grounded in a particular theory but rests on the assumption that the participants will socially construct an appropriate response for the situation. While the dialogic process seems to allow for new insights to emerge and for the coordination of interaction along the lines of social constructionism, it may also be assumed that the process of conversation is not always well documented and so may be difficult to share with those not present.

In contrast to reflexive forms used in the sense of the interaction between individuals, or between an individual and the data, this paper will focus on the reflexive form of analysis in the sense that suggests a relationship "within the data." Such a reflexive relationship has been suggested previously with some success. The "Container, Differences, Exchanges" model (Olson & Eoyang, 2001) may be briefly defined as: Container (the extent of the organization), Differences (between individuals in knowledge and power within the organization), and Exchanges (communication and work done between members of the organization). They claim that this model is "self-referent" because each of the three elements causes change in the other two when it is changed. Such a relationship suggests a way of looking at organizational components in a way that might be thought of as "co-causal."

A key aspect of reflexive forms of analysis may be its generative nature as suggested by "dialectic theory." In *Historical Social Psychology* (Gergen & Gergen, 1984), Georgoudi

suggests that a core assumption of dialectic theory is that in the process of dialectic transformation, "Both entities are mutually altered to create a new entity." In the same book, Rappoport notes the importance of the generative dialectic saying, "Generative theory efforts grounded on dialectical schemes of inquiry seem to offer the only plausible means of forging the tools to engage the deep structure crisis of our times." This paper may be seen as an exploration toward developing such a tool.

Clarifying Dimensional Dialectics

For this analysis, it may be useful to clarify some of the terms to be used – specially concepts such as "dimension," "dialectic," and "robust." First, a dimension might be defined as, "magnitude measured in a particular direction" (Webster's, 1989). A dimension might be seen as being forming in a dialectic process. In what might be called the "first stage" of the dialectic process (e.g. as described by Appelbaum, 1988), one may move from having one concept (e.g. "being") to having two concepts ("being" and "not being"). Nietzsche's (2005, original 1886) conversation seems to suggest that those two concepts might be placed on a conceptual "continuum" so that the two ideas may be seen as related by their relative magnitude of "Being-ness" - as in Figure 1.
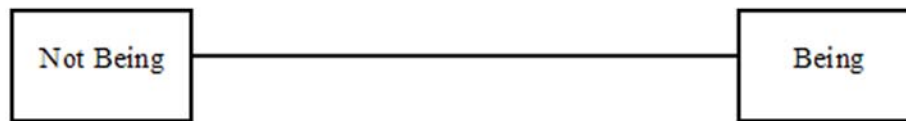

Figure 1: Dimension of Being-ness

A dimension has broad capacity for representation. It might represent, for example, a "system" (Jacobson, 2001), "process" (Kools & Spiers, 2002), or "customer complaints" (Gardner Jr., 2004).The direction may take the form of a topic or subject, or even a concept under analysis. For example, if "Agency" were used as an example, the dimension might be called Agency and might represent the magnitude of Agency (greater or lesser) that could be understood to exist in a particular individual or organization. It seems important to note that this relationship may exist, even though an observer might not be able to "see" any atomistic evidence of agency (any more than an observer can see the weight of a box of unknown contents).

Another key factor for this paper is the assumption that each dimension may be understood as being related by co-causality to all the other dimensions in a given model – so that a change in one will lead to a change in another. Nietzsche seems to suggest such a dimensional emergence in his conversation around our "given" world of "impulses." He states that, "…for thinking is only a relation of these impulses to one another …" His writing seems to imply that that a change in any one of those three may lead to changes in the others. Linking impulses, thoughts, and the "material" world, Nietzsche then goes on to describe this relationship as being a form of "life" that goes on to "branch off" and

develop in an organic process. Nietzsche seems to name this process as the "will to power" and, although his conversations seem to center around the will to power from what we might think of as a "human perspective," it seems that the root of this notion goes deeper so that it might be thought of as a process that drives what might be called a "dimensional dialectic" (where one or more dimensions generate one or more additional dimensions). On a human and societal scale, this same sort of generativity might be seen in Nietzsche's representation of society; indicating, "…that society is NOT allowed to exist for its own sake, but only as a foundation and scaffolding, by which a select class of beings may be able to elevate themselves to their higher duties…" In this view, it may be possible to see the "society" on one dimension (with greater and lesser extremes) and "select class" on another dimension (with greater and lesser extremes) where each is improved by the improvement of the other (in "co-evolutionary" fashion). In a sense, the notion of generativity, in dialectic form, might be thought of similar to the notion of "emergence" in the complexity theory literature. Where, "something new happens" (Stacey, 1996).
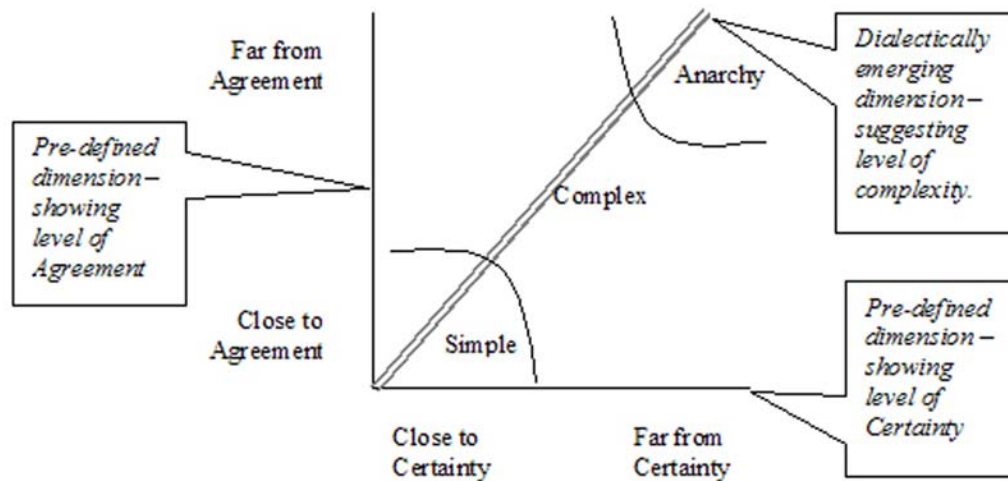

