Boundary Critique: A Minimal Concept Theory of Systems Thinking

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Abstract

Among a diverse array of general principles proposed for systems thinking are “boundary critique”, multiple perspectives, organization, and interconnectedness. Yet, no general theory of systems thinking (differentiated from a general systems theory) integrates these proposals. In "Minimal Cell Model" scientists model a single cell based only on the parts that are absolutely necessary for cell function. Some of the ways that scientists have progressed in their understanding of the components and interactions of a minimal cell is to use a technique called “knock out analysis” in which they remove or “knock out” one component at a time to see if the cell can function without that component.

Because systems thinking emphasizes *thinking*, a theory of systems thinking must be conceptual—that is, it must deal with concepts as its unit of analysis. Thus, a theory of systems thinking is a theory of how conceptual systems behave. By way of analogy to the minimal cell model, the simplest conceptual system is a "minimal concept model". I propose a complex adaptive model based on a simple rule set and fractal-like self-similarity across conceptual scale as a Minimal Concept Theory of Systems Thinking (MCT/ST). MCT/ST offers a formal integration of several principles of systems thinking. I present a formal algorithm for the theory and present several empirical research studies leading to the formalization. I also propose that MCT/ST may serve as a foundation of new education programs in systems thinking, science, and methodology.

Keywords: systems thinking; boundary critique; perspective; minimal concept theory

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The Minimal Concept Theory of Systems Thinking (MCT/ST)

A simple-complex and fractal "minimal concept theory" of systems thinking is offered. It is necessary to explore in greater depth what is meant by each of these terms. By simple-complex, it is meant that the process of systems thinking is based on simple rules despite the fact that the outcomes may be terribly complex. Nobel laureate Murray Gell-Mann, speaking about complex adaptive systems, explains (emphasis his):

What is most exciting about our work is that it illuminates the chain of connections between, on the one hand, the simple underlying laws that govern the behavior of all matter in the universe and, on the other hand, the complex fabric that we see around us, exhibiting diversity, individuality, and evolution. The interplay between simplicity and complexity is the heart of our subject.

It is interesting to note, therefore, that the two words are related. The Indo-European root **plek-* gives rise to the Latin verb *plicare*, to fold, which yields simplex, literally once folded, from which our English word "simple" derives. But **plek-* likewise gives the Latin past participle plexus, braided or entwined, from which is derived *complexus*, literally braided together, responsible for the English word "complex." The Greek equivalent to *plexus* is plektoV (*plektos*), yielding the mathematical term "symplectic," which also has the literal meaning braided together, but comes to English from Greek rather than Latin.(Gell-Mann, 1995)

That conceptual systems are complex is *a priori*. That conceptual systems are highly adaptive is also *a priori*. One might reasonably argue that conceptual systems are the most adaptive and complex types of systems because the physical and natural constraints placed on the evolution of conceptual systems is significantly dampened (i.e., while the biological structures responsible for conceptualization do adhere to the physical laws, there is nothing stopping one from imagining a world without gravity, or one in which a zebra head is placed upon the body of a trout). Therefore, it is reasonable to conclude that conceptual systems are complex adaptive systems. And while these conceptual systems are not constrained by the laws of physics *per se*, as complex systems with considerable order they may reasonably be thought to be derivative of simple rules. A theory of conceptual systems might attempt to identify these simple rules. Note that as we delve more deeply into what a model of systems thinking might look like, the lines between thinking and systems thinking become blurred. That is, it is difficult to differentiate between "systems thinking" and "thinking systems"; a *conceptual model* of systems thinking is, by definition, a thinking system or, more accurately, a conceptual system. That is, we are focused not on the ontological realities of existing systems but on systems of thinking and how these systems of thinking might be more "friendly" toward understanding ontological systems. Therefore, the line between thinking and systems thinking becomes much more fuzzy. The question is, what is the difference between systems thinking and thinking? It is suggested here that there is a real and pragmatic difference: a mind can have a systems thought without being a systems thinker. That is, systems thoughts may occur frequently but not consciously. This distinction may explain why so many "systems scientists" would never think to call themselves systems thinkers. To them, they are merely thinking about systems, and the net result is some systems thought, but it is not systems thinking. The central argument of this dissertation is that there are patterns to these systems thoughts, that underlying the factual knowledge of systems concepts are implicit and unconscious patterns that can be understood, turned into a schema or model, and developed and practiced on purpose. Systems thinking is a conscious, purposive act, whereas a systems thought may or may not be. Systems thinking is the conscious process of thinking in a methodical way by utilizing some set of patterns that universally underlie systems thoughts. This suggestion is very different from that made by most of the existing systems thinking literature, in which the construct is thought to be a taxonomy of systems concepts or methods.

