Systems thinking

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Abstract

Evaluation is one of many fields where ''systems thinking'' is popular and is said to hold great promise. However, there is disagreement about what constitutes systems thinking. Its meaning is ambiguous, and systems scholars have made diverse and divergent attempts to describe it. Alternative origins include: von Bertalanffy, Aristotle, Lao Tsu or multiple aperiodic "waves." Some scholars describe it as synonymous with systems sciences (i.e., nonlinear dynamics, complexity, chaos). Others view it as taxonomy—a laundry list of systems approaches. Within so much noise, it is often difficult for evaluators to find the systems thinking signal. Recent work in systems thinking describes it as an emergent property of four simple conceptual patterns (rules). For an evaluator to become a "systems thinker", he or she need not spend years learning many methods or nonlinear sciences. Instead, with some practice, one can learn to apply these four simple rules to existing evaluation knowledge with transformative results.
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1. Introduction

This paper offers insight into why people in many fields, including evaluation, are drawn to and motivated to implement systems thinking. The reasons for its growing popularity are likely as diverse as those who believe it holds great promise. Yet beneath these reasons may lay a more fundamental explanation for the allure of systems thinking: it offers a model for thinking differently. Despite this allure, there is disagreement about what constitutes systems thinking, and its meaning is ambiguous. This article seeks to address and eliminate some of this ambiguity so that the reader may gain more insight into what systems thinking is and, how to apply its main ideas to a particular field or practical context.

Systems thinking as an idea permeates both popular culture and numerous scientific fields including: planning and evaluation, education, business and management, public health, sociology and psychology, cognitive science, human development, agriculture, sustainability, environmental sciences, ecology and biology, earth sciences, and other physical sciences. Systems thinking can influence many of the existing concepts, theories and knowledge in each of these fields. Yet, systems thinking can also be ambiguous and amorphous. There are numerous conflicting models and claims about systems thinking that need to be reconciled, and while attempts have been made in the past to reconcile the myriad models in the systems "universe", most of these efforts can best be described as methodological pluralism (Gregory, 1996; Jackson, 1991, 2000; Midgley, 2000; White & Taket, 1997). Instead of a pluralistic approach, in this paper we identify four universal conceptual patterns that apply to all human thinking and thus crosscut systems models and systems thinking so that it be applied and its great practical promise can be realized.

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2. Systems thinking in evaluation

The application of systems thinking concepts to evaluation theory and practice explicates two separate, important ideas: *evaluation systems* and *evaluation of systems*. The idea of systems as entities to be evaluated is nothing new in the evaluation field, nor is the idea of designing and implementing an evaluation system. Many concepts found in the systems thinking literature have already been presented in the evaluation literature, for example, paying attention to multiple perspectives of different stakeholders and evaluating a system from multiple levels of scale.

Attempts to wed the two fields have been made since at least the late 1980s. Ulrich (1988) applied critical systems heuristics, a systems methodology, to policy analysis and evaluation. Gregory and Jackson (1992a, 1992b) applied systems methods to four broad classes of evaluation methodologies in an attempt to better gauge when different evaluation techniques should be used. Midgley (1996) surveyed the systems field and applied various systems methodologies to evaluation, and in 1998, Eoyang and Berkas wrote a paper, "Evaluation in a Complex Adaptive System" that was included in a larger volume on organizational complexity (Eoyang & Berkas, 1998). In November 2003, the EVAL-SYS (Systems in Evaluation) listserv was formed, and, as of this writing, has 288 members (The Evaluation Center, 2006). Shortly thereafter, a "Systems in Evaluation" topical interest group (TIG) was established by the American Evaluation Association in February 2004. In addition, many of the sessions sponsored by this TIG at the 2006 AEA conference in Portland were standing-room-only. Finally, the book *Systems concepts in evaluation: An expert anthology* was released in November 2006 and provides an overview of the application of various systems approaches to evaluation (Williams & Imam, 2006).

Movements of thought in systems thinking have also mirrored similar movements in evaluation. For example, "boundary critique", "critical systems thinking", and "critical systems heuristics" (Ulrich, 2005a, 2005b), read like evaluation methodologies and may be very applicable to evaluation contexts. At this, the evaluator should take heart. Systems thinking is not necessarily a matter of drawing an entirely new skill-set out of the intellectual ether; rather, it is a unique perspective that transforms the approach taken to evaluate any program, policy, or initiative.

3. Popularity and promise of systems thinking

Many types of people are drawn to systems thinking, including practitioners in evaluation, public health, education, and business who attempt to implement systems thinking in their organizations, and scholars and researchers who study systems thinking. Each of these people faces different problems and is concerned about different issues,

Table 1
Comparison of web of science search results for "Systems thinking" and "Critical thinking"

Key word searched	Systems thinking	Critical thinking
Number of hits	635	1659
Number with key word in title	270	830
Types of materials	499 articles	1324 articles
	55 book reviews	111 book reviews
	46 editorials	84 editorials
	35 "other"	133 "other"
Date range of materials found	1969–2007	1949–2006
Diversity of authors	44 countries	49 countries
Times cited	2376	5979
Average number of times cited	3.74	3.60

but each is drawn to systems thinking because they perceive the need to change how they, or others think.

Changing the way we think does not automatically solve the various problems, issues, or crises we face. However, it does reframe how we think about what we view as a problem in the first place, and what solutions might look like. Even after a person's, group's or organization's thinking is changed, much hard work remains to solve their problems. Systems thinking alone will not solve these problems. Whether the problems are local (e.g., organizational management, life management, parenting) or global (e.g., global warming, food security, violence, terrorism, public health, and even sleep deprivation), it is the vigorous problem-solving efforts in each of these areas, *informed by a systems thinking perspective*, that will uncover a viable solution to the issue, problem, or crisis at hand.

The reasons for the popularity and promise of systems thinking are extensive. Examples of its popularity show both that systems thinking as a discipline holds great promise and that as such, there is an increasing need for a greater understanding of "systems thinking" as a construct. In December 2006, a search[1] for the term "systems thinking" on the Web of Science (ISI Web of Knowledge) database shows the extent of interest in systems thinking. Table 1 shows the breakdown of the results of this search and contrasts it with an identical search for the term "critical thinking".

In a similar analysis of scholarly publications, Cabrera (2006) found that in contrast to critical thinking, systems thinking is interdisciplinary and may act as a bridge between the physical, natural, and social sciences. Whereas 88% of the papers in which the term critical thinking appeared were in the social sciences, arts, and humanities literature, systems thinking appeared only 48% in the literature from those fields, with the remainder dispersed across the disciplinary spectrum from business, administration, finance, and economics, to engineering, computer science, and mathematics, to physics, astronomy, and planetary science. This interdisciplinary dispersal is

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[1]Sources from 1900 to present, English language sources only.

increased when systems thinking is combined with its near cousin "systems science". Systems thinking may also act as a bridge between the academic, professional and lay communities, providing feedback between "what we know about systems" (e.g., systems sciences) and "the conceptual patterns of how we think systemically" (e.g., systems thinking) (Cabrera, 2006).[2]

In spite of its popularity, there is great ambiguity as to what constitutes systems thinking. For example, systems thinking is often thought of as synonymous with systems sciences, yet there are clear indications that they are not the same in practice. Both public and private organizations seek employees in leadership positions that have some expertise in systems thinking. Examples include frequent job postings for positions as diverse as the US Army War College Professor of Leadership Transformation (Visiting Professor of Leadership Transformation, 2006) to the President and CEO of the $90 million Casey Family Foundation (President and CEO, 2006). It seems clear that these job descriptions are not seeking an individual with expertise in the systems sciences (i.e., nonlinear dynamics, complexity and chaos), but those individuals who possess a particular ability to think in systemic ways. It begs the question: if systems thinking is not the same as systems sciences, then what is it? What are the patterns of thought that are so desired at the Casey Family Foundation and the US Army War College, among others?

As one ventures into the tangled overgrowth of the systems thinking literature, it is helpful to remember that systems thinking has become increasingly popular because people believe it provides a new way to think about, or conceptualize the world around us, whether our issues rest within a local or global context. Interestingly, because the construct of systems thinking is unclear, people who view systems thinking as a kind of solution see its potential even while they do not yet entirely understand what it is. We suggest that this is true for many evaluators and their clients, funding agencies, program planners, field staff, and other stakeholders involved in the evaluation process.

There are many ways to think about systems thinking. Some scholars and evaluation practitioners view it as a specific methodology, such as system dynamics, while others believe it is a "plurality of methods" (Williams & Imam, 2006). Others see systems thinking as systems science, while others see it as a general systems theory. Still others see systems thinking as a social movement. We propose that systems thinking is *conceptual*, because changing the way we think involves changing the way we conceptualize. That is, while systems thinking is informed by systems ideas, systems methods, systems theories, the systems sciences, and the systems movement, it is, in the end, different from each of these.

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[2]The distinction between systems science and systems thinking was first made by Checkland (1981) in his claim that systems thinking is thinking *in terms of* systems rather than being *about* actual systems; this distinction remains controversial in the systems science community today.

4. Thinking about systems

Commonly understood meanings of "system" generally refer to a "complex whole of related parts"—whether it is biological (e.g. an ecosystem), structural (e.g. a railway system), organized ideas (e.g. the democratic system), or any other assemblage of components comprising a whole. As such, when one sees a system, one usually sees the whole first, and then its elemental parts (Fuenmayor, 1991); that is, our view of the system is content specific. In its broadest sense, everything is a system, and what makes something a system is dependent on how each person thinks about the system. Thinking *about* systems is an ad hoc, primarily informal process that each of us does on a daily basis.