Figure 2: Eoyang's depiction of Stacy's model of decision-making

Figure 2 suggests an example of dialectic emergence that may be found in the complexity theory literature. It is based on Eoyang's (2003) diagram representing Stacey's (1996) description of organizational leadership in a decision-making situation. That diagram depicts two (what might be called) "pre-defined dimensions." One dimension represents the level of "agreement" (on the vertical axis) and the other dimension "certainty" (on the horizontal axis). These dimensions reflect what might be called "group behaviors" that might be experienced by members of a team. One interesting aspect of this relationship is that the depiction of simplicity/complexity/anarchy seems to form a new, emerging, dimension. With the recognition of a new dimension, a new perspective is created – suggesting that the complexity of the team might be shifted along the scale from simplicity to anarchy, which may then have effects on the other dimensions of agreement and certainty in a co-causal relationship. In short, the relationship between these three dimensions seems to suggest that change on any single dimension may cause change in one or both of the other dimensions.

Another concept applied in this paper is that of "robustness." Moreno and Ruiz-Mirazo (2002) use the term in what might be called a biological sense, suggesting that robustness is something needed for, "…maintenance, reproduction, and evolution." Such a definition seems close to what might be thought of as a traditional notion of robustness as "strong and healthy" (Webster's, 1989). In contrast, Lissack and Letiche (2002) cite Holling as suggesting that robustness or, "Resilience deals with the flexibility of responses to stress and the capacity for learning, selforganization, and adaptation at multiple scales." Lissack and Letiche note that Jen discusses robustness in terms of learning, and also in terms of overlapping systems. They conclude that, "Resilience or robustness entails a preservation of qualities, functions, or identity." In what might be seen as similar to identity, Juarrero (2002) uses robustness in a way that suggests that it represents a defining boundary's, "… dynamic membrane or information closure confers the requisite robustness to maintain the system's integrity." Such an identity might be seen as a boundary from the outside, but from the inside Capra (2002) suggests that robustness is a quality indicating a "…redundancy in genetic and metabolic pathways." In Capra's example, some cells in a sea urchin embryo are destroyed but the remaining cells interact to enable the emergence of a whole and healthy urchin.

Seeking a parallel between cells of an urchin and dimensions of a model, it might be imagined that the destruction of an important cell could be understood as eliminating of an observer's understanding of a dimension that defines the model (for example, imagine losing the concept of "hierarchies" while conducting an analysis of an organization). However, with a robust model, the insights imparted by that missing dimension would become apparent from the analyst's understanding of other dimensions (for example, if one was to consider communication networks and power relations, the notion of hierarchies might become apparent). In a similar sense, if a theory is made up of a set of dimensions that are essentially self-defining, or co-emerging, if one dimension were "destroyed" (or simply overlooked) that same dimension might be seen as re-emerging from the relationship of the other dimensions. Therefore, rather than looking at robustness as a boundary which defines a system, this paper will use the concept of robustness in the sense that a theory might have a robust identity where its dimensions are more effectively co-defined. An example of this would be Newton's law of motion ($F=mv^2$) where each aspect (e.g. mass) may be defined by the other two (e.g. Force and velocity).

Similarly, in research, Gardener (2004) notes that, "Dimensional analysis is simple, robust, and flexible…" Building on Gardener's description of dimensional analysis as a robust form of analysis, this paper will use the term "robust" to reflect the strength of a concept, based on what might called its "internal dimensional integrity." This is a somewhat different use than what might be termed the "knowledge management' use of the term which would indicate a "socially distributed" knowledge (Grey & Willmott, 2002). A robust relationship, in this paper, will indicate a model composed of dimensions that are co-defined (as might be seen in Figure 2, or co-emergent (as suggested by the above conversation around Nietzsche's insights into dimensional dialectics. Although biases (like points of view) may unavoidable, a robust model based on "interlocking definitions" might be a useful to the organizational scholar-practitioner as such a model

might provide a convention against which scientists might test their observations (Yeager, 1994).