Remember, too, from the review of the literature that no model of systems thinking can “violate” what is known about systems; if it does so, it is a special model not a general one. In addition, remember that a previously proposed definition for systems thinking (albeit very broad) was suggested that stated, “Systems thinking is thinking that is informed by knowledge-about-systems.” It is important here to revisit this idea in the context of the proposed model. First, the proposed model of systems thinking is a general model because it does not conflict with any aspect of knowledge-about-systems. That is, the components of the model (which will be discussed soon) are elemental to *any* systems concept. Second, one might imagine that such elementalism would also lead to abstraction, and it does. The model provides an abstract framework of scaffolding for knowledge-about-systems. It helps us to organize these myriad systems concepts. In this sense, the model is well-suited to educational settings. In the companion book to a seminal work by the same title, *How People Learn: Bridging Research and Practice,*(Donovan, Bransford, & Pellegrino, 2001) Donovan summarizes the three main findings of learning and educational research:

1. Students come to the classroom with preconceptions about how the world works. If their initial understanding is not engaged, they may fail to grasp the new concepts and information that are taught, or they will learn them for purposes of a test but revert to their preconceptions outside the classroom

2. To develop competence in an area of inquiry, students must: (a) have a deep foundation of factual knowledge, (b) understand facts and ideas in the context of a conceptual framework, and (c) organize knowledge in ways that facilitate retrieval and application.

3. A “metacognitive” approach to instruction can help students learn to take control of their own learning by defining learning goals and monitoring their progress in achieving them.(Donovan, Bransford, & Pellegrino, 2001)(pp10-13)

These findings suggest a dual approach to learning and teaching. That is, factual knowledge (e.g., systems science concepts) must be combined with a conceptual organizing framework. In addition, it is critical that teachers be aware (and students be reflective) about their own preconceptions and metacognitive process. They must develop a conceptual understanding of both the structure and dynamics of preconceptions and of new learning. By using patterns of systems thinking, students may understand how their preconceptions are conceptually structured to ignore certain important features the new learning focuses upon. In this way, there is a one-to-one mapping of preconceptions and new learning that cannot be undone. Similarly, the same process can be used by teachers to understand the structure of a student's preconceptions. Each of these processes are central to bridging the research and practice of learning.

In addition, it is suggested that the processes that occur at one level of thinking (say, inside the mind) between one thought and another are essentially the same set of processes that occur between groups or between organizations or between countries. That is, that the most complex systems of thought imaginable are structurally the same as a single simple concept. The term "fractal" is used to describe this self-similarity across scale. Figure 7.6 shows a fractal structure called the Mandelbrot fractal.(Evercat, 2006) "Fractals can be most simply defined as images that can be divided into parts, each of which is similar to the original object."(Wikipedia, 2006) This means that, like a fractal structure, the same conceptual structures are occurring across conceptual scale—that a single concept and a complex of concepts share the same basic structure and repeating patterns.

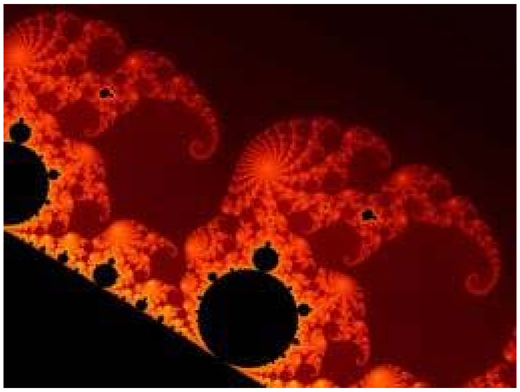

Figure 7.6: A Mandelbrot Fractal Showing Self-Similar Structures Across Scale(Evercat, 2006)

The terms "minimal concept theory" are used as an analogy to a theory in bioengineering called "minimal cell theory." In this theory, scientists are attempting to model a single cell based only on the parts that are absolutely necessary for cell function. A "minimal cell" is a "hypothetical bacterial cell with the minimum number of genes necessary to perform all the essential functions."(Cabrera, April 2006) Dr. Michael Schuler developed the Cornell minimal cell theory. Browning and Schuler write, "A model of a minimal cell would be a valuable tool in identifying the organizing principles that relate the static sequence information of the genome to the dynamic functioning of the living cell."(Browning & Shuler, 2001)(p187)

Figure 7.7 shows a sketch of a minimal cell model.

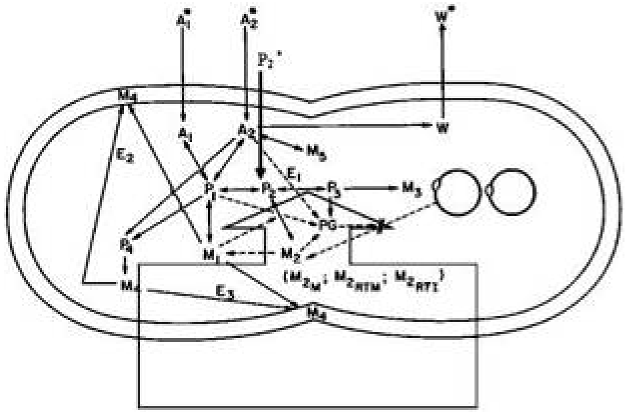

Figure 7.7: A Sketch of Minimal Cell Model (Browning & Shuler, 2001)

Some of the ways that scientists have progressed in their understanding of the components and interactions of a minimal cell is to use a technique called "knock out analysis" in which they remove or "knock out" one component at a time to see if the cell can function without that component. This is not a foolproof technique, of course, because there may be multiple dependencies, but it is a worthwhile technique that produces knowledge on the topic, and scientists are progressing toward a more complete understanding of the minimal cell.