In contrast, *systems thinking* is a more formal, abstract, and structured cognitive endeavor. While not all systems are complex, all thinking is complex, and as such, the process of thinking in a systemic way is complex. Systems thinking is also based on contextual patterns of organization rather than specific content. For example, systems thinking balances the focus between the whole and its parts, and takes multiple perspectives into account. Nobel laureate Richard Feynman (2006) provides a famous example of the kind of contextual patterns to which we refer. It makes no difference that Feynman refers to specific content domains (i.e., chemistry, climatology, physics, cognition, etc.). What makes this famous quote an example of systems thinking is the way he transforms contextual patterns: he transgresses parts and wholes, takes new perspectives, forms new relationships, and makes new distinctions:

A poet once said, 'The whole universe is in a glass of wine.' We will probably never know in what sense he said that, for poets do not write to be understood. But it is true that if we look at a glass of wine closely enough we see the entire universe. There are the things of physics: the twisting liquid which evaporates depending on the wind and weather, the reflections in the glass, and our imagination adds the atoms. The glass is a distillation of the earth's rocks, and in its composition we see the secrets of the universe's age, and the evolution of the stars. What strange arrays of chemicals are in the wine? How did they come to be? There are the ferments, the enzymes, the substrates, and the products. There in wine is found the great generalization: all life is fermentation. Nobody can discover the chemistry of wine without discovering the cause of much disease. How vivid is the claret, pressing its existence into the consciousness that watches it! If in our small minds, for some convenience, we divide this glass of wine, this universe, into parts—physics, biology, geology, astronomy, psychology, and so on—remember that nature does not know it! So let us put it all back together, not forgetting ultimately what it is for. Let us give one more final pleasure: drink it and forget it all!

In many ways, viewing an evaluand from a systems thinking perspective would likely reveal the same kind of elements Feynman sees in a glass of wine. For example, imagine an educational outreach curriculum designed to increase school age children's interest in science and ultimately their propensity to choose a career in the sciences. As evaluators, we typically begin our work with an examination of the content the program hopes to deliver to its participants, the outcomes desired, and a measurable way to assess progress towards those outcomes. One could argue that a more systemic approach (like Feynman's approach to wine) to evaluating any program would include: defining what the program is and is not; identifying the components (parts) of the program; and recognition of the relationships among the parts and between each part and the program as a whole. Note that each component of the program affects the delivery of content and achievement of outcomes. Further, many evaluators who advocate approaches that include multiple stakeholders in the evaluation process (e.g., participatory action research) do so because they recognize both the importance of taking multiple perspectives to better inform the evaluation design and to ensure that an evaluautor has a comprehensive understanding of the program relative to all the people who comprise part of the system in which the program lives.

Ultimately, we would argue that much like Feynman's glass of wine, any evaluand can and should be viewed in the same way that transforms contextual patterns: as parts, wholes, and the relationships among them; as well as the relationships between the program and the larger, external forces with which it rests; distinctions must be made to set boundaries on the program's scope and thus, establish criteria as to what can be measured to make assessments; and finally, the ability to take varied perspectives enables evaluators to better understand the richness of both a program's content and the system of which it is a part.

5. A bounded universe

Systems thinking is often considered an unwieldy agglomeration of ideas from numerous intellectual traditions. The precise beginning of the field cannot be pinpointed, as the beginning is a matter of perspective. To many, the roots of systems thinking reach back to ancient Western and Eastern philosophers (and -phies) including Aristotle and Lao Tsu. To many others, the field and study of systems began in the early 20th century with either Alexander Bogdanov or Ludwig von Bertalanffy (Midgley, 2000, 2006). Debora Hammond has done an excellent job of tracing the 20th century history of these theories, and Gerald Midgley has divided them into three broad "waves" of systems thought (which, he and others point out, correspond to movements or waves of evaluation theory) (Bawden, 2006; Hammond, 2003; Imam, LaGoy, & Williams, 2006; Midgley, 2000, 2006).

To put some workable limits on this mass of systems theories, we have chosen to define the systems thinking "universe" as all of the concepts contained in three broad and inclusive sources: the *International Encyclopedia of Systems and Cybernetics* by Charles Francois; *Some Streams of Systemic Thought*, a visual map of systems thinking compiled by Eric Schwarz and modified by the International Institute for General Systems Studies; and a four-volume set of the influential writings by systems thinkers, compiled by Gerald Midgley (Francois, 2004; General Systems Studies, Schwarz, & Durant, 2001; Midgley, 2003).

François' encyclopedia is a two-volume set containing approximately 3800 entries, drawn from approximately 1200 cited works.

Schwarz, visual map contains about 1000 nodes, each representing a different idea, theory, or scholar, connected to the other ideas through a network of colors and connecting lines. Each node contains the name of the idea, and most contain the name of one or two key theorists, for example "Systemic Selfness", by Paul Ryan. The colors represent 12 broad groupings of systems concepts: general systems, cybernetics, physical sciences, mathematics, computers & informatics, biology & medicine, symbolic systems, social systems, ecology, philosophy, systems analysis, and engineering.

In contrast, Midgley's four-volume set contains 76 papers which he selected from a list of over 700 papers suggested by a panel of experts from across the systems movement. The volumes in this set are arranged thematically.

These three sources are not infinite, but they represent three attempts by respected systems theorists and historians to exhaustively describe the systems thinking universe. There is a large degree of overlap between the three, which, by the nature of their different formats, necessarily include or exclude varying degrees of detail.

6. Patterns not taxonomies

By defining the "systems universe" one can then begin to think about what features are essential for membership and therefore arrive at a less ambiguous description of systems thinking. Though Checkland (1981) and Senge (1990), amongst others, have proposed influential systems thinking approaches that are more than taxonomies of methods, many scholars take a pluralistic approach and offer taxonomic lists of examples of systems methodologies. We propose that the question "what is systems thinking?" cannot be answered by a litany of examples of systems thoughts, methods, methodologies, approaches, theories, ideas, etc. Such a response is analogous to answering the biologist's question "what is life?" with a long list of kingdoms, phyla, classes, orders, families, genus and species. Taxonomy of the living does not provide an adequate theory of life. Likewise, taxonomy of systems ideas, even a pluralistic one, does not provide an adequate theory for systems thinking. In our attempt to move away

from a taxonomic approach to defining systems thinking, we define the boundaries of the systems universe using the work of Midgley, François, and Schwarz. In the end, we believe that an adequate description of systems thinking will be a fundamental conceptual pattern, not a pluralistic taxonomy. Recognizing that systems thinking is: (a) patterned and (b) conceptual, is essential to understanding systems thinking, especially in light of the considerable diversity of propositions about it in the literature.

If understanding the fundamental patterns that connect the many instantiations of systems thinking in the systems universe is the central process to describing what systems thinking is, then it is equally informative to give some thought to the patterns that do *not* connect. That is especially true for those claims that are popular in the systems thinking literature, but can clearly be shown not to be essential to every instantiation in the Midgley–François–Schwarz systems universe. We have already mentioned a few of these patterns that do not connect: not all instantiations are methodological, systems science, etc. Cabrera (2006) writes at length about these patterns that do not connect and includes some of the most common violators such as: systems thinking is the same as system dynamics; systems thinking is the same as any proprietary, insular field; systems thinking is holistic; and systems thinking is biological or ecological thinking. The reasons these claims do not apply across the Midgley–François–Schwarz universe are varied and deeper than can be covered herein. Suffice to say however, that understanding why these claims (which are made so often in the systems thinking literature) are *not* adequate descriptions of systems thinking is as revealing as understanding the patterns that connect.

Critical review of the theoretical and conceptual ideas underlying the systems thinking construct highlights several ambiguities that must be better understood and eventually resolved in order to properly implement systems thinking in practice. As practitioners are drawn to the hope and promise of systems thinking, their first objective is to identify it—that is, to understand what makes systems thinking different from other forms of thinking and to assess where the boundaries of the construct lie.

7. Systems thinking is conceptual

Concept theorists in the cognitive sciences and philosophy have proposed several theories about the nature of concepts including: classical, prototype, theory–theory, neo-classical, and conceptual atomism (Laurence & Margolis, 1999). Each of these competing theories is weakened in some way or another by problems[3] such as: compositionality, reference determination, categorization and stability.

This article draws on an alternative concept theory comprised of four component rules or patterns: Distinctions, Systems, Relationships, and Perspectives (DSRP) (Cabrera, 2006). DSRP provides the mechanism for a view of concepts as dynamic, patterned, evolving, adaptive, and complex. From this complex view, even a single concept can be thought of as a robust, complex system. Complex adaptive systems (CAS) are systems in which the individual behavior of agents following simple local rules, leads to complex and emergent properties. Nobel laureate Murray Gell–Mann (1995/1996) describes the relationship between simple rules and complexity:

> 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 πλεκτος (*plektos*), yielding the mathematical term "symplectic," which also has the literal meaning *braided together*, but comes to English from Greek rather than Latin.

Complex adaptive conceptual systems (CACS) is a term invented by the authors to describe a new approach to concepts. CACS explore the pattern of relations between concepts and their environment.

The system of any individual concept, or that concept's "ecology", is made up of content and context, where content is defined as the set of symbolic or informational variables in a conceptual space. Alfred Korzybski (1933), who developed the theory of general semantics, explained that the "map is not the territory". A concept is not merely its content (i.e., symbol-labels such as "dog" or "terrorist" or the image-symbol "~"), but is a function of the context it is in. Any given concept is a function of its inter-relationships and organization with other concepts in the conceptual space.