Finally, in this paper, it is recognized that the dimensions (whether pre-defined, emerging, or co-defining) may be considered as insights, or opportunities for insights, perceived by the author, and/or reader. This is in contrast to the possibility that might suggest (for example) that each dimension might be emerging on its own.

Literature of Dimensional Analysis

Gardner (2004) credits Epstein's 1957 "A proposed measure for determining the value of a system" in *Operational Research*, as recognizing the value of approaching issues from the perspective of a physicist using "dimensionless indices." Gardner also notes that Epstein's work was apparently based on Bridgman's *Dimensional Analysis*. In contrast, Kools & Spiers (2002) cite the origins of dimensional analysis as a grounded theory method, informed by Kools, McCarthy, Durhma, and Robrecht (1996) as well as the work of Schatzman (1991). Jacobson (2001), adds that dimensional analysis is founded on symbolic interactionism. Within the body of literature, authors describe useful techniques; however, there may also be the issue of bias reflecting a point of view that might be thought of as atomistic, modernist, or positivist.

Gardener (2004) used dimensional analysis to study "airline quality" based on available quantitative data. His choice of dimensional analysis was based on his concern that previous analyses were based on "weighted averages" of the data and caused misleading results. Gardener began looking at relativistic relationships (such as ratios between the arrival times of two airlines), rather than atomistic components (such as number of bags lost, and arrival times). Kools & Spiers (2002) use dimensional analysis in a different way for their study of caregivers. They begin with interviews (continuing until saturation is achieved), then the data is "dimensionalized" ("… examined in relation to the numerous dimensions or themes in the interviews…") and "differentiated" (placed into categories that were pre-determined by convention). "Finally, the components of the analysis were *integrated*, that is, the relationships between salient dimensions were described and a grounded theory on expertise in adolescent care was generated…" Goulding (2002) describes dimensional analysis as an alternative version of grounded theory and suggests that a difference between the two is that grounded theory, "…rejects the use of received theory as a basis of analysis…" choosing to focus instead on relationships among the data. Based on the existence of pre-determined categories in the Kools & Spiers (2002) study, Goulding's claim would seem to be true – in at least one case.

Glaser (2002) notes that a grounded theory is an abstract of time, place, and people. And that the process of abstraction, allows the analyst to develop a theory on a "core variable." However, it may be speculated that the notion of a "core variable" may suggest a focus to the study. A focus might, in turn, be seen to suggest a bias (if it is not clearly understood by the reader). This kind of hidden bias may also be seen in the pictoral representation of study results. For example, Clarke (2003) seeks to, "…disconnect grounded theory from its positivist roots…" Yet, Clarke also emphasizes the use of maps for displaying data. It seems that Clarke would replace Cartesian reductionism with

cartographical representation. This may be a cause for concern if the use of maps results in a tacit bias. For example, by placing a spot on a map the observer may note where the spot is in relation to other details of the map, but may miss the tacit assumptions inherent in the map itself.

In contrast to the bias that might be found in other forms of dimensional analysis (e.g. grounded theory's core dimension, the tacit biases that might be found in maps, the use of pre-defined dimensions) the method presented in this paper may be more robust and less biased (or, at least, possess an alternative bias). That is because the focus of the presented analysis is in seeking to find an understanding of CAS theory where each dimension might be thought of as "co-definitional" or "co-emergent" because each dimension is defined by the other dimensions. In a sense, co-emergent dimensions might be seen to be similar to those that exist in classical Newtonian mechanics where, a rock has mass (m), velocity (v), and force (F). In what might be called an abstract or dimensional sense, relevant aspects (not atomistic components) of the object are defined by those three dimensions. It is important to note that the object cannot exist without these dimensions. For example, there are no rocks without mass. It might be said that the rock is a system – one that has been deconstructed into these non-systemic dimensions. If the rock is broken into fragments, each piece will also be defined by mass, velocity, and force. It is important to note, that the formula $F=mv^2$ seems to purposefully recognize the non-systemic dimensions of force, mass, and velocity, but leaves as implicit the concept of the system itself. In a sense, the system emerges from the interaction of its non-systemic dimensions and the non-systemic dimensions are the result of the system.

From the techniques suggested by this reading of the literature, it seems that there should not be a strong emphasis placed on the coding process. Additionally, because reflexive techniques are relatively new, it may be speculated that an *ad hoc* analysis might be appropriate for identifying the relationships between dimensions. To counter what might be considered the "opacity" of *ad hoc* analysis, the opposite concept of "transparency" may (in a dialectic sense) be called for – where the analyst describes the thought-process used in the analysis.

Reflexive Dimensional Analysis - Method & Application

In this section, the method of Reflexive Dimensional Analysis (RDA) will be explained and demonstrated. Broadly stated, the five steps of RDA include: 1) Define a body of theory. 2) Investigate the literature to identify sources that define it. 3) Code the sources to identify relevant components. 4) Clump the components into mutually exclusive categories. 5) Define each category as a dimension. 6) Investigate those dimensions – looking for a robust relationship.

