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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.

Keywords: Systems thinking; Systems evaluation; Concept ecology; Patterns of thinking; DSRP

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

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

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

[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.

[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 evalautor 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

[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*)
	$(D)(S)(R)(P) \Rightarrow \{DSRP\}$
	Distinction (D) $\Leftrightarrow$ {*identity* (*i*) $\Leftrightarrow$ *other* (*o*)}
	System (S) $\Leftrightarrow$ {*part* (*p*) $\Leftrightarrow$ *whole* (*w*)}
	Relationship (R) $\Leftrightarrow$ {*cause* (*c*) $\Leftrightarrow$ *effect* (*e*)}
	Perspective (P) $\Leftrightarrow$ {*subject* (*s*) $\Leftrightarrow$ *object* (*ȯ*)}

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

[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

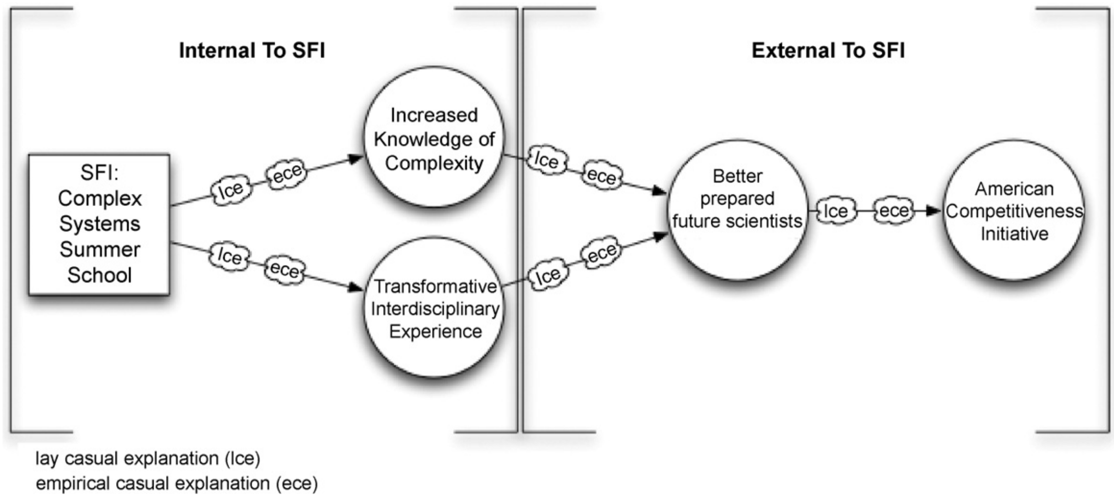

Fig. 1.

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).

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Appendix A. Additional references for DSRP rules

Distinction rule

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