Context is a set of processing rules for content; the resulting pattern of interaction yields concepts. This is evident in the underlying contextual patterns in Richard Feynman's thinking above; the contextual patterns, not the specific content, are what we recognize as being uniquely systemic. This treatment is similar to Guilford's original framework for divergent thinking, a key concept in creativity research. Baer and Kaufman (2006) explain that Guilford's divergent thinking was an "attempt to organize all of human cognition along three dimensions". Guilford's

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[3]Laurence and Margolis (1999) provide a thorough review in their edited volume covering such theories and problems in greater depth.

three dimensions include thought processes, content, and the products of the interactions between process and content. A whole mess of these conceptual patterns is referred to as a "CACS"—a pattern of content (symbolic variables) and context (processing rules). As a formal set of processing rules, DSRP offers a mechanism for the pattern of interactions among content and context that result in concepts. It is important to note that while not all systems are complex, systems thinking, because it is based in thinking, is both complex and conceptual.

8. Four fundamental patterns that connect the systems universe

What follows is a concise explanation of the four rules of conceptualization: Distinction, System, Relationship, and Perspective. Each of the four rules contains an interaction between two elements as shown in Table 2. It is shown that the existence and nature of concepts necessitates these dynamical rules, and that these rules are also sufficient to describe conceptual dynamics. It should be noted that theoretical, empirical, and practical examples exist for each of the individual patterns of D, S, R, and P and that this work is often transdisciplinary (occurring across different fields). The reader may refer to the inventory of such works relating to each pattern in Appendix A as references, but future work should include evaluative and integrative reviews of this literature.

In cognitive systems such as the human mind, ideas are constantly evolving. Concepts are not static; they simultaneously adapt in response to other concepts, link together with them, conflict with them, or coexist. How might this occur? As is often the case, the essence of the objects in question (concepts) determines the rules by which they behave. Consider a simple conceptual system consisting of a concept A. Concepts exist only in context with other concepts. For instance, my concept of DOG exists in the context of ANIMAL and FURRY and THING, etc. In general, any concept A has identity only in contrast to some other concept from which it can be distinguished (for instance, there must at least be a concept of "not A" or "other than A").

Table 2
DSRP rule-set

Concepts (content + context)	
Content (∀ *informational or symbolic variables*)	Context (*processing rules/patterns*)
	(D)(S)(R)(P) ⇒ {DSRP}
	Distinction (D) ⇔ {*identity (i)* ⇔ *other (o)*}
	System (S) ⇔ {*part (p)* ⇔ *whole (w)*}
	Relationship (R) ⇔ {*cause (c)* ⇔ *effect (e)*}
	Perspective (P) ⇔ {*subject (s)* ⇔ *object (ŏ)*}

This interplay of "A" and "not A" is the essence of distinction making: in order to make a **distinction**, one must establish an identity and exclude the other. Previous work in the systems literature reinforces the importance of drawing distinctions. For example, Von Foerster (1984) offered the idea that a concept has meaning only in its relationships with other concepts, and Bateson (1970) emphasized the significance of "difference", which is directly related to "distinction". In addition, Fuenmayor (1991) recognized the importance of distinction in its relationship with an opposing concept. Finally, Midgley (2000) and Mingers (2006) refer to Spencer Brown's (1969) work, indicating that distinction is more than the concept of a number in mathematics.

All distinction making involves a boundary that differentiates between what/who is in and what is outside the set boundary, between internalities and externalities. As an example of the universality of distinction making, consider one of the most common distinctions we make: the act of giving something a name. When we describe something by name, we are creating a boundary between that named thing and everything that it is not, thereby highlighting or valuing certain patterns over others. So, the existence of concept A necessitates the existence of some other concept, which will be called B.

Consequently, A also necessitates the distinction between A and B. The interrelation of concepts may also be thought of in terms of a general notion of affect and effect, where "affect" refers to the action taken by an agent and "effect" refers to the result of that action on or to another entity. For instance, in the case of distinctions, A affects B to be distinct from A, and B affects A to be distinct from B, etc. Thus, a distinction is comprised of the two concepts in question and four relations or two interrelations: the affect of A's identity, the effect of A's identity on B (i.e., if A is an "identity", B is an "other"), the affect of B's identity and the effect of B's identity on A. This does not imply that A affects B in the sense that A "causes" B to exist or vice versa, but that A affects an A-like-effect on B and vice versa. Think of this interaction as the effect your boss might have on you in a meeting. Your boss (or wife, siblings, colleagues) does not *cause* your identity, but can shape it in a particular context. Just as our identity and behavior is often a function of the people and context in which we are situated,[4] the same is true for concepts.

If there is a distinction between A and B, there must be some concept of **relationship** between them, namely at least that relation of being distinct from one another. The relation of being distinct is dependent on the more general relationship rule. That is, relations are comprised of two relations and four interrelations: the affect of relation from A to B and from B to A and the effect of relation on B from A and on A from B. Making relationships between otherwise different concepts increases connectivity and

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[4](Davis-Blake & Pfeffer, 1989; Granovetter, 1985; Ridgeway & Correll, 2004; Smith-Lovin & McPherson, 1992; Tsui & Oreilly, 1989).

expands the within-group distinction; realizing the degree to which we are interconnected makes the lines between in/out group increasingly fuzzy and eventually redrawn. Relationship-making forces our conceptual systems to expand and become more interconnected and fuzzier, but over time as these relationships mutually reinforce each other, concepts can also crystallize or become more concrete.

Any collection of related concepts can naturally be viewed as a **system**, since the simplest definition of a system is a whole made up of two or more related parts. So A necessitates a system which can be expressed as the collection of concepts and the two, two-way relations between them: the affect of system membership from A, the effect of system membership on B, the affect of membership from B and the effect of membership on A. Note also that in addition to parts A and B, the relationships between them are also considered "parts" of the system. Here, membership can be entire or partial, in the sense that A may be contained in B, B may be contained in A, A and B may be effectively disjoint, or sub-concepts of A may be contained in B and vice versa (partial membership). To visualize this, think of a traditional Venn diagram of overlapping circles. If one circle represented A and the other B, the places where they crossed would be where A is contained in B, or vice versa. Of course, at any given time, concept A fully contains A, but the constitution of A will almost certainly change over time given that systems are constantly in flux. We may take a "snapshot" of a system at an instant, but a moment later the system will likely be different.

Furthermore, any concept naturally carries with it a **perspective** or frame of reference, for instance A from the perspective of B, or vice versa. This conceptual perspective taking is akin to viewing one concept from the point of view of another, and therefore necessitates a subjective viewer (subject) and an objective view (object)—a subject–object relationship. Each concept has a unique identity, but can also take a point of view on its environment. This point of view is attributional and it always has a human "root" perspective. That is, any one concept (subject) cannot literally "see" another's point of view, but instead interprets and attributes a particular perspective to the other (object). Therefore, reorienting a system of concepts by deciding the focal point from which attribution occurs is a central function of all conceptual systems. By attributing a conceptual state to a conceptual point in the system, a view of the other objects in the system can be established (e.g., a point of view).

This "perspective taking" or "conceptual attribution" can have a catalytic effect on the conceptual system as a whole, causing a cascade of interconnections and reorientations. Perspective has the potential to instantly transform whole systems, rearrange distinctions, and cause relationships to appear or disappear. Perspective can similarly be characterized by the relevant concepts and the four causal interrelations: the affect of subject or observer from A, the effect of object or observed on B, etc. This can be most easily demonstrated by bringing a third concept C into the mix; the BC system can be viewed from A's perspective as A(BC), or alternatively AC can be viewed from B as B(AC), etc.

This conceptual perspective taking—attributing a perspective to a concept rather than an individual—is an essential aspect of human thought processes, creativity, innovation and problem solving. It is the conceptual equivalent to attribution of mind theories in cognitive psychology. Also, perspectives may be regarded as distinctions between the viewer and the viewed, or as systems of viewpoint (frames of reference). One might take the perspective of an individual or of a group of individuals or of a single concept. Of course, when one takes another's perspective, one is not actually *seeing* the other's perspective but instead is making a conceptual attribution of one's concept of the other (Gregory, 1992; Midgley, 2000).

The nature of any concept necessitates the existence of **distinctions**, **relationships**, **systems** and **perspective** taking. Each of these four rules is a special kind of relation between two elements: identity–other for distinctions, affect–effect for relationships, part–whole for systems, and subject–object for perspectives.

Furthermore, each of these rules and elements is itself a concept, to which the DSRP rules apply. For instance, a relation R may be viewed as a concept, which is distinguished from another concept (such as A and B, or some other relation R'). A relation may also be viewed as a system or part of many systems, or one can view a conceptual system from the perspective of R. The same analysis can be applied to a system: a system can be thought of as, for instance, a relation between other systems (for instance the system of "science education" might be regarded as a relation between the systems of "curricula" and "educational outreach").

9. An example of DSRP in practice

A practical description may offer insight into the utility of DSRP generally, and specifically to the field of evaluation. The Santa Fe Institute's Complex Systems Summer School (CSSS) provides a framework for scientists to learn from each other, benefit from methods and techniques pioneered in diverse fields of study of complexity at SFI, and exposes the next generation of scientists to interdisciplinary approaches that might enhance their future success as scientists. When this program sought out evaluation consultation, the authors applied DSRP elements to what would be typically thought of as traditional evaluation practice. *It is important to note that an evaluation approach that incorporates our proposed notion of "systems thinking" (informed by DSRP) does not require a new set of evaluation tools for an evaluator, but rather a shift in their thinking to re-frame components essential to any evaluation.*

The ideas of DSRP are all very useful to any evaluation. Many evaluators begin the dialogue with a client by setting boundaries on the program, policy, or initiative they are working with by determining what the program is and is not. In other words, in order to evaluate any program, we must know what it actually consists of. This often includes not only the "who, what, where, and when" of a program, but more importantly, the larger context in which an evaluand is situated (otherwise known as "the bigger picture"). While this may sound obvious to most of us, it is clear that setting boundaries on the program itself is a much-needed step to designing an effective evaluation. It is also often that case that the staff or managers of a given program lack a full understanding of their program, and at times, either overstate or underestimate its scope. This common problem can be resolved by a dialogue guided by the need to draw distinctions, and thus, determine what a program is and is not.