By way of an analogy to the minimal cell theory, a "minimal concept theory" is proposed in which we attempt to identify the structure and dynamics of a single concept that are absolutely necessary. In this way, it would be possible to identify the basic components of a conceptual system and the underlying rule structure of systems thinking.

An overview of the Minimal Concept Theory of Systems Thinking (Table 7.2) is proposed here with full knowledge that a more complete treatment than can be provided here in the conclusion is necessary.

Table 7.2: Toward the Middle Way Ideal: The Minimal Concept Theory of Systems Thinking

Systems thinking is a conceptual framework, derived from patterns in systems science concepts, theories and methods, in which a concept about a phenomenon evolves by recursively applying rules to each construct and thus changes or eliminates existing constructs or creates new ones until an internally consistent conclusion is reached. The

rules are:

- **Distinction making**: differentiating between a concept's identity (what it is) and the other (what it is not), between what is internal and what is external to the boundaries of the concept or system of concepts;
- **Interrelating**: inter-linking one concept to another by identifying reciprocal (i.e., 2 x 2) causes and effects;
- **Organizing Systems**: lumping or splitting concepts into larger wholes or smaller parts; and,
- **Perspective taking**: reorienting a system of concepts by determining the focal point from which observation occurs by attributing to a point in the system a view of the other objects in the system (e.g., a *point of view*).

Figure 7.8 illustrates the rule structure of MCT/ST. Most important, it shows that each component of the Theory (i.e., *Distinction-making (D)*, *Organizing Systems (S)*, *Inter-relating (R)*, and *Perspective-taking (P)*) is self-similar to the other components and to the model itself (i.e., it is a *mise en abime* fractal structure). For example, the *Organizing* portion of the pie includes two elements that relate in four ways (a relationship 2 x 2). One of the elements (part) can be thought of as reductionistic, while the other (whole) can be thought of as holistic (i.e., middle way). The two elements together make up the larger whole of the component, *Organizing Systems*. Similarly, each of the other components is structured the same way (two balanced elements) and shares the same dynamics (i.e., fractal self-similarity). That is, each component is itself a system of interrelated distinctions, one with its own perspective on the larger whole. The elements of each component are parts, while the component itself is a whole. The two elemental parts of each component interrelate in way that is unique to that component. All three, the interrelations, the component and the elements, are distinctions, and these distinctions interact to define each other, and each offers a unique point of view (perspective) on the system as a whole. Because each component is self-similar to the whole Model, no component or element can exist without the other components or elements. This is precisely why the Model reaches an enclosed state and why additional components are not needed (i.e., satisfies knock-out analysis). Occam's Razor states, in Latin, "*Entia non sunt multiplicanda praeter necessitatem*" which in English means, "*No more things should be presumed to exist than are absolutely necessary.*"(Haddon, 2003) The algorithm (the DSRP rule set) that underlies the MCT/ST explains why other components are not necessary to create a concept.