The first step begins by defining a body of theory. The focus for this study will be CAS theory, as developed by scholar-practitioners in human organizational systems. This study works under the assumption that authors who develop a concise statement, or definition, of CAS will include what they believe are the most important aspects of CAS. Therefore, to encompass the greatest breadth of theory possible, this study interrogated the literature to find 20 definitions of CAS that were thought to be relatively concise (one page or less). By using concise definitions, this study can use more abstracted

representations of authors' insights to cover the greatest possible "ground" with the greatest possible efficiency (recognizing, however, that some accuracy may be sacrificed). Although the definitions will not be listed for reasons of space, this study uses concise definitions from: Ashmos, Huonker, & McDaniel (1998), Axelrod & Cohen (2000), Bennet, & Bennet (2004), Brown & Eisenhardt (1998), Chiva-Gomez (2003), Daneke (1999), Dent (2003), Harder, Robertson, & Woodward (2004), Hunt & Ropo (2003), Lichtenstein (2000), McDaniel, Jordan, & Fleeman, (2003), McGrath (1997), McKelvey (2004), Moss (2001), Olson & Eoyang (2001), Pascale (1999), Shakun (2001), Stacey (1996), Tower (2002), Yellowthunder & Ward (2003).

RDA – Coding
Next, the concepts within the 20 definitions were coded, based on the technique of "open coding" suggested by grounded theory.

> "Open coding is the process of breaking down the data into distinct units of meaning. It is the product of early analysis and describes what is happening in the data. Open codes may comprise key words, phrases, or sentences." (Goulding, 2002)

For an example of coding, one definition states:

> "In a complex system, the component parts interact with sufficient intricacy that standard linear equations do not predict their behavior. There are so many variables at work in the system that its overall behavior can only be understood as an emergent consequence of the holistic sum of the myriad variables embedded within it." (Hunt & Ropo, 2003)

Redundant terms are ignored for this process. For example, the term "so many variables" might be seen as conceptually similar to "intricacy." Their definition can be deconstructed and coded as shown in Table 1:

Table 1: Codes for Hunt & Ropo's Components of CAS

Component	Code
Component parts	1
Interact	2
Intricacy	3
Standard linear equations do not predict their behavior	5
Behavior can only be understood as an emergent consequence	12

The following list contains the 19 codes suggested by the data. Table 2 shows the relationship between the authors' and the coding of their respective definitions.

1. Agents
2. Interrelated / Interacting
3. Variety / Diversity
4. Co-evolutionary
5. Non-Linear / Unpredictable
6. Self-Organizing
7. Far From Equilibrium / Edge of Chaos
8. Pursue Goals / Maximize Success
9. Semi-Autonomy
10. Change
11. Time/History/Irreversibility
12. Emergence of Order
13. Environment
14. Multiple Levels
15. Boundaries
16. Tools/Knowledge/Resources
17. Flow
18. Agents Evolve & Adapt
19. Schemas / Mental Models

Table 2: Coded Components of CAS by Author.

Authors	Coded Components of CAS																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
McDaniel, et al., 2003	X	X			X	X	X				X							X	
Hunt & Ropo, 2003	X	X	X		X							X							
Ashmos, et al., 1998		X			X				X				X	X				X	
McGrath, 1997	X	X						X					X		X	X			
Yellowthunder & Ward, 2003	X				X	X				X	X								
Moss, 2001		X	X		X	X				X		X	X			X		X	X
Dent, 2003	X	X		X				X	X	X									
Stacey, 1996	X	X						X		X								X	X
Chiva-Gomez, 2003	X	X	X			X	X	X		X			X			X	X	X	X
Lichtenstein, 2000		X			X				X			X							
Harder, et al, 2004		X		X		X							X				X		
Pascale, 1999	X							X	X	X							X		X
McKelvey, 2004	X		X	X	X	X	X												

Source																
Bennet & Bennet, 2004	X	X	X		X	X		X		X			X			
Axelrod & Cohen, 2000	X	X	X				X			X				X		X	X
Brown & Eisenhardt, 1998	X	X	X		X	X			X		X	X				X	
Tower, 2002		X	X	X	X	X	X	X	X	X		X	X	X	X		X	X
Olson & Eoyang, 2001	X				X			X	X		X	X				X	
Daneke, 1999	X	X	X	X			X	X								
Shakun, 2001	X	X	X			X		X								X

Once the data are coded, the next step is to combine the coded data into closely related groups. This grouping was accomplished by a critical comparison of the coded data to identify conceptual relatedness. Again, in process similar to grounded theory (e.g. Goulding, 2002).

RDA - Grouping
In seeking to group the related members of the 19 categories, not all of the relationships were immediately apparent. For example, one view might suggest that FFE/EOC might be combined into the same category as Change, based on the notion that FFE/EOC leads to change. However, within the literature, authors linked FFE/EOC with Self-Organization (which is linked with Interactions). This suggests that an *ad hoc* process may not be sufficient and so may suggest a more purposeful, even critical, comparison.