After the program is defined, it is important to look at the program in a larger context—or more specifically—the system of which it is a part. In our work with SFI, it was evident that the CSSS program was both a self-contained program and a part of a larger whole—the Santa Fe Institute. The system itself is also a distinction that has an identity and interacts with things other than it. The CSSS program relies on external phenomena to function (as does SFI). First, the program must have institutional support from the Santa Fe Institute. Second, it relies on faculty involvement to teach for the program. Third, it must have a reasonably predictable audience of students to remain stable and thus, be delivered annually. So, while an evaluator may typically zero in on the specific program of interest, a more systemic approach to evaluation explores the impact of system membership on the program's specific content, organizational contribution, and impact on its target population.

Another common component of evaluation is the distillation of program activities and outcomes and the relationship between them. Some evaluators utilize tools such as logic models, or "causal pathway models" to do this. These models are useful when focusing on program content only, but programs do not exist in vacuums. As a result, we believe that an evaluation is strengthened by not only examining the relationships between activities and outcomes, but the relationships (affect and effect) between and among all of the components of the program and its larger context or system.

It is important to recognize that drawing distinctions involves a perspective, and each distinction can also be attributed a unique perspective. Not all perspectives are from an observer outside of a system looking in. In fact, many perspectives involve sentient beings taking attributional perspectives of non-sentient concepts. So, one might conceptualize the CSSS program from the point of view of the Santa Fe Institute, the topic of inter-disciplinarity, the scientific community, ideas of complexity science, or students in the program. It is not always necessary to anthropomorphize these perspectives. That is, one can view the system from multiple perspectives to see or sense things that a human cannot. At each step along the way, we make choices about what to recognize, about what to include and exclude and from which perspective to view a given system. There are various distinctions, inter-relationships, organizations of parts and wholes, and perspectives, and some of these are visible to the naked eye and some invisible. But there are many more that are invisible to the "mind's eye", limited by one's knowledge of the topic, program, or area of study itself. Or, humans may purposefully limit themselves to avoid intellectual gridlock and as a matter of pure functionality. It is not practical nor is it feasible to take *every* thing into account. This is true for most endeavors and certainly holds true for evaluators who are familiar with the many tradeoffs made (to either fit an evaluation budget, or satisfy a funder, etc.) in the course of an evaluation. These boundaries are drawn constantly out of necessity, and are done so many more times than are conscious to us.

10. Conclusion

All of the rules of DSRP are interdependent and simultaneously implemented by each concept. At a micro-level it is important to note that an instantiation of: D requires instantiations of SRP; S requires instantiations of DRP; R requires instantiations of DSP; and P requires instantiations of DSR. So, it can be said that each rule is dependent upon the other rules, that: D is dependent on SRP; S is dependent on DRP; R is dependent on DRP; and P is dependent on DSR. These micro-interactions occur on every concept at every step in time. At a macro-scale, DSRP operates on complexes of content (A, B, AB, etc.). Concepts (content and context) exist in a space of concepts and interact with each other. Each concept is comprised of a system of sub-concepts, all of which are implementing DSRP rules. Concepts interact with each other via the DSRP rules, i.e. forming distinctions, relations, etc., as their sub-concepts interact. The sub-concepts also have sub-concepts, which overlap with other sub-concepts, all of which are simultaneously implementing DSRP. At each step and at each point in the concept ecology, DSRP operates simultaneously. The number of such associations (sub-concepts and DSRP implementations) is so large that it can be taken to be effectively infinite, yielding an essentially scale-free DSRP network (meaning that DSRP is a sort of fractal algorithm).

It is important to note that the DSRP rules are used to elucidate patterns that underlie all thoughts; in essence, to identify deeper levels of understanding by recognizing patterns in what one already knows or by "blindly" (algorithmically) creating new knowledge by simple alterations of contextual pattern. We suggest that because systems thinking is a pattern of thought, it can apply to any existing body of knowledge. This may appear to be an ambitious claim; however, we contend that systems

Internal To SFI

SFI:
Complex
Systems
Summer
School

Increased
Knowledge of
Complexity

Transformative
Interdisciplinary
Experience

External To SFI

Better
prepared
future scientists

American
Competitiveness
Initiative

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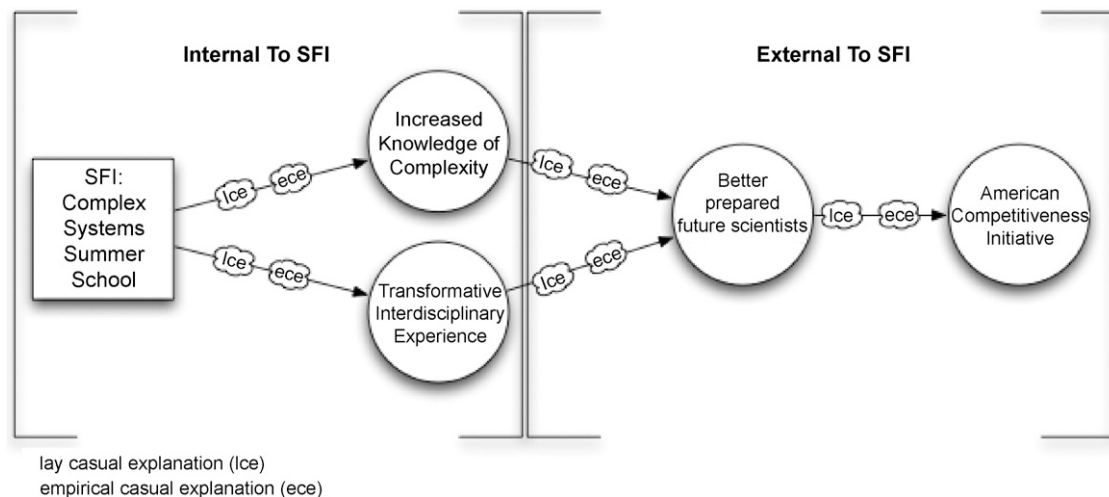lay casual explanation (lce)
empirical casual explanation (ece)

Fig. 1.

thinking is simply a way of reframing one's thinking in a domain, accomplished by a reconstruction of systems thinking based on the elements of DSRP, allowing for a universal approach to manipulation of concepts relevant to all thinking in both professional practice and intellectual disciplines. Note also that many systems methodologies and methods have been developed over the years, and they can be drawn upon in support of DSRP (Midgley, 2003).

Systems thinking is not the same as a pluralistic taxonomy of systems thoughts. It is the underlying conceptual pattern that connects all instantiations of systems thoughts.

Systems thinking is not content specific and is therefore not disciplinary in scope. It is a pattern of thinking that formally alters context and therefore transforms the meaning of any kind of content (i.e., subject matter).

Systems thinking is not the same as systems science(s). Each of us already thinks about systems. To become a systems thinker, one need not spend many years learning new methods or scientific content knowledge such as complexity, chaos, or nonlinear dynamics. Instead, we propose that systems thinking can be readily learned and can be formally, explicitly, even algorithmically applied.

Not all systems are complex, but all systems *thinking* is complex because thinking is, by definition, a complex system. It follows then that the "emergent property" that we perceive as systems thinking is based on remarkably simple rules (i.e., DSRP). Therefore, systems thinking is not something one *does*, but something one *gets* as a result of applying simple rules based on patterns of thinking.

To become a systems thinker, one need only to understand and apply these four conceptual patterns: draw distinctions between an identity and a non-identity; recognize the bi-directional properties (affect and effect) of relationships; organize parts and wholes into alternative nested systems; and take new perspectives by transforming one's point-and-view. Although we are always making distinctions, interrelating, organizing systems, and taking

perspectives, this does not mean that explicit and formal practice in these thinking skills is not important. Indeed, it is precisely because we are using these schema implicitly that we must recognize their usage explicitly. For example, we will draw a distinction between what something is and is not (i.e., terrorism), but if we are unaware that these boundaries are dynamic and related to the systems and perspectives we recognize as important, then we will be unaware of our own biases. To make these patterns explicit is to know how one thinks and therefore how one might alter this thinking to avoid bias, to be more compassionate, more creative, or to better understand the structure of one's own thoughts. This all bodes well for practitioners in evaluation who want to apply systems thinking to their daily work because systems thinking is easily learned, applicable to the existing knowledge base of evaluation and will lead to transformative results for any endeavor (Fig. 1).