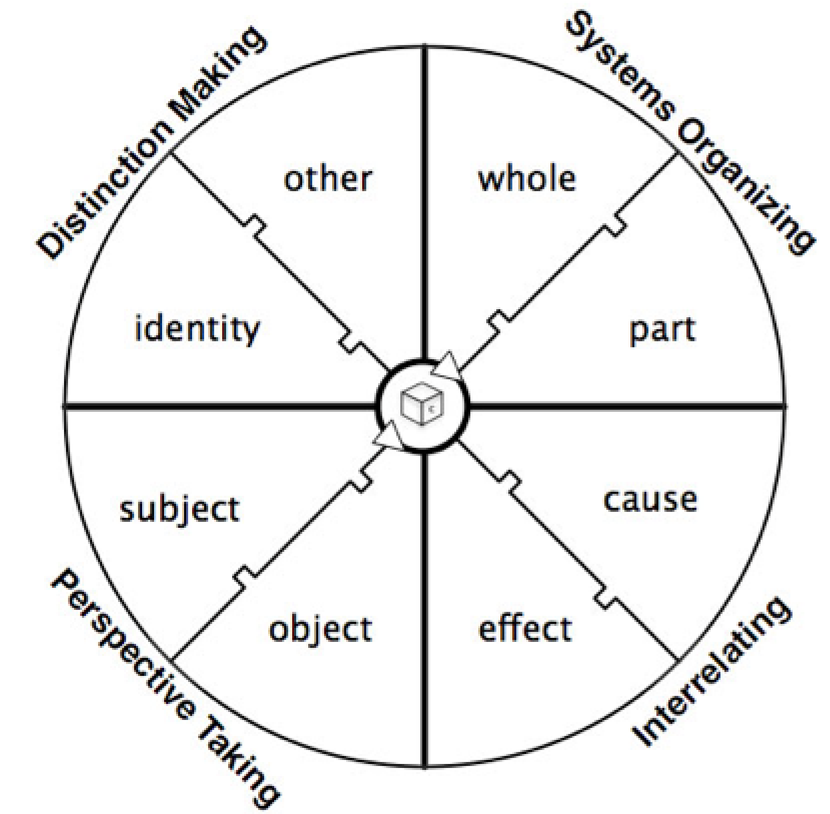

Figure 7.8: A Minimal Concept Theory of Systems Thinking

The dynamics of the Model are simple, yet the result is extremely complex. Table 7.3 illustrates how each component interacts with dynamic complexity. Note that the variables of each component (e.g., identity, other, part, whole, etc) shown in Figure 7.6 also interact in a similar matrix to Table 7.3 (not shown here).

Table 7.3: The Dynamic Complexity of the MCT/ST

	Distinction Making	**Organizing Systems**	**Interrelating**	**Perspective Taking**
Distinction Making	-	A distinction (a whole) is an organization of *identity* parts and *other* parts	A distinction is a relationship between identity and other	Every distinction involves a perspective in order to establish an identity
Organizing Systems	An organization is a distinction between parts and whole and between what is internal and external to the whole	-	Organizing is relating parts to their whole and creating nested relationships with wholes as parts within still larger wholes	Organizations contain numerous perspectives including the whole itself and each of its parts
Interrelating	A relationship is a distinction between the causes of one object and the effects on another.	A relationship (a whole) is an organization of cause parts and effect parts	-	A relationship is made up of a quadratic set of perspectives based on bidirectional cause and effect (feedback)
Perspective Taking	A perspective is a distinction	A perspective (a whole) is an	A perspective is a relationship	-

	between the view of a subject (identity) and the objects viewed (other)	organization of subject view (part) and viewed object (part)	between a subject view and an viewed object

It is widely accepted that all thought is born of *distinction making*. Distinction making is identical to a boundary critique as both processes cause one to demarcate between what is in and what is out of a particular construct. Boundary critique may also allude to how one must be explicit (e.g., critical) of these boundary decisions. Distinction making, on the other hand, is autonomic—one constantly makes distinctions all of the time. Whether one is critically reflective of the boundaries one draws when making distinctions is secondary to the fact that one is always making distinctions. Systems thinking, then, is looking systemically at how these distinctions are made, informed by the counterclaims discussed in Chapter 3; that is, informed by a process that is reductionist and holist, conceptual, cognizant of relational and structural parts, and characteristic of the patterns of thinking that inform knowledge-about-systems. MCT/ST is aligned with each of these counterclaims. Figure 7.8 and Table 7.3 show how the Model works to make distinctions in a way that is both discrete and proximal.

All thinking is distinction making. But distinctions are more complex than one might initially expect. This complexity, however, is based on simple rules that determine how a distinction is made. Because all distinctions are created based on these rules, they can be compared and contrasted, summarized and integrated according to these rules.

Figure 7.9 illustrates some of the complexity involved when a distinction is made. For the purpose of explanation, one can assume a finite and static universe of concepts represented by the linear network of grey nodes. Each node represents a concept. For the purpose of explanation one can assume these concepts cannot be further reduced, although it is obvious that they could be. That is, they are not systems of concepts but are merely singularities or chunks that cannot be broken down any further, and no additional concepts can be added.

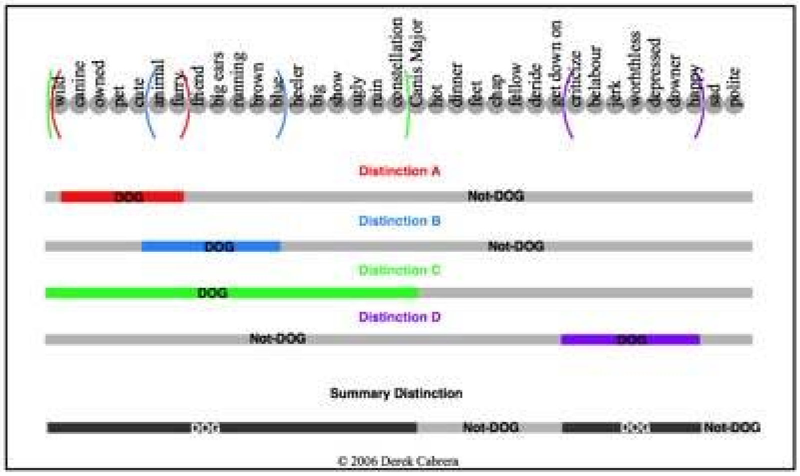

Figure 7.9: Discrete and Proximal Distinction Making

Now, suppose that there are four people, and each of them, upon seeing the finite universe of concepts, makes a single distinction. This would be akin to seeing a large grouping of pixels and seeing a face or a vase or some other distinctive feature. The first person (red ellipse/bar) makes distinction A; the second person (blue ellipse/bar) makes distinction B; the third person (green ellipse/bar) makes distinction C; and the fourth person (purple ellipse/bar) makes distinction D. Each of the participants gives his or her conceptual distinction a name. The only problem is that each person gives his or her distinction the *same* name: DOG. In other words, four people have used the same term to represent very different conceptual systems.