Ashmos (1998) links Interactions with Evolves/Adapts. Similarly, Harder (2004) links Evolves/Adapts with Co-Evolutionary saying, "…systems are coevolutionary… [because they]… engage in a continuous input-transformation-output cycles…" (where input and output are seen as forms of interaction). Next, Evolves/Adapts is linked by McDaniel et al. (2003) with Self-Organizing, and linked by Olson & Eoyang (2001) with Pursues Goals. Tower (2002) links the Pursuit of Goals with Autonomy (although Autonomy seemed to be weakly explained in the literature). Finally, both McDaniel et al. (2003) and Chiva-Gomez (2003) link Self-Organizing with FFE/EOC conditions. In short, suggesting that these categories might be combined under the heading of "Interactions." For future discussions, this heading will refer to Interactions as a dimension – representing a scale of connectedness. In a sense, all systems may be seen as "connected" to other systems. Yet, without differentiation, it might not be possible to differentiate them. This might be summed up by saying, "All things are connected, but some things are more connected than others." In a sense, this dimension might be thought of as "interactedness" as a combination of quantity and style of interactions, rather than (for example) a simple enumeration of interactions.

Time might be thought of as another category. Olson & Eoyang (2001) and Yellowthunder & Ward (2003) both note that history and time are irreversible (this relationship between time and its irreversibility is described by Prigogine (1997). McDaniel et al. (2003) note that agents interact over time – an observation that may be as

simple as it is true. This category, as with the others, will be later defined as a dimension. However, Time as a dimension suggests the need for a better understanding of the scalar aspect of the dimension. That is to say, one way of looking at the dimension of Time is to see it as a clock, or calendar, marking how much time has gone by. A more relevant understanding, based on the above discussion of the relatedness of dimensional dialectics suggests that a more useful understanding of the Time dimension is as a representation of how rapidly time is passing relative to other time that is passing. Work in this area has been addressed, to some extent, by Csikszentmihalyi (1991) and his concept of "Flow" where time seems to pass differently for individuals in different situations. In short, it raises the question of how an individual, or other CAS, perceives time.

Two coded components that may be closely related are Variety/Diversity and Multiple Levels. Many authors (e.g. Ashmos et al., 1998; Tower, 2002), describe the Multiple Levels concept in their discussion of systems as existing as nested within other systems. This seems to suggest what might be thought of as a "large" difference between levels - the sort of difference in levels that might be perceived by an individual investigating the differences between a nation, and an individual. Others, (e.g. Axelrod & Cohen, 2000) discuss the Variety/Diversity of Agents, suggesting a "small" difference, as might be found by an individual investigating the differences between individual motivations. While the differences between individual motivations might be thought of significant from one point of view, those differences might be smaller than the differences between an individual and a nation that contains many individuals. Combining these notions suggests that there is a single category of "Levels" that might be defined as a dimension, where that dimension represents smaller differences (as in those between similar types of individuals), and larger differences on the other end of the scale (as in those differences between a single nation and a single individual).

Another category might be seen in the category of "Change." That notion might stand on its own, as Ashmos et al. (1998), as well as Brown & Eisenhardt (1998) note that the environment changes. Lichtenstein (2000) simply notes that change is constant. Moss (2001) also notes the "…Heraclitan idea of flux…" However, Tower (2002) notes that change emerges, often unpredictably, which seems to create a conceptual link between Change and the concepts of Emergent Order and Unpredictable/Non-Linear. Those two concepts are noted as similar by Brown & Eisenhardt (1998). In linking those three categories into a larger category of Change, then considering that category as a dimension further seems to suggest that the dimension of Change might be understood as a scale of "predictability of change." For example, there are some situations (e.g. picking up a pencil) where the results may seem to be highly predictable (though, perhaps, not perfectly so) and other situations (e.g. asking for a raise) where the results may seem much less predictable.

For the fifth, and final, category, there are many different forms of systems discussed by the authors. In the CAS literature, there are a wide variety of systems that are called CASs. Axelrod & Cohen (2000) note that a CAS may be an individual, organization, nation, or even a computer program. Other examples of CAS include molecules & birds (Brown & Eisenhardt, 1998), and ecosystem (Dent, 2003). In short, it seems that almost anything might be thought of as a CAS. McGrath (1997) describes a CAS as having smaller systems, or members, "embedded." Similarly, Chiva-Gomez (2003)

describes schemas as "nested" within agents. From another point of view, Axelrod & Cohen (2000) describe agents as "interacting" (with each other, and with tools), suggesting that they are not so much nested, as all existing on a "level playing field." Indeed, all descriptions of CAS indicate that the CAS is composed of agents (or, is itself an agent), or other sub-systems. It may be imagined that whatever "level" is observed, there will always be levels of scale, both above and below – that might be graphically represented by fractals of indeterminate scale.

Rather than attempting to "unravel" these atomistic descriptions of relationships between systems (e.g. by identifying hierarchies), the solution presented in this paper is to place all these concepts into a single category that recognizes only that they have a sense of "Agentness" in common. Thus, the following coded components may be combined into the larger category of Agentness (Agents, Environments, Boundaries, Schemas, and Information/Tools/Resources). The term Agentness is used only because it seems to be a term commonly used in the literature to represent a particular aspect of CASs (and, sometimes, the CAS). By Agentness, this paper does not mean to suggest that non-human systems (e.g. molecules or nations) have agency in the same sense that a human might have agency. Rather, Agentness may be understood as referring to the "undefined something" about the way these systems exist and/or are perceived that has not been grasped in any of the other four categories. In a sense, Agentness might be thought of as a "placeholder" concept; the true meaning of which may only be fully understood when its relationship with the other categories is well known. To clarify, it should be noted that this study is not an attempt to identify five well-defined dimensions of CAS; instead, it may be thought of as identifying five dimensions that might define one another. This process has brought the number of categories to five. These five, may be conceptualized as Agentness, Interaction, Levels, Change, and Time. These categories, and their related, coded, subjects are summarized in Table 3.