Acknowledgements

Appendix A. Additional references for DSRP rules

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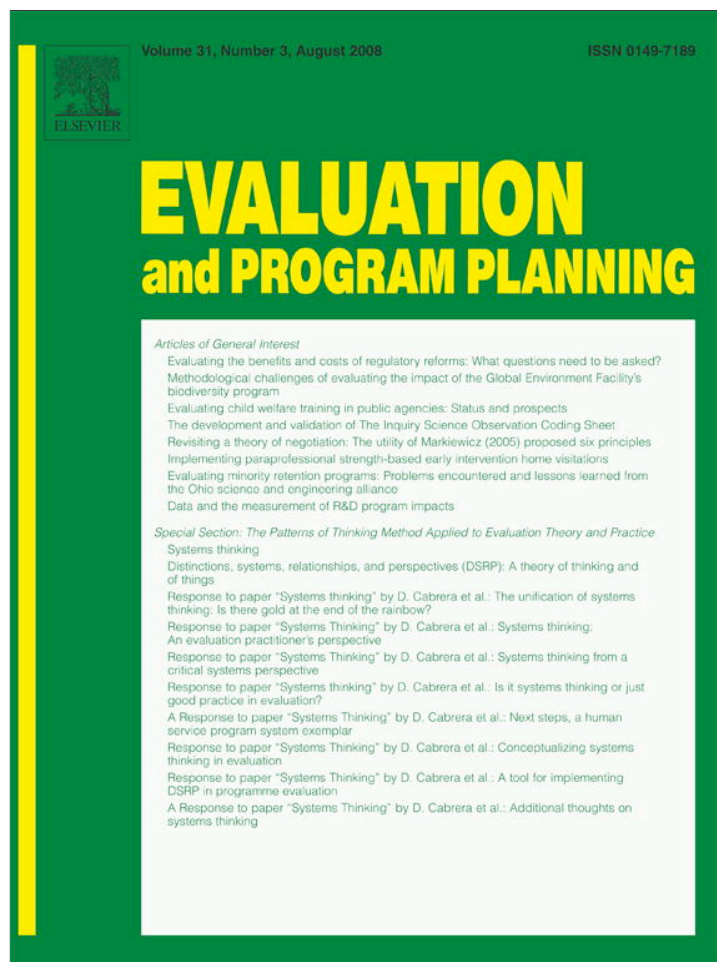Senge, P. (1990). *The fifth discipline: The art and practice of the learning organization*. London: Random House.

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Discussion

Distinctions, systems, relationships, and perspectives (DSRP): A theory of thinking and of things

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1. Introduction

In the interest of public scientific discourse and the inclusive spirit of systems thinking, 25 experts in both systems thinking and evaluation were invited to respond to our article, Systems Thinking, which offered a thinking framework—distinctions, systems, relationships, and perspectives (DSRP). We were delighted there was broad interest; we received 22 responses. The following nine responses were selected from a pool of excellent papers; we only wish space allowed for the inclusion of all of the responses. We had several criteria for selection of the responses. The first criterion was that the response be focused on the topic of the original publication. Both negative and positive responses were selected. In fact, the most critical of the responses are among those selected. In some cases, respondents were asked to make minor edits. In addition, we attempted to be balanced in our selection between those papers focused more heavily on evaluation versus those focused on a discussion of systems. As our original paper focused on both systems and evaluation, we felt that this balance of views would offer a more useful collection to the evaluator interested in systems.

Academia is not a place for the intellectually timid, so when we agreed with the editor to invite responses, we naturally expected some harsh criticisms. We are pleased by the overwhelming support for the DSRP model; most of the responses were positive. Of course there were criticisms. Yet, most of them were the result of our inability to elaborate our position in the original paper due to space considerations. Thus, this additional opportunity to respond allows us the additional space to dispel some misunderstandings of the original article.

This response focuses on the most salient issues requiring clarification and acknowledges and appreciates the positive things many respondents had to say. We hope to clarify two misunderstandings and elaborate on two areas that will answer some of the concerns relayed by respondents:

1. the false dichotomy between methodological pluralism (MP) and universality;
2. the misunderstanding that the DSRP model is a set of four elements rather than a formalism for thinking with complex structure and predictive internal dynamics;

3. the practical tools, techniques, and methodology that compliments DSRP; and
4. the broader implications of DSRP as: (1) a general model of thinking, (2) as the missing code necessary for evolutionary epistemology, and (3) as a general theory of things.

1.1. Our positions on universality and MP

Midgley critiques what he misunderstood to be our position *for* universalism and *against* MP. To clarify, we do not claim this false dichotomy. Quoting our original paper can sum up our position:

> We propose that the question "what is systems thinking?" cannot be answered by a litany of examples of systems thoughts, methods, methodologies, approaches, theories, ideas, etc. Such a response is analogous to answering the biologist's question "what is life?" with a long list of kingdoms, phyla, classes, orders, families, genus and species. Taxonomy of the living does not provide an adequate theory of life. Likewise, taxonomy of systems ideas, even a pluralistic one, does not provide an adequate theory for systems thinking.

When we say that MP is not adequate as a *formalism* for systems thinking, we also suggest that MP has serious pedagogical problems for practitioners who are attempting to learn and understand systems thinking. MP is both necessary and useful. MP provides examples and instantiations of systems thinking but it does not provide a formal construct. From a pedagogical perspective, Midgley should consider this: would a newcomer to systems thinking be better served by reading 87 different academic papers (such as found in his four volume set) or by learning about four patterns of thinking by using tactile manipulatives? Even if they were able to make it through Midgley's four volumes, a newcomer would be hard pressed to summarize them all and emerge with a deep understanding. In addition, MP has another pedagogical problem that is best described by the adage, "Give a man a fish and he eats for a day, teach a man to fish and he eats for a life time". As we said, MP is useful for giving situated examples or instantiations of systems thinking, but those instantiations are so contextualized that they are limiting in their application (especially in light of human's difficulty with knowledge transfer). A universal formalism like DSRP gives the learner an ability to make their own instantiations

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based on simple rules; thus, paradoxically, leading to a much larger plurality of solutions.

As systems theorists, our concern with MP is that, although it is rich with examples and instantiations of systems thinking, it is a wrong paradigm for developing a formalism for systems thinking. As educators, our concern with MP is that it is pedagogically difficult, especially where many newcomers are trying to get a grasp of the field. We believe that the field should continue to welcome various methodological perspectives and at the same time, universality should be sought after and developed. It should be noted, to appeal to the pluralists in all of us, that to seek a universal model does not mean that one must cast out or "shoehorn" certain perspectives from being considered. Only a bad attempt at universality "shoehorns" or casts out things that do not fit. Einstein, who gave us both universality and relativity in one elegant theory, is proof of this.

Midgley offers an insightful review of previous attempts and failures to unify systems thinking. He also suggests that MP is factual, common wisdom, and widely accepted in the field. Yet, we were not persuaded by his historical arguments and appeals to the norm. This is because we could wax poetic and write long about the many fields in which the accepted truth and common wisdom was turned on its head by bold universalists who saw patterns no one else could see.

Nobel Laureate, Murray Gell-Mann (2008) explains that a theory that is beautiful or elegant is "more likely to be right than a theory that is inelegant". He explains that beautiful and elegant theories are based on simplicity, universality, symmetry, and self-similarity across scales. In fact, many theories (like his own and Einstein's) that disagree with experimental data turn out to be right in the end. The reasons why right theories have these properties are too complex to go into here. Nevertheless, DSRP is such a theory. It is simple and elegant, symmetrical, universal, and self-similar across scales. Gell-Mann explains that it is these features that make beauty "a successful criterion for selecting the right theory".

1.2. On the structure and dynamics of the DSRP model

The most common misconception of DSRP is that it is a set of four elements. This can be written in symbolic terms as follows, where the theory, T, is the set of patterns that contains the elements D, S, R, and P:

$$T \in \{D, S, R, P\}$$

In contrast to this set theoretic and reductionistic understanding of DSRP there is a more accurate formulation. More than four principles, DSRP is a simple and elegant, symmetrical, self-similar, universal model with complex interactions capable of vast complexity. Even though the four patterns are simple, the result of their interactions can be wildly complex. In the same way that you can mix and match just four base colors (Cyan, Magenta, Yellow, Black), to create an infinite number of colors; or in the same way that all biodiversity is the result of interactions of just four molecules of DNA (cytosine, guanine, adenine, and thymine); DSRP is a powerful set of four basic patterns that underlie all of human thought. In each of these cases, it is the elements *plus the interactions* that makes the model work.

The DSRP patterns are each a base pair of two elements. These elements interact and imply each other in complex ways. In the notation below, the $\Rightarrow$ means "implies" and the $\Leftrightarrow$ means "co-implies". Therefore, the notation, A $\Rightarrow$ B, simply means that if A exists, then B also exists, in the same way we might say, "if there is night then there is also day". The co-implication arrow, $\Leftrightarrow$, simply means that the implication goes both ways. Thus, it is shown in (1) that the four patterns are made up of different base pairs and that the existence of each co-implies the others:

$$\text{Distinction (D)} \Leftrightarrow \{\text{identity (i)} \Leftrightarrow \text{other (o)}\}$$
$$\text{Relationship (S)} \Leftrightarrow \{\text{part (p)} \Leftrightarrow \text{whole (w)}\}$$
$$\text{System (R)} \Leftrightarrow \{\text{affect(a)} \Leftrightarrow \text{effect(e)}\}$$
$$\text{Perspective (P)} \Leftrightarrow \{\text{subject (s)} \Leftrightarrow \text{object (ö)}\} \tag{1}$$

In (2), it is shown that any single instantiation of D, S, R, or P implies a full instantiation of DSRP. Likewise, any single instantiation of the base-pair elements (i, o, p, w, a, e, s, ö) implies a full instantiation of DSRP.

$$(D) (S) (R) (P) \Rightarrow \{ DSRP\}$$
$$(i)(o)(p)(w)(a)(e)(s)(ö) \Rightarrow \{ DSRP\} \tag{2}$$

The dynamic interactions of DSRP are shown in (1) and (2) above. It is these interactions, not the elements themselves, that make DSRP a powerful thinking tool capable of framing the complexities of human thought. The interactions of DSRP are universal, symmetrical, and self-similar across scales. This means that every idea is engendering DSRP patterns simultaneously. To miss these interactions, internal structure, and prescriptive internal dynamics is to misunderstand DSRP. DSRP is not a set of four words or even four elements. It constitutes a specific theoretical structure of interactions based not only on the four patterns (D, S, R, and P) but also on the sub-elements and the fractal self similarity across scales. This gross misconception of DSRP lies at the core of critiques that do one or more of the following:

1. Debate the semantics of DSRP (i.e. "I wouldn't use the term 'system' here…").
2. Deal with D, S, R or P in isolation. (i.e. "I think that each D, S, R, P element correspond to this or that approach").
3. Be reductionist about DSRP, assuming the sum of parts equals the whole and ignoring its structure and dynamics (i.e. "DSRP is like what we've been doing or the same ideas as XYZ").