Figure 7.9 illustrates how each of four people uses a finite universe of base concepts to make a distinction. It so happens that the distinction they make is given the same name, but it is clear that the content of each distinction differs dramatically because each distinction includes different concepts (nodes). Each distinction is a system of concepts and relationships organized in a particular way. Thus, the nodes inside the red parentheses are how one person defines DOG, while the nodes inside the blue, green, and purple parentheses are how the other three people define DOG.

The bars beneath (Figure 7.9) illustrate that each person's distinction of DOG is composed of both what the person perceives is included in DOG and what the person perceives is not included in DOG. That is, a distinction is a boundary. A distinction is not, as we often are prone to misunderstand, the object itself but is instead a boundary between the object and what it is not. These two states are called *identity* and *other*. One could alternatively think of these states as thing and not-thing, here and there, this and that, us and them, in and out, internalities and externalities. Although the terms “identity” and “other” are used here, of importance is that what all of these contrasted distinctions have in common is that they are relative. In other words, one could view them from two directions. Consider for a moment that we make the distinction *us* and *them*. It is easy to see that from the perspective of those whom we call “them,” “us” is a group that they would call “them.” Therefore, conceptually, when we take perspective, we are oscillating between a scenario in which we are in one moment *us* and in the next moment *them*. The distinction is relative because we are attributing a state of mind to *them*, and in seeing the world from their perspective, we see a group of people (a group that we actually belong to) called “them.” This is the interaction between distinction-making and perspective-taking. One conceptual activity could not occur without the other; therefore, both are necessary in a thinking model of any kind. The fact that explicit distinction making and perspective taking causes one to be critically reflective about the boundaries one makes and how different boundaries will be perceived differently by different perspectives is, at its core, systems thinking.

It turns out, however, that in order to make just a single distinction, distinction making and perspective taking are not enough. Two other functions are *required*; that is, not a single concept could be made (not even one!) without these functions. In order to make even a single concept, four functions are required. The first two we have discussed (Distinctions and Perspectives). The remaining two are Interrelating and Organizing.

Notice that each distinction is actually a collection of smaller distinctions. This collection of smaller distinctions is *organized* in some way based on containment (parts inside wholes that are, in turn, parts of larger wholes). Even in its most abstract state, a distinction is made of some conceptual object that is identity and another conceptual object that is other. Of course, the distinction is the inter-relationship between this identity and other. This relationship, the perspective, the different parts (including the relationship), and the organization of those parts into a whole (such as DOG or any other concept) is a complex process based on very simple rules.

Each person's distinction then, is made up of both what he or she considers is internal to the construct, DOG, and what he or she considers is external to it. Note that there is some agreement and some disagreement about this. The lowest bar in Figure 7.9 illustrates a simple summary distinction of the four distinctions; a more complex analysis based on a proximal distinction is yielded by MDS analysis on the distinction making of each perspective (see Table 7.4).

Table 7.4: The Summary Table for the Distinction DOG

Content ID	**Content**	**PersonA**	**PersonB**	**PersonC**	**PersonD**
node1	wild	1	0	1	0
node2	canine	1	0	1	0
node3	owned	1	0	1	0
node4	pet	1	0	1	0
node5	cute	1	1	1	0
node6	animal	1	1	1	0
node7	furry	0	1	1	0
node8	friend	0	1	1	0
node9	big ears	0	1	1	0
node10	running	0	1	1	0
node11	brown	0	1	1	0
node12	blue	0	0	1	0
node13	heeler	0	0	1	0
node14	big	0	0	1	0
node15	show	0	0	1	0
node16	ugly	0	0	1	0

node17	ruin	0	0	1	0
node18	constellation	0	0	0	0
node19	Canis Major	0	0	0	0
node20	hot	0	0	0	0
node21	dinner	0	0	0	0
node22	feet	0	0	0	0
node23	chap	0	0	0	0
node24	fellow	0	0	0	0
node25	deride	0	0	0	0
node26	get down on	0	0	0	1
node27	criticize	0	0	0	1
node28	belabour	0	0	0	1
node29	jerk	0	0	0	1
node30	worhthless	0	0	0	1
node31	depressed	0	0	0	1
node32	downer	0	0	0	1
node33	happy	0	0	0	0
node34	sad	0	0	0	0
node35	polite	0	0	0	0

In Table 7.3, a 1 was entered if the person included the node-concept, and a 0 was recorded if the person did not include it. Table 7.3 shows four distinctions. Figure 7.10 shows a graph of the positive (identity) values for the four combined distinctions. Ror example, one can see that node5 (cute) and node6 (animal) are most often included as parts of the DOG construct in our hypothetical world. Figure 7.11 shows the same data input into an MDS analysis to produce a concept map.