Table 3: Summary of Groups of Coded Components.

Groups	Coded Components																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Agentness	X												X		X	X			X
Change					X				X		X					X			
Interaction		X		X		X	X	X	X									X	
Levels of difference			X											X					
Time											X								

RDA - Dimensions

This step involves the reconceptualization of each of the five categories as a "root" dimension. As such, each dimension may be assumed to be composed of a direction or focus (the category title), and a scale (representing a greater, and lesser, quantity of that category).

RDA - Identifying Dimensional Dialectics

Drawing from techniques of dimensional dialectics, the next step of the RDA method is to investigate relationships among the dimensions. The goal of this step is to identify what might be thought of as conceptual relationships between two dimensions that suggest the synthesis, or emergence, of the "third" dimensions. In a sense, this might be thought of as the "reconstructing" of the dimensional dialectic process. If each root dimension can be reflexively understood as one dimension, emerging dialectically from the relationship of other dimensions, the result may be thought of as a robust understanding of the body of theory.

For each definition discussed, an appropriate extract of the original definition will be provided. After the quotation, a close rephrasing will be provided, in the terminology of the root dimensions. Following each reframing, a diagram will also be provided. After the exemplars, a diagram will summarize those definitions for which the study was able to extract useful relationships. Unfortunately, many definitions were primarily atomistic in nature – listing the aspects of a CAS, rather than describing the causal relationships between them. Due to limitations of space, only a partial treatment of the data is possible.

In Ashmos, et al. (1998), a part of their definition suggesting a relationship may be stated as, "Systems have the capacity for self-organization and this capacity is enhanced by the quality of connections among organized sub-systems." If that statement were to be rephrased in terms of the emergence of the root dimensions, it might be stated as, "More Agentness (agents), with more Interactions (connections) causes the emergence of more Change (self-organization). Other authors (Bennet & Bennet, 2004; Dent, 2003) make essentially identical statements. This relationship might be graphically depicted as shown in Figure 3.
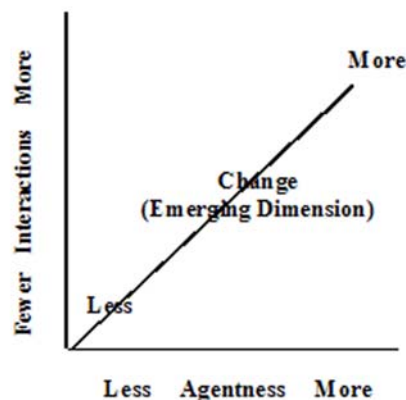

Figure 3: Dialectic Emergence of Change from Agentness and Interactions.

Olson & Eoyang (2001) note, "Agents are semi-autonomous units that seek to maximize some measure of good ness or fitness by evolving over time (Dooley, 1996)." It may be said, in the spirit of a process definition, that a "Agentness (agent) emerges when there are Interactions (evolving) over Time (time)" as in Figure 4.
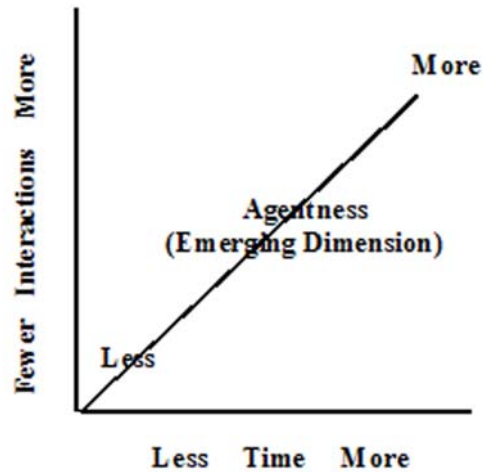

Figure 4: Agentness Emerging from Interactions and Time.

Pascale (1999) notes that a CAS, "First, it must be comprised of many agents acting in parallel." "Second, it continually shuffles these building blocks and generates multiple levels of organization and structure." Which, in the terminology of the root dimensions might be understood as, "Agentness (agents) Interacting (acting) causes Levels (of organization and structure)." Axelrod and Cohen (2000) develop a similar insight, as in Figure 5.
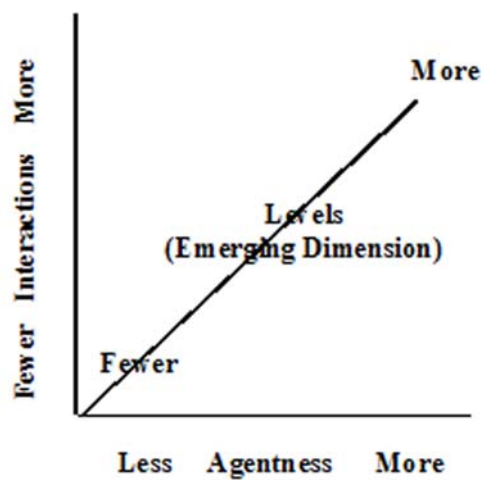
Figure 5: Levels Emerging from Agentness Interactions.