Regarding #1 above, it makes no difference what terms we use. DSRP could just as easily be called PQRS. It is not the terms that makes the theory robust but the self-similarity across scales and the interactions between the four patterns and eight elements.

Regarding #2 and #3 above, when people make distinctions, form relationships, organize part–whole structures, or take multiple stakeholder perspectives, it does not mean they are already "doing DSRP". In order to be "doing DSRP" they also need to, for example, take a relationship and see it as an explicit critical distinction, consider the relationship as a system and ascertain its parts, and even take conceptual (i.e. non-human) perspectives of the larger system from the point-of-view of the relationship itself. And, they might continue to do this, vice versa, for each of the individual D, S, R, or P in the system.

For example, when we look at any one of the most basic relationships in evaluation practice, such as that between the funder and program, we see that this relationship is a whole system in itself comprised of financial and relational, political, and intellectual parts.[1] We can view the larger evaluation from the point-of-view of any one of these individual relational parts (i.e. money) and we can even deconstruct the parts into parts (i.e. soft or hard money). We can further deconstruct and critique the boundaries of these lesser distinctions while adapting the greater distinctions of which they are a part.

Because DSRP is a universal model of patterns of thinking, there will be similarities between DSRP and other models. At the same time, these similarities may be skin deep. DSRP is not

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[1] Note that any of the constructs in Wasserman's excellent table are subject to the same type of DSRP deconstruction.

merely a set of four universal elements—it is a set of patterns of interaction. This is precisely why we call DSRP the "Patterns of Thinking" method because unlike an element, a pattern connotes interactions rather than objects. Understanding DSRP without understanding its internal structure and dynamics does not understand it at all.

It is human nature to want to take something we do not understand and situate as something we already do. To err is also human. It is reasonable to suggest that distinction making is similar to much that has been written about boundary critique or that perspective taking is just like the ideas that have been proposed for eons about taking perspectives of multiple stakeholders. Yet, while these claims are accurate at a coarse grain level, they are misconceptions at a finer grain level. Distinction making ala DSRP is *like* boundary critique but it is a disservice to one's understanding to take this likeness too far. To isolate one element, from the others (D from SRP for example), is to totally misunderstand the DSRP theory. DSRP prescribes that in order to understand the way we make distinctions (i.e. the way we critique boundaries) we must understand: how we decide which parts to include and how to organize these parts; which relationships to recognize and what parts those relationships are made up of; and from which perspective we are seeing it all. Taking multiple stakeholder perspectives may be like the perspective taking ala DSRP, but it fails to recognize that both the subject and the object that make up any point of view are themselves negotiated through complex assemblies of distinctions, parts and wholes, interrelationships, perspectives, and even subsystems of perspectives, and so on. Taking multiple stakeholder perspectives is also a scale-specific (i.e. human scale) principle, whereas perspective taking ala DSRP is scale free and self-similar. That is, DSRP not only prescribes taking multiple human perspectives (i.e. stakeholders) but also encourages one to attribute perspectives to everyday objects and even ideas. There is great value in looking at an evaluation from the perspective of non-human elements in the system. For example, how does this program look from the point-of-view of:

- the environment;
- the economy;
- No Child Left Behind legislation;
- technology;
- various parts of the funder–program relationship;
- evolutionary theory; or
- any one of the concepts that make up the evaluation construct.

Each one of the concepts in our evaluation construct is a unique pattern of DSRP. As evaluators, we need tools to help us co-relate the reality of the evaluand on the ground level and our mental picture of it. We need conceptual models that are simple yet complexity producing, elegant and beautiful, symmetrical, self-similar, and based in the nested constraints of physical, chemical, biological, ecological, psychological, and social realities. DSRP is such a theory.

2. Broader implications of DSRP

Another criticism requiring clarification is that DSRP cannot be useful in understanding the "physical world of living and non-living phenomena". Midgley writes,

> They associate themselves with the new paradigm with its philosophical focus on the construction of meaning (e.g., von Foerster, 1984; von Glasersfeld, 1985; Maturana and Varela, 1992). They therefore leave themselves open to the accusation

that they cannot adequately relate to those aspects of science that are focused on better understanding the physical world of living and non-living phenomena.

Midgley continues by concluding, "therefore, multiple pluralists address a wider constituency". Later, Midgley writes correctly about the systems thinking community's inability to make an impact in the physical and natural sciences. He writes, "This is because, although we have developed philosophical positions that respect their insights, we have not yet demonstrated that we can enhance their scientific practice".

There has always been a debate in the systems and larger scientific community about the ontology and the epistemology—what are realities of the universe versus constructions of our mind. Midgley prematurely places us in the constructivist camp. As educators, we are constructivists—we understand the mind to be a powerful influence on how we construct reality. Yet, we are also realists. The mind is an artifact of natural selection and constrained by the same universal physical laws and evolutionary history that it attempts to comprehend (our comprehension of these laws is also evolving). We have not experienced the kind of non-utility in the physical and natural sciences that Midgley suggests. Indeed, scientists use DSRP and its subsidiary methods, techniques, and tools.

In our paper, we took a perspective on DSRP in which we attempted to explain its utility as a model of thinking systemically in evaluation. There are many other uses of the DSRP model, in particular as a universal "theory of things".[2] That is, rather than describing the interactions of concepts, we can describe the interactions of any abstract unit of physical reality: quarks, atoms, elements, molecules, cells, organs, organisms, or organizations. Of interest is that the same DSRP rules apply with all the same interactions. All things (i.e. physical units) have a distinct "thingness" that gives them identity and differentiates them from the other things in their environment. These things interrelate with each other. As they interrelate, they form systems that are new things at a different scale, differentiating them even while they are the incorporation of individuals. Each thing also has a unique perspective of its experience and its environment that it "perceives" within the limitations of its sensory capacity.[3] This might sound strange but consider that when you gouge a wooden table it has memory. Or consider that a crime investigation unit can take a single tiny object and recreate the crime scene from the information contained in it. Objects experience their world, connect with their world, incorporate with their world, and experience their world in the ways that they can.

DSRP is unique among the systems community because it serves both as a theory of things and as a theory of thinking (a universal descriptive grammar of cognition). Several respondents

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[2] It is interesting to note that the ideas of distinction, relation, system, and perspective all center around our notions of spatial and temporal extension (as illustrated in the causal structure of rules). That is, DSRP views concepts as objects (albeit fuzzy ones) existing in space and flowing through time. The *degree* to which this is determined by general physical rules of computational dynamics and to which it is determined by how our minds have evolved to model causation within our range of physical experience is open to speculation.

[3] The material application of psychology and sociology attributes a trivial or crude psychology of identity and traits to inanimate or material objects. For instance, a star is a big ball of hydrogen undergoing certain processes, but it can be regarded as "Star", with personality traits "big" and "hot". It has the trivial psychological perspective, "I am Star, Planet is constantly tugging at me" etc. This is a trivial psychology in relation to concept bags, but a psychology nonetheless. "Star" also has a "sociology" in that it interacts with, for instance, "Planet" via gravity, etc. They move each other and distort each other's shape, etc.; in general they convey information to each other. "Star" also has a sociology in so much as it affects the behavior of Carl the astronomer.

highlighted the relationship between thinking systemically and thinking in general.

It is important to note how DSRP rules are built into, both manifestly and implicitly, earlier conceptual models such as semantic networks and symbolic logic. For example consider symbolic logic. In classical logic, concepts are represented by variables like {A, B, C, =, ¬, ⇨, {, (, [} etc., which are taken to be static objects. These variables form what is called the model's lexicon. All variables are considered objects, but objects like = and ⇨ are further defined as relations. These relations distinguish between objects like A and B, and form relationships between them. Furthermore, collections like {A, B, C, ⇨} can be grouped into systems using objects like ("or" { , for instance as written below:

{A, B, C,), (, }

Or as a relational system, for instance:

A ⇨ (B ⇨ C)

Perspective is implicit in the formulation of classical logic since statements like A ⇨ (B ⇨ C) and (A ⇨ B) ⇨ C are *a priori* taken to be distinct systems, i.e. statements can be made from the perspective of A or B or C or (A ⇨ B), etc. Any equivalence of such statements must be proven.

Causal interrelations are also implicit in symbolic logic. Consider the statement A ⇨ B. Here "⇨" is the relation of implication from A to B, which can be thought of in terms of the affect of implication from A, the effect of implication on B, the affect of implication from B, and the effect of implication on A. Similarly, A is distinct from B due to the affect of identity from A and the effect of identity on B, etc. These causal relations are not explicitly stated in the axioms of symbolic logic, but are inherent to the structure of its statements.

