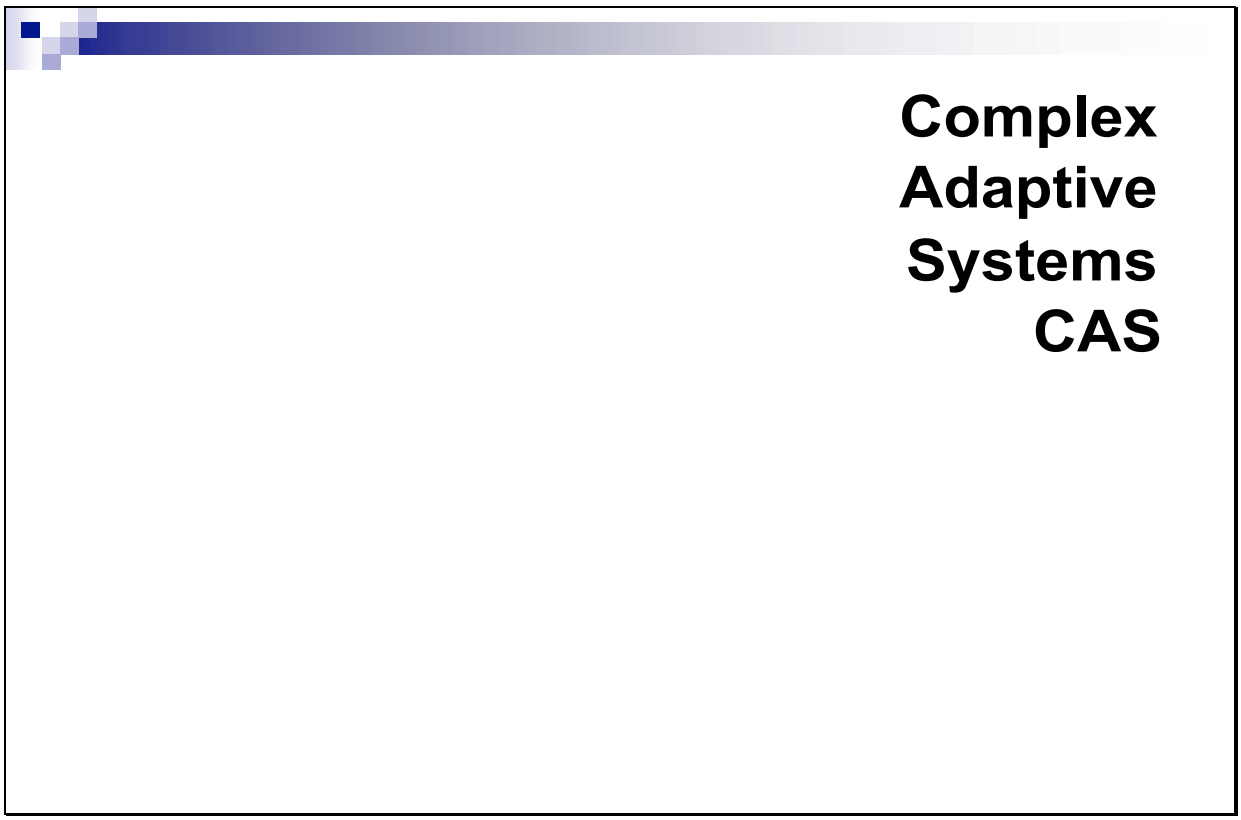


Introduction

The original version of this document was prepared by Glenda Eoyang as part of a workshop organized by Glenda, Bob Williams, Bill Harris for staff of the WK Kellogg Foundation.

Our thanks to the Foundation for allowing us to circulate this document more widely.

This document explores complex adaptive systems in three sections

1. Some of the fundamental distinctions that shape the landscape of systems thinking as applied to individuals and organizations.
2. Definitions of complex adaptive systems.
3. Tools to support analysis and action in complex systems.

1. *Distinctions in the Systems Thinking Landscape*

The field of systems thinking includes a wide range of tools, techniques, methods, and concepts. Some of the approaches that emerge from a systems approach are intuitive to those of us who work successfully with individuals and organizations. Other systems concepts are counter to our usual ways of thinking and working. The following distinctions can help to describe the landscape that becomes accessible through thoughtful applications of systems concepts and methods.

Complex and Complicated

Both complex and complicated patterns can be difficult to understand, but the methods we use to understand them should be quite different because the natures of their ambiguities are quite different.