Figure 7.10: Graph of Positive (Identity) Values Dog Distinction for Four Perspectives

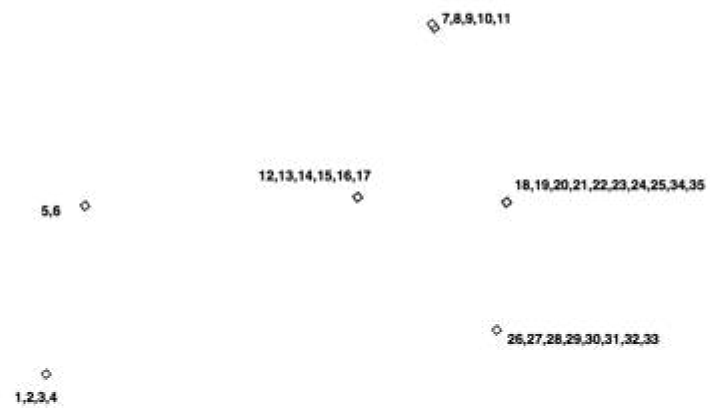

Figure 7.11: Multidimensional Scaling Analysis of "Dog Concept" from Four Perspectives

Note that the individual nodal-concepts are stacked into six piles. This is because the sorting from Table 7.4 is binary (each person has only two sort piles). Each of these piles corresponds to obvious line segments in the graph in Figure 7.10. However, the MDS configuration of these data is very different. First, this MDS map is non-metric. This means that the absolute position of each numbered item is meaningless. What is meaningful is the relative position of each item to the other items. We already know that there are 35 discrete concepts in this map. We also know that these are merely parts in a more complicated distinction process involving four different perspectives (people, in this case). But what is really going on is much more complex, even though it is based on simple rules.

Figure 7.12 illustrates the MDS analysis of the four perspectives on the DOG construct. Overlaid onto the map is the dynamics of the Middleway model. The DOG concept is anchored at points 5 and 6. The NOT-DOG concept is anchored at overlapping points 18, 19, 20, 21, 22, 23, 24, 25, 34, and 35. These are the points that the four persons included in their definitions of DOG and, conversely, NOT-DOG. Note that the perspective-taking rule is the mechanism that causes DOG and NOT-DOG to oscillate between the coupled identity and other states. These states are “coupled” because when one state switches, the other state will switch to its opposite state. The distinction-making rule accounts for these two states only (identity and other), but it is the perspective-taking rule that acts upon these states to entirely transform the distinctions, inter-relationships, and organization of the construct by selecting the identity-state and determining the point of view. So, using binary numbers, DOG and NOT-DOG can be in either “On” or “Off” positions (1,0). Because they are both concepts themselves (one can actually think about the concept NOT-DOG), one can attribute a perspective to either concept. Therefore, if NOT-DOG is “on” (1), then DOG is “off” (0). This means that the collections of things that are part of DOG are actually, for this brief moment, a collection of things that are part of NOT-NOT-DOG. NOT-NOT-DOG (a.k.a., “DOG”) is the “other-state” to the identity of NOT-DOG. This may sound complicated, but it is really no different from the us/them oscillation. A double negative is a positive, so that DOG is the same as NOT-NOT-DOG.

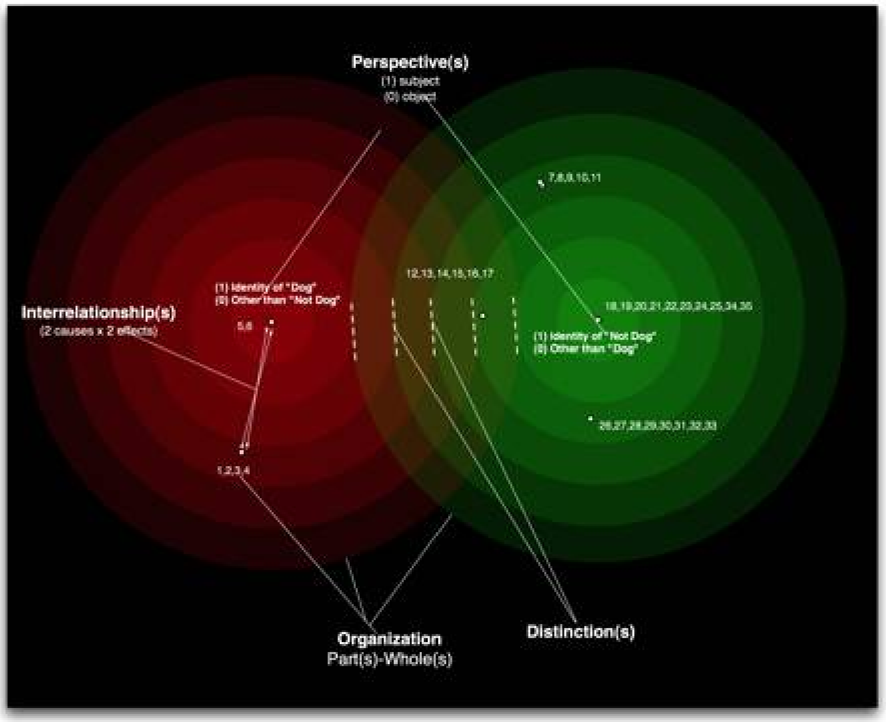

Figure 7.12: MDS Analysis of “Dog Concept” from Four Perspectives Detailing the Dynamics of the MCT/ST

The concentric circles in Figure 7.12 radiate from the two coupled anchor points that are in alternative states, identity and other. The concentric radiation represents distance away from the anchor. In a sense, the farther one moves from the 5,6 anchor points, the farther one moves from DOG (or, alternatively, NOT-NOT-DOG). Playing with boundary critique, when one draws a boundary at the third concentric circle, one makes a distinction (dotted line) at the interface of the two radiating concentric circles. What is most important, however, is that if one could freeze for an instant in that distinction making act, one would see a great number of moving parts come to a halt.