The rules of distinction, relation, system and perspective are necessary for the construction of classical logic. However, classical logic describes static and atomistic objects with precisely defined relations. These extra assumptions reduce its robustness. Also, a great deal of what has been explained above—especially where the *elements* of DSRP are concerned—is *implicit* in logic. Logic therefore fails to model the composite and dynamic nature of concepts by neglecting to implement DSRP rules at every level of conceptualization. Table 1 contrasts logic and DSRP.

The dynamics of DSRP make it remarkably similar in structure to quantum mechanics and chemistry, and even to cosmology. DSRP also provides a mechanism for the mimetic behavior that must exist in order for evolutionary epistemology to be a viable proposal. For these reasons, DSRP should be considered a more robust alternative to logic where complex cognitive systems are concerned.

2.1. Conceptual systems

In human conceptual systems, concepts are not always clearly defined; in other words, they are "fuzzy". Concepts are made up of many associations: many other overlapping concepts, all of which are interacting in terms of distinctions, relations, systems, and perspectives simultaneously. For example, my notion of DOG consists of many other concepts such as FURRY and FRIEND and (because I've actually eaten dog in a roadside eatery in Vietnam) VIETNAMESE FOOD, each of which overlap with other concepts such as BUNNY and another Vietnamese culinary favorite PHO, respectively.

From this recursive application of DSRP, concepts become fuzzy sets, each (partially or wholly) containing other ideas, which overlap with other ideas in a large network of fuzzy ideas or sets of ideas. These DSRP interactions between concepts and sub-

Table 1
Contrasting symbolic logic and DSRP

Symbolic logic	DSRP
Static, atomistic	Dynamic, emergent, adaptive, redundant
Limited case, finite; "smoothly connected"	Scale free, fractal, self-similar
Implicit dynamics	Explicit dynamics
More tractable	Less tractable
Less robust representation of conceptual systems	More robust representation of conceptual systems

concepts at all levels of conception lead to time evolution of concepts in the form of warping of the fuzzy set and changing degrees of overlap with other fuzzy sets (making fuzzy connections in the fuzzy conceptual network).

In DSRP, concepts follow a sort of "conceptual chemistry" in which conceptual interaction via iterated DSRP is modeled by a conceptual bond, quantified by the conceptual orbital. Concepts in the conceptual network can then cluster as atoms do, to form complex conceptual molecules, which can flex and move and modify themselves, as in molecular chemical dynamics. These conceptual molecules can be said to form the basis for large systems of interrelated ideas, such as complex theories like DSRP or religions like "Pastafarianism" (Henderson, 2006).

As concepts evolve, conceptual molecules become more common and well defined and arranged into regular patterns (in a limited conceptual space) or "crystallized". A human, who can be regarded for our purposes as a bag of concepts, has limited conceptual space due to physical constraints. When a mind is young, few conceptual bonds have been made and there is still much conceptual space in which to work. As the mind evolves in time, more connections are made in the conceptual network. More concepts bond to other concepts in response to data, and conceptual molecules become more firmly established. As the mind approaches its limit of conceptual space, the conceptual network is forced into more regular patterns in order to fit within conceptual space. Conceptual molecules are better established due to more association, and are organized into more regular structures. That is to say, the human mind goes through a sort of conceptual crystallization throughout its development.

If all iterations of DSRP solidify the various bonds concepts become more crystallized or concretized. Over time, and through repeated evaluation and selection, conceptions become more defined, leading to phenomena such as belief perseverance. Alternatively, if DSRP rules are used, for example, as an explicit processing heuristic, randomly searching conceptual spaces for bonds across fractal scale, this means that cognitive capacity such as creativity can be increased using a blind variation strategy by using DSRP as processor.

In this sense, concepts move through a conceptual ecosystem, interacting and ultimately competing for survival. They constantly evolve in response to their conceptual environment, obeying rules of conceptual Darwinism that are simply an emergent property of the underlying DSRP algorithm, as Darwinian selection in biology is an emergent property of genetic robustness. Thus DSRP necessarily imparts mimetic behavior to concepts and is therefore a mechanism for evolutionary epistemology that describes the micro and macro processes of blind variation and selective retention (Campbell, 1974a, b, 1977).

Table 2 summarizes the similarities of note between quantum mechanical rules and subsequent chemical, biochemical, evolutionary, ecological, psychological, sociological, and cosmological dynamics, and DSRP rules in relation to their conceptual dynamics.

The dual role DSRP plays as a universal theory of things and as a theory of thinking makes it an ideal model for teaching what we call "21st century thinking skills". Whether in evaluation specifically, or in general, the demands of the 21st century point to the need for a kind of "amphibious" thinkers. Those who are: as cognitive as they are emotional, as analytical as they are creative, as disciplined as they are interdisciplinary; 21st thinking involves six types of thinking, each of which is different from but complimentary to the others:

- critical thinking: the ability to analyze, deconstruct, and evaluate;
- creative thinking: the ability to construct new lines of thought;
- systems thinking: the ability to understand complex patterns in context;
- scientific thinking: the ability to observe, validate, and evidence;
- interdisciplinary thinking: the ability to unify, transfer, synthesize, and integrate;
- prosocial thinking: the ability to build rapport through compassion and concern.

The 21st century is often referred to as the information or knowledge age. In 1900, 8 out of 10 jobs involved building things with one's hands (US Department of Labor, Bureau of Statistics, 1960). In 2010, 8 out of 10 jobs will involve working with ideas (US Department of Labor, Bureau of Statistics, 2006). In large part, the bricks and mortar of the industrial age have been replaced.

Table 2
Dynamic similarities between material and conceptual worlds

Magnification	Material universe	Conceptual universe
	Atoms fuzzy; quantified by wavefunction[a] Ψ (i.e. quantum mechanics)	Concepts very fuzzy; quantified by conceptual wavefunction Ψ (i.e. innate DSRP patterns, subconscious cognition)
	Wavefunction Ψ approximated by orbital picture; overlap quantifies interaction strength; "stable" configurations: molecules & arrays (i.e. chemistry)	Wavefunction Ψ approximated by conceptual orbital picture; overlap quantifies strength of conceptual relation; "stable" configurations: concepts, schema, idea composites, (i.e. metacognition)
	Robust molecular systems replicate in response to environmental energy demands; constitute organisms (i.e. biology)	Robust conceptual systems replicate in response to conceptual environmental demands; constitute prototypes, categories, etc.
	Material systems have systemic material identities, embody and systematize material traits (i.e. psychology)	Concept "bags" form systemic personal identities, embody and systematize personal traits (i.e. "embodied mind", psychology)
	Molecular systems adapt in response to interaction with other organisms & resources; best adapted survive (i.e. evolution)	Conceptual systems adapt in response to interaction with other conceptual systems; best adapted survive (i.e. memes, fads, evolutionary epistemology, BVSR)
	Contain systems of evolving organisms (i.e. ecology, sociology)	Contain systems of evolving conceptual systems (i.e. culture, society of ideas, religion, beliefs, knowledge, interdisciplinarity)

[a] A concrete model to this dynamical picture leads to reinterpretation of the fuzzy idea as a probability distribution or a conceptual orbital or *wave* function. Specifically, given a concept (fuzzy set) A as above, we can reasonably model its fuzziness as a conceptual nucleus of core sub-concepts surrounded by a *wave* function quantifying its fuzziness, similar to the atomic model of quantum mechanics. Continuous implementation of DSRP by sub-concepts of A average to form this wave function ΨA, which quantifies the fuzziness of the concept A in a similar manner as the wave function of quantum mechanics quantifies the fuzziness of the atom.

Concepts and connections now lay the foundation for the knowledge age.

In addition, a recent survey of over 400 employers in the US shows thinking skills are among the most important skills found in new hires. Whether the goal is professional success, personal self-fulfillment, national competitiveness in science and technology, or solving complex global problems, new skills are needed to thrive. The knowledge age requires people: to be adept thinkers and learners; to use and build knowledge; to differentiate and combine, compare, and contrast, and construct and deconstruct ideas. The dynamic similarities between material and conceptual worlds shown in Table 2, in addition to a new definition of thinking skills for the 21st century, shows that DSRP is a cognitive tool that underlies and can facilitate the development of robust, essential skills needed in the future.

3. On the lack of practical tools and methods of DSRP

Several respondents criticized the perceived lack of practical tools available for DSRP. Others critiqued that there was no method to DSRP. "It is because Cabrera et al offer a multi-faceted theory, but no tools and techniques, that I feel justified in saying that it is only half a pluralist perspective". While it is a valid point that there is a significant need for practical tools, it is a point that needs some clarification.

First, due again to space limitations, the example of SFI CSSS used in the original paper was incomplete. We did not intend to present a full case study of the SFI CSSS evaluation but instead used it as an example.[4] Second, there are tools (which were not mentioned in the original paper) and methods for DSRP that go beyond a simple set of written methods or proposed methodologies (e.g., SSM, CST, etc.). In particular, the invention of Think-Blocks, a tactile tool for teaching systems thinking, and a US patent (Cabrera, 2008a) for the DSRP method are excellent resources for the methodological and technical steps involved in "doing DSRP". In addition, the patented teaching method is used in workshops in corporate, university, and school settings. It has been explicated and written about in published works; has been the basis of many academic presentations; and has generated numerous video tutorials. Of equal importance is that each of these methods and the value of the tactile manipulatives, ThinkBlocks, have been assessed in case study research conducted with academic researchers, graduate students in many fields, elementary and secondary school teachers, and parents of children of different ages. Here again, descriptions of these items were not included in the original paper due to space limitations and the need to focus on introducing DSRP as a theoretical model.