A complicated pattern is one that is intricate in the number of parts and their hidden relationships to each other. Such a system appears to be "folded" so that parts are hidden from view. To understand such a system, the parts must be separated from each other and the relationships clearly defined. Though it may take a long time and much effort, a complicated system can be understood in terms of its parts. Reductionism is an effective method of investigating the nature and function of a complicated system.

A complex pattern, on the other hand, involves the weaving together of parts into an intricate whole. Each part is massively entangled with others, and the emergent (complex) pattern cannot be discerned from its components. The whole emerges from the interaction of the parts. In the same way that a tapestry depends on the relationships among threads of various colors, other complex systems derive from the parts AND their intricate relationships to each other.

If a system can be understood in terms of its parts, then it is a complicated system. If the whole of the system is different from the sum of its parts, then it is complex.

This distinction is important in evaluation practice because complicated and complex systems require different methods of analysis. Good evaluation of a complicated system involves repetition, replication, predictability, and infinite detail. Good evaluation of a complex system involves pattern description, contextualization, and dynamic evolution.

Practice and Theory

The languages and metaphors of systems thinking have evolved to the level of art. Archetypes, interrelationships, mathematics, models, tools, and formalized

relationships have been defined to sustain focus on the systemic rather than the particular. Yet, practice takes place in the particular. The more complete and elegant the theoretical basis for systems thinking, the more difficult it becomes to bridge learning back to action. Even case studies, which promise to carry theory into practice, often fail to move from retrospective to prospective insights. To be most helpful, a systems approach must provide support for proactive decision making in real time with real challenges.

This distinction is especially significant in terms of evaluation because persons involved in program work already tend to think of evaluators as people of theory more than practice. Unless we are able to bridge from the thought to the action, how can we support our clients whose existence depends on their actions more than their thoughts?

Static, Dynamic, and Dynamical

This distinction derives from physics and can help us think about the patterns of human systems and their emergent patterns.

Static systems are ones that are essentially still. We analyze them while they are at rest—before and after motion has occurred but not during motion. Many evaluation processes (e.g., pre to post) are essentially static. We are concerned about the before and the after, but the sometimes complex path from one to the other is not of our concern.

Dynamic systems are ones that are moving in response to known, linear (or at least continuous) forces. A perfect example is the arc of water from a garden hose. We know that the momentum of the water and the force of gravity resolve to form the graceful parabolic curve that we observe. Some evaluation techniques treat programs as dynamic systems. Procedures for longitudinal studies, for example, acknowledge the dynamic nature of programs and social change.

Dynamical systems are ones that change in response to nonlinear, high dimension, and/or discontinuous forces. Weather patterns, evolution, dripping faucets, and injury rates in industrial settings have been shown to exhibit dynamical patterns of behavior. The sciences of complexity and deterministic chaos are being developed to understand these emergent and unpredictable systems. The traditional evaluation method that is most able to capture the dynamical nature of social systems involves stories and storytelling. The emerging science of complexity may provide other tools to track and understand patterns of dynamical change.

Being and Knowing

This distinction is known by a variety of names:

Being	Knowing

Reality	Perception
Ontology	Epistemology
Reductionistic	Holistic
Objective	Subjective
Absolute truth	Shared perspective

There are many ways in which this dichotomy, whatever it is named, affects evaluation method and practice. The stance of the evaluator will be quite different depending on which perspective is chosen as primary. If he or she expects to be investigating reality, the search will be for truth and objective, verifiable and generalizable fact. On the other hand, the evaluator who takes an epistemological stance will be primarily concerned with how participants view the situation and each other and how they interact to move the work forward.

Neither stance is right or wrong, but each has its strengths and limitations, and an effective evaluation design makes a conscious, consistent, and explicit choice.

Inductive and Deductive

An inductive approach begins with the details and builds up a picture of the whole as it emerges from the particular. A deductive approach, on the other hand, begins with a coherent model or expectation and seeks for or shapes phenomena that match the expectation.

This distinction has many implications for systems thinking, but one that is most relevant has to do with systems models. Statistical modeling techniques, including time series or curve-fitting models, are inductive. The process begins with a data set that is manipulated until it matches some pre-set model. It moves from data to pattern. Systems dynamics models, on the other hand, are deductive. They begin with the variables and some understanding of the interactions among them—equations of interactions. These are built into the model and specific behaviors are generated and studied. It moves from pattern to data.

Both inductive and deductive modeling methods are designed to provide new insights, but each one works from different assumptions and toward a different kind of knowledge about the phenomenon under consideration.