For example, perspective would collapse onto DOG as the identity-state, which would in turn place NOT-DOG into the other-state. At the same instant that the distinction is drawn at the fourth concentric circle, an interface is occurring between a host of relationships between different parts (all of the numbered concepts in the alternative four concentric circles). Each of these relationships alternatively is a distinction (so it can become tremendously complex). All of this, the perspectives, the relationships, the distinctions, is organized into a whole composed of all of these moving parts that have not been frozen in time. The net-result is the concept DOG. The important conclusion is that all distinctions are based on other distinctions. Furthermore, every distinction requires the four functions described above. In turn, each of these four functions (combined with content such as DOG) spins off new distinctions. Thought is infinite, endless, and ongoing. Because systems are essentially entities of some kind, and because the Middleway model is really nothing more than a theory of how entities interact, developing one's ability to think in systems is no more complicated than understanding how entities fundamentally interact. When two entities come together and relate in some way, there are at least two perspectives, which means that the entire organization of reality can be configured in at least two distinct ways. This may sound constructivist or even relativist. It is, in one sense. But, as has been shown, the combination of multiple perspectives—whether they be four thoughts, four people, four groups, or four countries—can be shown to have both proximal and discrete outputs. In another sense, therefore, there is reality beyond the relativity. It has also been shown that the whole (even in something as abstract and complex as a concept) cannot possibly be more than the sum of its parts. It is sometimes difficult to understand or capture all of the parts because there are so many of them, even in relatively simple systems, but there is no need for metaphysical metaphors of emergence.

It is not feasible to provide a complete treatment of the MST/ST herein. Such a treatment would require at least an additional book's length. Thus, this section serves as an appetizer of sorts for future theoretical and empirical work in systems thinking.

Ecosphere: A Model System

The progression above is a "slightly" more abstract description of the MST/ST. However, these are meaningful abstractions that help us to think about real systems. It may assist the reader to consider a more tangible example based on something one can hold in one's hand but which also maintains most of the complexities of real-world systems. In the example, key words that have to do with the proposed systems thinking model are underlined.

All systems thinking is "closed" systems thinking. That is, all thinking involves a boundary of some kind. This boundary is often arbitrary or based on the particular needs of the systems thinker. One good example of a tangible closed system is the ecosphere. Drs. Joe Hanson and Clair Folsome first developed the "ecosphere"—a self-contained miniature biological world—and NASA became interested in these closed self-sustaining systems under their Mission to Discover Planet Earth program. Today, small ecospheres are sold for $100 to $500 for educational purposes or as home dŽcor. Commercial ecospheres, such as those sold by Ecosphere, Inc., include a number of inter-related parts. A glass-blown bulb provides enclosure for the system. Therefore, the system itself is a <u>distinction</u> that has an <u>identity</u> (ecosphere) and interacts with things <u>other</u> than it. Although we call an ecosphere a closed system, it relies on three external phenomena. First, it must receive sunlight (energy). Second, it must be kept at a reasonable temperature for sustaining the life balance within it. Third, it must have a reasonably stable environment (e.g., a stationary table or a shelf). That is, an ecosphere perpetually mounted on the hindquarters of a racehorse will eventually not sustain itself.

Inside the ecosphere the parts include brine shrimp, a branch-like twig, gravel, snail shells, algae, and water. Each of these things is a distinction but also a part in the larger whole. Of course, each of these things is a whole, too, made up of lesser parts that are not all visible to the naked eye. For example, the brine shrimp is made up of a tail, head, eyes, and internal organs. Each of these parts is a distinction and each of these is a whole system, an organization of many inter-related parts. The ecological system we call an ecosphere has ecological analogs in the tiny intestine of the brine shrimp, for example. Each of these systems is built upon inter-relationships between parts of the whole. The system itself, including all of these parts and inter-relationships, is exactly equal to the sum of these parts and relationships. The difficulty is knowing whether one has accounted for them all. We think of most of the relationships as invisible. But this is not necessarily the case. The brine shrimp, for example, can be thought of as a relationship between the algae and shrimp feces in the same way that a combustible engine is a relationship between gasoline and exhaust. The brine shrimp is the relationship between these two parts of the whole ecosphere. The feces inter-relates to the microorganisms and bacteria that break down the shrimp's waste into inorganic nutrients and carbon dioxide that are again used by the algae that in turn provide sustenance for the shrimp. Like each of these individual relationships—complex in and of themselves—the brine shrimp is merely a collection of lesser parts—an organization of inter-relations. These lesser parts are merely organizations of inter-relations. At each level of scale (perspective), one can "zoom in" and see inter-relationships and organization.