Shakun (2001) notes, "(1) players, agents, negotiators or decision makers in a group (coalition); (2) values or broadly stated desires; (3) operational goals, or specific expressions of those values; (4) decisions, actions, or controls taken to achieve these goals…" Which, broadly stated, might be reframed as, "Levels of Agentness (agents, coalition, values) cause the emergence of Interaction (action)," as represented in Figure 6.
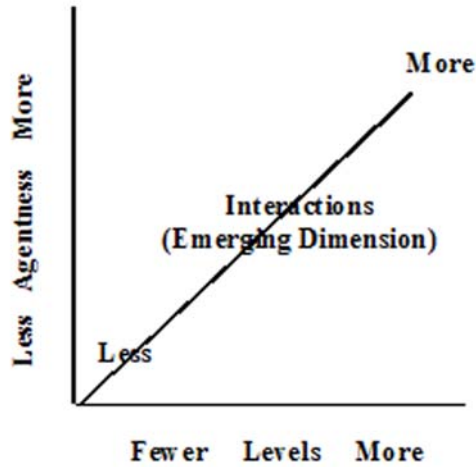

Figure 6: Interactions Emerging from Agentness and Levels.

Figure 7 incorporates the dialectic relationships described by the above authors. Figures 3-6 have been re-oriented and combined to better see the relationships between them.

Less Interactions More   More Agentness Less

Less   Fewer

More Agentness Less   Change
                             (Emerging Dimension)   Interactions
                                                           (Emerging Dimension)   Fewer Levels More

                                          More

Fewer Interactions More   Agentness   Levels
                                 (Emerging Dimension)   (Emerging Dimension)   Fewer Agentness More

Less   Fewer

Less Time More   More Interaction Less
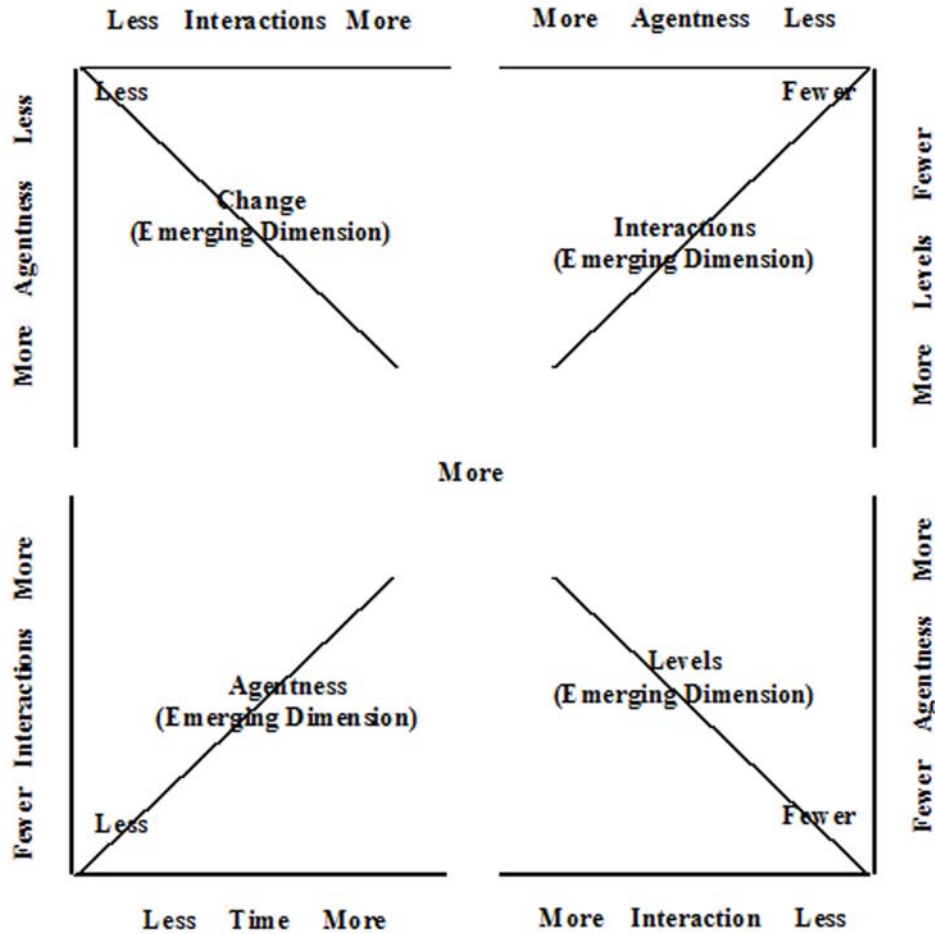
Figure 7: Combined & Simplified Summary of Dialectic Relationships.