Particular and Pattern

This is the primary distinction between systems and non-systems approaches. Systems approaches focus on patterns of interrelationships among multiple things. The assumption is made that in a system, the individual components will give you limited understanding at best. At worst, the parts will distract you from seeing the more significant patterns that emerge from the whole.

Neither one by itself is sufficient for thought and action. We must attend to both the particular and the pattern, but there are different strategies and tactics for analyzing and understanding each level. Like many of the other distinctions, the diversity of perspectives is best, and a capacity to distinguish is key.

Emergent and Designed

If the world were always predictable and under our control, we would always make a perfect plan and ensure that materials and forces coalesced to make the plan a reality. When forces are not predictable or under our control other creative options arise. Rather than pre-designing the outcomes of a program or an evaluation program, one can let the program emerge from a short list of simple rules or a "good enough" design. This second, more emergent approach to work is consistent with highly complex and adaptive systems. You cannot predict or design them for specific outcomes. Rather you set conditions and shape the path of development as it progresses.

Why evaluate?

In the course of this conversation, a critical question arose. If we cannot be sure of the nature of the system and if we make assumptions about the patterns we expect and observe, then why should we evaluate at all? The group came up with interesting responses to the question. We evaluate to:

- Judge the better from the worse
- Learn from our mistakes and those of others
- Understand the nature of the systems in which we work
- Make decisions based on data and experience
- Modify actions when the effects are different from what we intend
- See and name patterns that you can generalize
- See what effects of your actions are as input for the next cycle

These distinctions establish a landscape in which systems decisions are made, but neither of the choices is any better or worse than the other. As long as one is conscious of the options and chooses to fit the nature of the situation and the question, then the work will be effective. On the other hand, if one is unconscious of the differences and chooses unintentionally, then the process and the outcomes are likely to be confused and confusing.

2. COMPLEX ADAPTIVE SYSTEMS (CAS)

Discover a CAS

Rules

- Keep your eyes closed.
- Think of a number.

- Arrange yourselves in numerical order in a circle.
- Talk to only one person at a time, and you must be touching that person.

What did you feel?

What did you think?

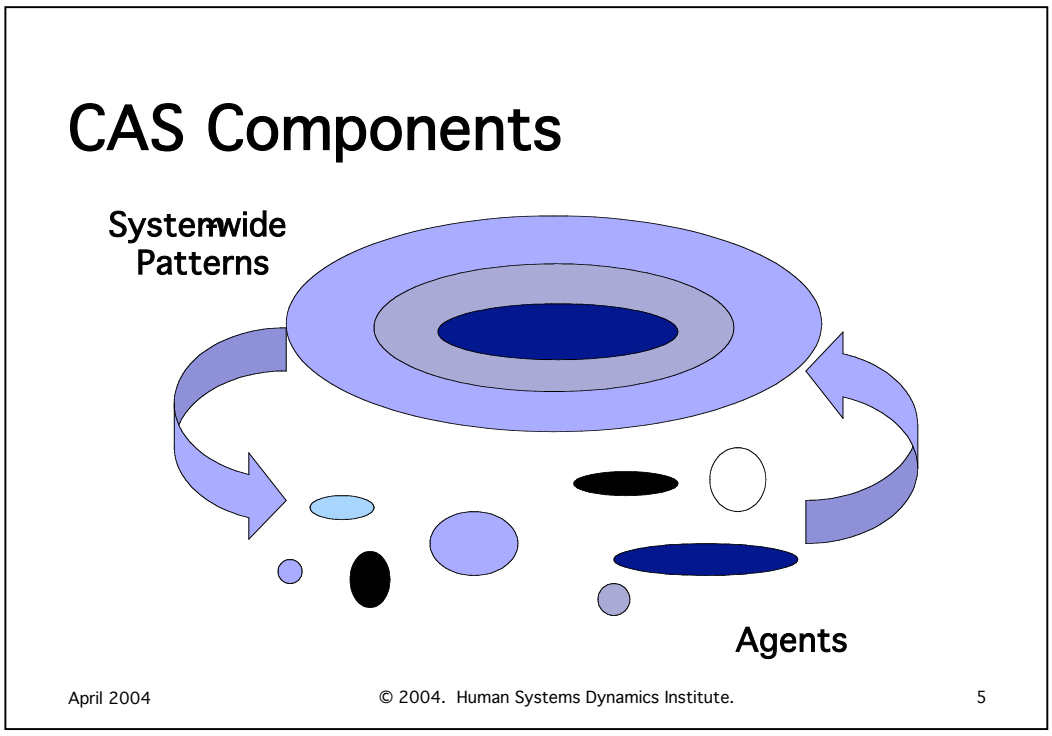
PATTERNS OF CAS BEHAVIOR

Organized	Self-Organizing	Unorganized
Machine	Living organism	Ricochet bullets
Predict/control	Watch for patterns	React blindly
Policies/procedures	Teamwork	Customer response
Directive leader	Empowering leader	Disinterested leader
Parts/connections	Whole	Independent parts s
Efficient/reliable	Adaptive	Reactive
Safe	Interdependent	Creative
Designed shapes	Emergent shapes	No shapes
Organized	Self-organizing	Unorganized

April 2004 4

What aspects of your programs are organized, self-organizing, unorganized?