There are also many distinctions we don't "see" or that we have decided not to recognize. For example, an important functional part of the ecosphere is the *atmosphere* that exists directly above the water. The water and the atmosphere are made up of gasses and molecules, each of which is a distinct part in a larger, organized and interrelated whole. The gravel, twig, and glass provide important "surface area[s]" that "act as hiding places where microorganisms and algae can attach themselves."("EcoSphere Care", 2006)

The distinctions we make are not absolute. That is, like the DOG distinction, they are each proximal in nature. For example, what the untrained eye might call a "twig" is actually a corral called *gorgonia*. From the perspective of a biologist who studies *gorgonia,* there would likely be many more complex and refined distinctions he or she would consider. Likewise, a physicist's perspective, as Feynman explained, might see the glass globe as a "distillation of the Earth's rocks," and he or she might see the gravel as mineral deposits assisting in the delicate balance of the ecosphere. Each of these is an organized distinction comprising other inter-related distinctions, and each of these organized systems of distinctions is changes dynamically according to where the emphasis is placed by virtue of the perspective. Metaphors, similes, and analogies are also types of perspectives that transform the organization of inter-relationships and distinctions of the whole system. For example, ecospheres are sometimes thought of as "biological batteries" because they store light energy that was converted from biochemical processes.

Not all perspectives are from outside the system looking in. Not all perspectives are from actual people. Remember that each distinction involves a perspective. In addition, each distinction can be attributed a unique perspective. Therefore, we might conceptualize the ecosphere from the point of view of the brine shrimp or the algae. Furthermore, we may not want to anthropomorphize these perspectives when we attribute them. That is, we may want to view the system as the shrimp "views" it, with all the sundry mental and sensory faculties of a brine shrimp; these may include actually seeing or sensing things that we do not, like tiny microorganisms that exist throughout the ecosphere and are critical in its functional balance. Or we may wish to make an anthropomorphic analogy between the shrimp and the human participants who lived in an actual, human-scale ecosphere in Arizona called Biosphere 2, or even those of us who are living, right now, in another ecosphere called Biosphere 1 (a.k.a. the Earth).

There are also numerous other perspectives, all of which transform the organization of inter-relations and distinctions. For example, as in Biosphere 2 (and many hope someday for Biosphere 1), the tiny pink occupants of the ecosphere were "chosen because they do not show aggression toward each other."("EcoSphere Care", 2006)

At each step along the way, we are making choices about what to re-cognize, about what to include and exclude, and from which perspective we view the system. There are various distinctions, inter-relationships, organizations of parts and wholes, and perspectives; some of these are visible to the naked eye and some invisible. But there are many more invisible to the "mind's eye," limited by our knowledge of the shrimp, or the algae, or the glass, or the system itself. On the other hand, we may purposefully limit ourselves, knowing that taking into account the sun's energy (a constant) in order to plan our next management meeting is unnecessary. We draw these boundaries constantly, many more times than we are aware.

Systems thinking is the process of becoming more aware of these processes—processes we are already experiencing all of the time. What we so rarely do, however, is to think critically and reflectively about how we form the distinctions we make or from which perspective these distinctions are made, or which relationships we have ignored because they are invisible either to our naked eye or to our mind's eye.

Pluralism of the MCT/ST

Why, then, is it suggested that the MCT/ST is more pluralistic than other models of systems thinking such as system dynamics? It is because the components of the model are abstract in nature. That is, the model tells us that there are inter-relationships and it tells us how they will always work at a fundamental level, but it does not tell us what types of relationships exist in the particular system of interest. This is appropriate because there are many types of relationships: linear ones, nonlinear ones, simple and complex ones, feedback relationships of various kinds (vicious, virtuous, and balancing, for example), or structural ones such as the shrimp itself as an organization of lesser parts. Similarly, the organizing rule tells us that all wholes have parts and that all parts are themselves wholes, and vice versa. The organizing rule does not tell us what type of organization exists in the particular system of interest. As with inter-relationships, there are numerous types of organization (hierarchical, heterachical, flat, complex, simple, human, biological, mechanistic, etc.), but all of these types work on this fundamental rule structure. The types of relationships, distinctions, organization, and perspective one decides to emphasize (recognize) depends on the particular system of interest and the situation one is attempting to think about. The systems thinking models that exist today are predicated on certain types of systems of interest such as systems that are best described as organic (GST), or those best characterized by feedback and stocks and flows (system dynamics), or by stakeholders (various social systems models).

While the MCT/ST is linked to basic physical systems because it deals with abstract entities of any kind, it is intended to be a conceptual system. That is, it describes how conceptual systems work, rather than "real" systems *per se*. Because the Model is based on the fundamental interactions between and the organization of any set of abstract entities, it can be applied to any physical, biological, or social system. At its core, however, it deals with conceptualization.

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