The relationships shown in Figure 7 suggest that wherever an "emergent" dimension can also be seen as a "causal" dimension, there exists the opportunity to understand that relationship as a robust relationship of CAS theory. Because this figure is developed from a reduced data set, Change appears only as an emergent, rather than both emergent, and causal dimensions. However, in a more comprehensive analysis, Change was also identified as a causal dimension. Rather than creating a more robust picture, however, the more comprehensive treatment of the data also surfaced more interesting relationships. For example, a close reading of Moss (2001) suggests that the dialectic of Change and Interaction would result in the emergence of two dimensions – those of Agentness and Levels. This study, however, will confine itself to the information presented.

Figure 7 may suggest contradictions between the insights of the authors. While such differences may be understandable, given the relative "youth" of CAS theory, these contradictions suggest the opportunity to reconcile the understanding of the theory, and to obtain new insights. While the temptation may exist to reconcile the disparities shown in this study by delving deeper into the more nuanced writings of each author, it may also

be that that sort of atomistic approach may be no more successful. Instead, it may be speculated, that future studies (perhaps in computer modeling, or studies within human organizational systems) might be used to surface a more robust understanding of CAS theory.

Conversation and Conclusion

In this preliminary exploration, the techniques of dimensional analysis were linked with the concepts of dimensional dialectic and the concept of reflexive analysis to suggest the Reflexive Dimensional Analysis (RDA) method. Using the RDA method, the original data were coded, and a comparative analysis was performed to combine the coded data into five, root categories of CAS theory concepts. Those categories were defined as dimensions; and, the dimensions were examined through the literature to identify their robust, reflexive, co-emergent nature. Some "robustness" was found in this analysis of CAS theory; yet, from a dimensional dialectic perspective, some questions remain before CAS might be declared "fully robust."

First, the dimension of Time (which many models accept as an implicit component), Zaheer, Albert, & Zaheer (1999) claim that a Time scale is a, "…critical specification lacking from much theory…" The observations in this study seem to suggest a "weak link" of CAS theory, in that that nothing seems to "cause" time. From that it may be possible to conclude that time is an "atomistic" building block. However, Csikszentmihalyi's work on "Flow" has suggested that is not the case in a social sense, just as the theory of relativity in physics suggests that time may be relative.

Second, parallel notions are suggested. In one, Pascale (1999) seems to suggest that Levels may be seen as emerging from the Interaction and Agentness. While, from that same interaction, Change is seen as the emerging result by others (Ashmos et al., 1998; Bennet & Bennet, 2004). This seems to beg the question, "Are dimensions of Change and Levels synonymous?" One must ask, does every unpredictable event and every emergence of order (both examples of change) also suggest a re-ordering of the participants? For one example, it may be imagined that some system displaying Agentness (e.g. a group of individuals) who Interact (e.g. to enact a law over themselves) have created change and another level of order. It may also be imagined that social construction leads to such change and re-ordering. However, individuals interacting may also reduce the levels of order (e.g. in a revolution). On the other side, having differing levels may be seen as increasing the amount of change. For example, in an egalitarian office (e.g. few individuals working together) one might expect fewer surprises (a form of change) than in a large corporation where many organizational layers (a form of levels) separates the CEO from the worker – and may contribute to large surprises when the CEO makes an announcement (e.g. downsizing). Again, this seems a rich area for additional research, and may be related to the area of "surprise."

Third, Pascale states that a CAS will be, "…exhibiting entropy and winding down over time…" If this is so, it seems to beg the question, "Where does that energy go?" Or, put another way, If the Interaction of Agentness leads to Change, and Change suggests the emergence of new Agentness, than where does that new Agentness emerge? Do they arrive in what might be considered "internal" to the system, or far away, or some

complex combination thereof? For example, if an individual chooses one course of action over another (say to collaboration instead of competition), where will the Change happen? Will competing individuals see more change within themselves as individuals, within their relationship, or in the surrounding environment? How long will it take for those changes to become apparent? This may be related to the theory in economics of "externalities."

In the above Reflexive Dimensional Analysis, the focus was essentially on identifying emerging dimensions; then, identifying the relationship between the emerged dimensions. Another "path" to take through the data would be to look into the work of a single author, or body of theory, and identify (*a priori*) three (or more) concepts – then conduct a reflexive analysis to identify how those three concepts may have a robust relationship.

Overall, RDA seems to provide a useful method for surfacing gaps and contradictions in a body of theory. The greatest benefit to RDA may be that it enables analysis to take a sideways look at systems – and avoid the atomistic trap of hierarchy. In a sense, this work answers the call by van Eijnatten et al. (2003) who suggest looking for "invisible" things (including thoughts, values, and assumptions). Relationships might be thought of as invisible things because, for example, it is much easier to count the number of employees (more visible), than it is to understand the relationships between them (less visible). There are limitations, however. For example, the *ad hoc* nature of the process suggests that another analyst might develop different categories (and/or a different number of categories). Whatever atomistic categories are developed, however, the reflexive process of seeking dimensional robustness should provide interesting insights into the subject body of theory under analysis. If the "promise" of RDA is fulfilled, it may enable the creation of more robust theory. Such a robust theory might enable the emergence of a "second generation" of complexity theory for organizational scholar-practitioners.

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