What aspects of your current evaluation programs are organized, self-organizing, unorganized?



Self-Organizing
Complex Adaptive

A collection of individual agents, who have the freedom to act in unpredictable ways, and whose actions are interconnected such that they produce system-wide patterns.

Examples: termite colonies, stock markets, the Internet, gardens, human beings, groups of people

How are your projects complex adaptive systems?

What implications do complex adaptive dynamics have for evaluation?

Particular features of CASs

- Purpose of the whole emerges over time from the interacting purposes of the parts.
- The means of assessing performance is fit with the environment.
- Decisions are made by dialogue among parties.
- Subsystems are massively entangled and participate in each other.
- Components interact as free agents.
- Interactions are generative.
- Change can be continuous or discontinuous.

Patterns in Self-Organizing Systems

- Butterfly Effects
- Boundaries
- Transforming Feedback Loops
- Fractals
- Attractors
- Self-Organization
- Coupling

Butterfly Effects

Small cause may have big effect.

- Sensitive dependence on initial conditions.
- Makes unpredictability a necessity.
- Also means large efforts may have small effect.
- No value judgments inherent in the pattern.

Simple Example

An evaluation design used survey data collection method. One question was culturally biased. The survey test sample was homogeneous and didn't catch the problem. The question offended participants and invalidated data that was collected.

Implications for evaluation

- Find ways to track "noise" in the system.
- Design for iterative re-design.
- Don't waste time looking for "root" causes.
- Consistency is important to lend stability.
- Take multiple points of view.
- Else?

Boundaries

Lines of difference are turbulent.

- Information will be distorted.
- Some differences are more significant than others.
- Turbulence can be constructive or destructive.
- Boundary conditions change over time.

Simple Example

A single evaluation report was planned to meet the needs of internal and external audiences. Neither received the information relevant to them. A better approach would be to make separate reports, one for internal and the other for external consumption.

Implications for evaluation

- Know the landscape.
- Use diversity of design and communication.
- Facilitate meetings across boundaries and expect turbulence.
- Collect data at boundaries and far away from them.
- Else?

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Transforming Feedback Loops

Action across boundary brings both change and stability.

- Exchange of energy, information, funds can be transforming.
- Both sides must be engaged for transformation.
- Amount of difference, speed, and frequency determine whether change or stability follow.

Simple Example

When an evaluation report from a project is not read or considered by either the funder or project personnel, then it is NOT a transforming feedback loop.

Implications for evaluation

- Make the evaluation process a two-way conversation.
- Expect transformation from any exchange.
- Design the evaluation process as a transforming feedback loop—length, width, mode, frequency.
- Else?

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Fractals

Similar patterns appear at multiple levels.

- Nature uses it for coherence.
- Simple nonlinear equation generates fractal patterns.
- Change at one scale ripples into others.
- Single part can give information about the whole.

Simple Example

Reflective Evaluation process designed for organization that had no funding or expertise for evaluation, but had a dynamic process they needed to track over time.

Implications for evaluation

Evaluate at multiple levels.

Look for repeated patterns.

Use iterative processes to generate adaptive complexity.

Use multiple points of view and consistent process to see the whole.

Else?

Attractors

- Patterns emerge over time.
- Recognize attractors:
    - Point
    - Periodic
    - Strange
    - Random
- Strange attractor marks chaos.
- Finite bounds. Infinite possibilities.

Simple Example

Evaluation of administration that included academics, bureaucrats, health care pros. Needed to work together, though their cycle times were quite different. Quarterly marketplace for ideas created shared pattern.

Implications for evaluation

Match eval design to dominant attractor.

Use time series modeling to see pattern.

Use multiple viewpoints to look for and evaluate patterns.

Use the wise practitioner.

Else?

Self-Organization

Complexity gives "order for free."

- Motion from FFE to new structures.
- Dissipative structures.
- Conditions for self-organizing.
- Human systems do it all the time.
- Not all self-organizing is good.