The four patterns of DSRP are quite simple; it is easy to see that all ideas are made up of other ideas (part–whole) or that ideas connect with other ideas (relationships), etc. It can be a bit more difficult to see how the interactions occur, because they happen simultaneously and in parallel. For this reason, the research that led to the discovery of DSRP also led to the invention of ThinkBlocks (Cabrera, 2008b). ThinkBlocks are plastic blocks that are designed to teach DSRP thinking skills. In the same way that an ergonomic chair incorporates expert knowledge of anatomy, physiology, and ergonomics into its physical design, ThinkBlocks incorporates expert knowledge of how we think into one of the most timeless and ubiquitous tactile objects—a block. Each block's design has four important features corresponding to D, S, R, and P. Each block is: dry erasable, magnetic, nesting, and reflective. Because each block is dry erasable, one can write words,

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[4] We agree with Wasserman's assertion that an important next step is to address the need for taxonomic development in the field of evaluation.
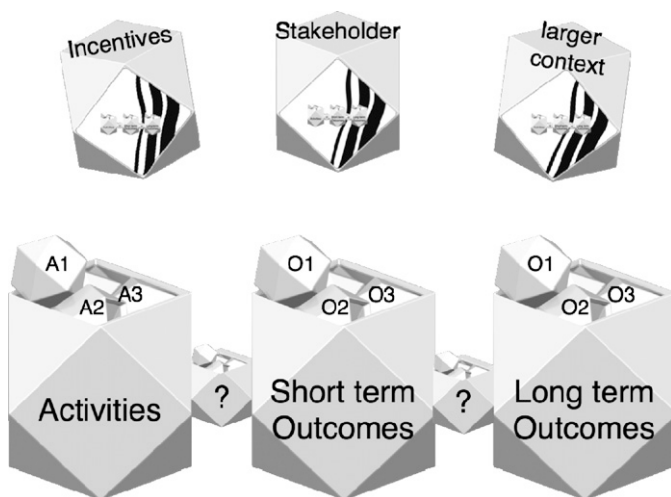
Fig. 1. ThinkBlocks are used to create conceptual models of any idea—including evaluation concepts such as activities and outcomes. In this simple example, ThinkBlocks are used to model the relationships between activities and outcomes and three different perspectives of a given evaluand. Note that each of the blocks can be differentiated (dry erase), contain parts or be a part of a larger system (nested fractal), relate to other blocks in different ways (magnetic), and/or function as a unique perspective (reflective) from which to view the entire system or its subcomponents.

symbols, or pictures to differentiate one idea from another. Because each block is magnetic, the user can connect ideas and analyze their relationships. Because each block nests inside other blocks, big ideas can be broken into smaller ideas and then again into even smaller ideas (Fig. 1). Because each block is reflective, the user can look at any idea(s) from the perspective of another idea. These are the four design features of ThinkBlocks. But the most important design feature is their self-similarity across scale—every block is the same as every other block, even though they are of different sizes. This feature helps to teach the complex interactions of DSRP. For example, if two ideas are related by a third idea, it is clear that this relationship is simultaneously acting as a system with lesser parts (because it can accept ideas inside it) and it can also be a unique perspective or have a distinct name because it is both dry erasable and reflective.

ThinkBlocks are an educational tool that helps to develop complex, 21st century thinking skills because they develop a deep understanding of the inner workings of concepts and knowledge. ThinkBlocks are first and foremost pedagogical and secondarily, they are utilitarian. That is, although ThinkBlocks are used to think through complex ideas, they were designed to teach thinking skills. Once these thinking skills are learned, they can be used without the blocks; the mind is exponentially more fluid, more plastic, and more adaptable than any tactile manipulative can be. Research shows that people develop an internal picture of their thinking process as a result of using ThinkBlocks.

In the examples in evaluation given above, we can use the conceptual ergonomic design (ThinkWorks, LLC, 2008) of Think-Blocks to demonstrate this. The tactile and step-by-step methodological implications of ThinkBlocks are an advanced set of practical tools and methods. Contrary to the criticism, these tools of DSRP go well beyond the tools and methods of existing models of systems thinking with the additional benefit of being universally applicable. In contrast, the practical tool developed to support DSRP exist in written and video format, are prescriptive and formalized, and have been designed into tactile manipulatives that facilitate deep understanding of systems thinking skills.

All thinking is conceptual. So, it makes a lot of sense that whether the thinking is critical, creative, scientific, or prosocial, it is based on conceptual patterns. The evaluator is required to use any or all of these types of thinking in their work. Each of the 21st century thinking skills (i.e. critical thinking, creative thinking, systems thinking, etc.) is a whole world unto itself; hence it is impossible to give examples for every category and subcategory within these areas, but a few examples will suffice to demonstrate the link between these types of thinking and conceptual thinking.

*Example #*1: At the core of both critical and scientific thinking is the ability to evaluate and validate the source of information. This ability may be as simple as knowing the reputation of the author of an editorial in the newspaper or the political leanings of the newspaper itself. Or, it may be as complex as understanding the long history and deep methodological principles of different epistemological approaches (i.e. constructivism, positivism, reductionism, etc.). In either case, the ability to draw distinctions in finer or coarser grain, to deconstruct those distinctions into systems of related ideas, and to view one's analysis from different perspectives is absolutely essential. It is one thing to know which epistemological method (e.g., the scientific method) was used to generate a "fact" or "theory", it is another thing to understand the nuances of that method and critically analyze it.

*Example #*2: It is a common misconception that creativity is an innate ability possessed by a lucky few or a mysterious process that cannot be captured, taught, or learned. Yet, research shows that creativity can be understood, taught, and learned. That is, there is an underlying method to the "madness". Looking at something from a novel perspective, critiquing the accepted boundaries of things (sometimes called thinking out of the box), making unseen relationships explicit, or digging deeper or seeing more broadly the parts of an idea are "algorithmic" ways of being creative.

*Example #*3: Prosocial thinking involves the ability to build rapport with others through compassion and concern. The ability to take the perspective of another person, place, thing, or idea is absolutely essential and foundational to prosocial behaviors such as altruism, empathy, compassion, understanding, and listening. Without an ability to take perspective, cooperative society would cease to exist.

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Response to paper "Systems thinking" by D. Cabrera et al.: The unification of systems thinking: Is there gold at the end of the rainbow?

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1. Introduction

I am writing this reply to Cabrera, Colosi, and Lobdell (2008) because they pose a significant challenge to the systems community by dismissing the practice of methodological pluralism. Methodological pluralism has both a practical and a theoretical dimension: it involves drawing upon different methods from different paradigms as part of a reflective systems practice, and it also involves the development of a multi-faceted philosophical position or theory to underpin this approach (Jackson, 1991, 2000; Midgley, 1992, 2000). Cabrera et al. claim that, instead of proposing frameworks to support methodological pluralism, we can reconstruct the systems thinking enterprise using a theory of conceptualisation. This theory suggests that there are four essential foci of systemic thought, namely distinctions; systems; relationships; and perspectives (represented by the letters 'DSRP'). It also proposes that most people already have experience of systemic conceptualisation in their day-to-day activities. Therefore, people only need to use the DSRP concepts more consciously and more regularly to make their actions more systemic.

The theory of DSRP is based on a search for 'patterns' across the literature on systems thinking: i.e., Cabrera et al. (2008) have sought to develop a theory that will include or reconstruct most of the concepts that have been proposed by others. They suggest that those concepts that do not fit their theory are not really fundamental to systems thinking. Hence, this is an attempt to rationalise and unify the field. However, the suggestion that we only need to use existing thinking skills more consciously (rather than design new methods) flies in the face of accepted wisdom in the systems community. For about 50 years researchers have been producing innovative (quantitative and qualitative) methods to support systems thinking, going beyond 'common sense' conceptualisation (see Midgley, 2003, for just some of the variety). Also, in the last 10 years, most people have embraced methodo- logical pluralism (which Cabrera et al. criticise) in recognition of the fact that we can enhance our systems practice by drawing upon multiple methods designed for different purposes.

If someone offers a coherent and credible argument against received wisdom, as Cabrera et al. have done, it is worth subjecting it to some scrutiny. Indeed, it seems to me that, by proposing this theory, they have reopened an important debate on the unification of the systems enterprise that has been dormant for about 10 years. Given that work in the field has continued to diversify during this time, making it progressively more difficult to define systems thinking in anything approaching a comprehensive and consensual manner, I think it will do the systems community some good to re-engage with this debate.

Although I welcome engagement, I do have some issues that I want to raise with DSRP. Below, I will first of all argue that the DSRP theory actually has a lot in common with much of the philosophical and theoretical work that has been undertaken to underpin methodological pluralism, which is rather paradoxical given that Cabrera et al. oppose their theory to this approach. I will also point to the lack of methods to support people in strengthening their use of the DSRP concepts, and these methods would be readily available to Cabrera et al. if they were prepared to accept the practical dimension of methodological pluralism. Then I will reflect on the reception that previous unifying and pluralist theories have received in the systems community, and this will leave an open question over the future of Cabrera et al.'s work. While I suggest some paths for further research that I believe will maximise the chances of longevity for DSRP, we will be able to answer the question about its future only in about 10 years, when we see how the systems community, and others, have reacted to the attempt at unification.

2. Is DSRP a whole unifying theory, or just half a pluralist perspective?

Paradoxically, I suggest that the DSRP theory of Cabrera et al. (2008) is actually very similar in kind to several theories that have been used to underpin methodological pluralism (e.g., de Raadt, 1989; Flood, 1990; Flood & Jackson, 1991; Jackson, 1988, 1991;