Simple Example

Foundation setting 10-year goals establish one set of criteria for first year and allow others to be defined in future.

Implications for evaluation

Set conditions for self-organizing.

Capture dissipative structures as they form.

Plan to plan again.

Use the perspective of the group.

Else?

Coupling

Habitual feedback builds couples.

- Tight, loose, and uncouples.
- Feedback loops form couples.
- Tight couples lead to lock in.
- Couples can and should change over time and scale.

Simple Example

Eval used to control funding gives strong couple. Work in agency is unfocused and reactive. High autocratic management develops within agency.

Implications for evaluation

Define what aspects of design expect which couple.

Assess coupling between and within.

Use data collection to assess level of coupling.

Else?

In what evaluation situations is CAS particularly useful?

- When boundaries (time or space) are fuzzy.
- When outcomes are long-term or unpredictable.
- When you have multiple audiences for evaluative data.

What kind of evaluation questions does CAS address?

- How are patterns changing over time?
- What are the relationships among units of analysis (individual, family, city, etc.)?
- What holds a social group together?
- What differences are significant within and between groups?
- What connections are most effective for specific purposes?
- What are the sources of coherence and/or dissonance for the group?

So what for evaluation?

- Use CAS tools:
- Agent-based models for simulation
- Time series analysis
- Short lists of simple rules
- Catastrophe archetypes
- Design dynamic evaluation:
- Iterate design process
- Evaluate at multiple scales

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- Embed traditional evaluation within CAS model

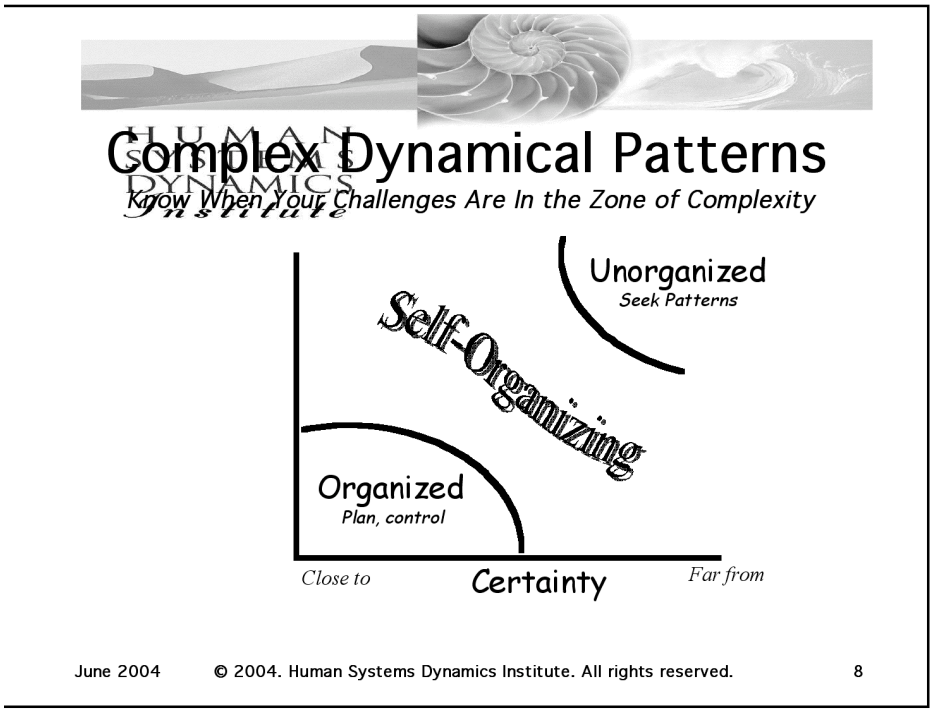
3. TOOLS AND TECHNIQUES

Complex adaptive systems involve agents that are semi-autonomous. They interact, and over time new system-wide patterns emerge. Such an environment generates situations that are complex, dynamical, and emergent. The rules of engagement and effective tools and techniques for evaluation are different for these systems than for systems that are structured and predictable.

In our time together, we discussed several tools and techniques that can help describe and understand the patterns that emerge during complex adaptive processes. They are described below.

Three Dynamics

One way to think about complex dynamics is to consider two variables that shape interactions in human systems—agreement and certainty (Zimmerman et al, 1998, p. 136). These two dimensions define a landscape in which phenomena exhibit different emergent patterns of behavior. The diagram below depicts these three dynamical patterns and they are explained below.



- Organized patterns are predictable and controllable. They appear when the system is close to agreement and outcomes are relatively certain. You will see such patterns emerge when relationships are traditional and hierarchical, when expectations are clear, and when change is linear. The organized pattern is most productive when change is slow, relationships are stable, outcomes are predictable, and causality is simple and linear.

  Organized patterns are important to evaluation when programs are small, well understood, or simple. A variety of traditional evaluation techniques are appropriate in this space including outcome evaluation.

- Unorganized patterns are hardly patterns at all. The separate agents are independent. They do not work together to form system-wide patterns. The behavior is random. These behaviors appear when the connections among the agents are weak, change is radical and fast, and unpredictable.

  Evaluation systems must adapt to unorganized structures early in a project, when patterns of relationship or culture have not yet been established. Storytelling, observation, and ethnographic methods can help move a system from the random to the self-organizing domains by making patterns explicit.

- Self-organizing patterns appear when there is enough structure to give identity and coherence and enough diversity to make the system unpredictable. The key to self-organizing is a constant tension between stability and surprise.

  Evaluation methods for self-organizing systems are still being developed. Process measures have been used in the past, but they are insufficient to demonstrate the emergence of patterns and changes in fundamental structures and meaning making. Other CAS-based tools can be of assistance, including the CDE Model, nonlinear time series analysis, participant engagement, and iterative redesign.

Difference Matrix

In a complex adaptive system, the amount of difference and the amount of exchange among agents help shape the emerging pattern. The Difference Matrix (Eoyang, 1997) provides a way to think about four common dynamical patterns, to assess a current state, and to intervene to shift the pattern to one that is more productive. For a presentation of the Difference Matrix, refer to http://www.chaos-limited.com/gstuff/Diffmat1099.pdf.

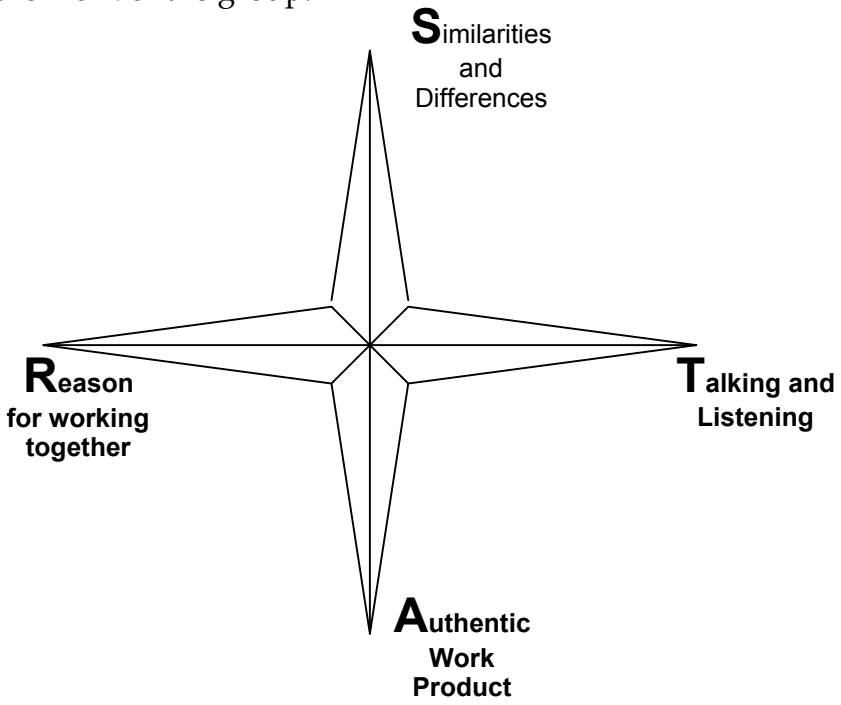
T\he Difference Matrix as a way to:

- Discuss and resolve issues in teams

- Identify new organizational procedures
- Elicit perspectives from participants during evaluations
- Building in diversity in data collection and analysis techniques
- Managing meetings
- Improving relationships with co-workers and clients

Generative Relationship STAR

When a team works well together it creates new visions and actions. Such a relationship is generative because it creates things that did not exist before. The Generative Relationship STAR (Zimmerman & Hayday, 2003) presents four factors that build generative relationship and shows how they must be balanced to support the work of the group.



- Similarities and differences. An effective group must have similarities to bring them together and differences to introduce new ideas. If a group is too much the same, it gets stuck in old ways of thinking. If the group is too different, members find it difficult to build relationships. To build and sustain productive work, a group must learn to establish their similarities and make the most of their differences.
- Talking and listening. Communication across differences provides the "glue" that holds a generative relationship together. Talking and listening among members of the group provide opportunities to learn and grow. Communication beyond the group allows for sharing and learning. If a

group does not talk or listen well, it gets stuck in misunderstandings and hurt feelings.
- Authentic work products. A generative relationship is focused on accomplishing real work. Without a focus, the group loses energy and thinks more about itself than about its goals. Over the life of a generative relationship, many different products are imagined, created, and tested.
- Reason for coming together. Every generative relationship must have shared objectives. Without a common, stated reason for working together, a relationship can turn from being generative to being competitive.

Lessons from the STAR:
- All four points of the STAR are important to building a lasting and productive relationship.
- Too much focus on one or another of the points gets a group stuck and frustrated.
- Groups move from focus on one of the points to another over time.
- A group must spend shared time talking about and practicing each point of the STAR.
- When a group is in trouble, it is because one or more points is neglected.
- Each point requires a different set of skills and sensitivities.
- Some individuals like one or another of the points best, but the group as a whole has to balance their attention on all points.

The Generative Relationship STAR was developed by Dr. Brenda Zimmerman and her team as she supported non-profit boards in establishing productive and resilient relationships.

CDE Model

Self-organizing patterns emerge from complex interactions. One cannot predict or control the products of self-organizing. On the other hand, three conditions shape the path, speed, and outcome of self-organizing processes. These three conditions are represented in the CDE Model for self-organizing in human systems (Eoyang, 2003).

- **C**ontainer holds the agents of the system together long enough for them to interact and form new patterns. Anything that performs this function is a container. Three types are most common:
    - Fence surrounds and constrains the agents. Examples include rooms, membership lists, organizational silos
    - Magnet draws agents toward a common center. Examples include visionary leader or shared goal.
    - Affinity connection the agents to each other. Examples include identity groups of race, gender, or education.
- **D**ifference establishes the pattern within the self-organizing system. It also provides the impetus or potential for movement. Any complex human system includes a large number of differences (race, gender, height, age, experience, education, etc.). One or more of these differences is most relevant, and it becomes the significant difference that forms and informs the pattern emergent.
- **E**xchange is the transfer of information, energy, resources between and among the agents as the system self-organizes. If the agents are not connected by exchanges, then no self-organizing system-wide pattern will emerge.

These three conditions (container, difference, and exchange) influence how the self-organizing progresses. For example, a small container, few differences, and tight exchange mechanisms will bring about rapid and almost-predictable patterns over time. On the other hand, large containers, many differences, and loose exchanges will make the patterns slow to emerge and unpredictable in outcomes.

These distinctions make powerful tools for evaluation as one considers the conditions that led to an initial state, those that move the system to a new place, and those that establish foundations for future.

Shorts and Simples

Complex dynamics emerge from simple rules that are applied repeatedly in diverse environments.

- The structure of the rules is simple:
    - Verb phrases

    - 5 plus or minus 2 total rules
    - Can be used retrospectively (What rules brought the current patterns?)
    - Can be used prospectively (What rules will bring preferred patterns?)
    - Each rule influences the container, the difference, or the exchanges that will shape the self-organizing pattern

- Boids example
    - Fly toward center
    - Match speed of others
    - Don't bump into anyone
- Organizational examples
    - Teach and learn in every interaction
    - Attend to the part, the whole, and the greater whole
    - Look for the true and useful

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CAS CASE STUDY – WHY DO COALITIONS FALL APART ?

Coalitions are an important part of social change. The Kellogg Foundation funds such coalitions and was interested in the use of CAS to help them understand the complex dynamics of such arrangements.

Considering a coalition from a CAS perspective uncovers some fundamental patterns that affect the stability and cohesiveness of the group. The complex adaptive systems perspective gives particular insights into alliances and allegiances.

For example:

- Each person in the coalition simultaneously belongs to other coalitions. He or she is continually interacting in many different contexts and participating in new emergent patterns in all of them.

- Relationships and the shared patterns of behavior that emerge from them are in constant change. An understanding at any moment is no more than a snapshot and cannot provide much insight into the history that led to or the motivations that will lead away from the current state.

- Individuals themselves are continually engaged in dynamic meaning making. An insight that seems true at one moment may be less certain at another. The unpredictability of understanding, expectation, and commitment is a given in the world of coalition building.

- Patterns that emerge from complex dynamics are "sensitive to initial conditions." A very small change can cascade into enormous consequences. (Sometimes this is called the "butterfly effect" because in computer simulation models the flap of a butterfly wing in Argentina may result in a hurricane off the coast of Florida.) These dynamics make the stability of any relationship or emergent pattern unpredictable. A small schism may be amplified over time until it disrupts the coalition entirely.

- History matters. Today's connections and clarity emerged from conditions that existed in the past. The past never disappears, it simply becomes the raw material for future possibilities. This principle affects coalition-building in two ways. First, circumstances of the past are deeply embedded into the patterns of the present. Even if you cannot see their influence, prior connections can strengthen or threaten currently emerging patterns. Second, today's events with a coalition will influence the richness and resiliency of relationships that will form in the future.

The most compelling question, however, focuses more on action than mere understanding. "How do these insights inform action to build and maintain effective coalitions?"

The CDE Model

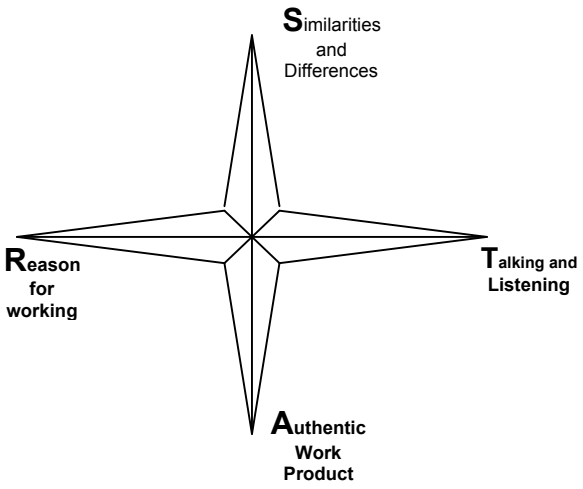
Looking at the history of coalition failures you can see the following threads :

Container – small range of shared goals
Differences – large
Exchanges – frequent but almost no way to address significant differences.

This leads to no self-organizing, stable, dissipative structure at the overall level. What you are left with is the force of Foundation money vs the force of industry lobbyists. And the force that coincided closest to the needs of individual coalition members dominated what emerged.

Generative Relationship STAR

The Generative Relationship STAR (see above) can provide insight into this question



Options for Action

With this model in mind, there are many tips for how to prevent coalitions falling apart and bring effective coalitions together, sustaining their vigor and reflecting (as in this case) why they might fall apart.:

We look at three steps that can be taken to reduce the possibility of coalitions failing.

Step One

Assess the current STAR of the coalition and determine whether one or another of the parameters is out of balance. The following table gives a brief overview of the kinds of issues that arise when one or another of the points of the STAR is weak.

	Will produce effects—			
Weakness in—	**Long term**	**Short term**	**Micro**	**Macro**
Similarities and differences	Isolation of a few	Polite chit chat	Unproductive meetings	Dissipation of energy or focus
Talking and listening	Rumors and misunderstandings	Silence or single dominating voice	Individual frustration	Loss of voice or message for individuals and group
Authentic work	Loss of interest and energy	Questions about value/purpose of the activity	Impatience of individuals	Lack of respect as a viable group
Reason for coming together	Distracted by irrelevant or trivial issues	Conflict over next steps or resources	Resentment among individuals or subgroups	Shifting goals or expectations; lack of continuity

Step 2

After defining which of the parameters requires attention, take action to strengthen the focus in that area. The following table gives examples of ways to strengthen each of the parameters of the STAR.

Similarities and differences	• Share stories • Amplify and discuss the diversity in the group • Share information about individuals or organizations involved • Acknowledge strengths or special contributions • Meet at different locations over time
Talking and listening	• Use a talking stick • Ask people to respond in order to a single question

	• Use standard questions (e.g., What did you see, feel, think, do? Or What, so what, now what?) • Use multiple media including email, phone, text, face-to-face, video, and others to match the needs and preferences of participants • Communicate frequently and in various ways
Authentic work	• Define outcomes and activities • Build schedule • Assign accountabilities • Work in committees • Document a plan of action
Reason for coming together	• State missions and goals • Talk to individuals to find out their agendas that are in addition to the shared one. • Align the shared agenda with individual agendas. • Recognize a timeline in which the shared reason is likely to continue.

Step 3

Take action, watch the outcomes, and assess the STAR again.

Conclusion

These tools and techniques have been derived from a wide array of theories and practices applying complexity to human systems. This emerging field is called human systems dynamics (HSD) because it is different in kind from other complexity applications and from other approaches to social science. For more information about HSD or the HSD Institute, please visit our website www.hsdinstitute.org

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