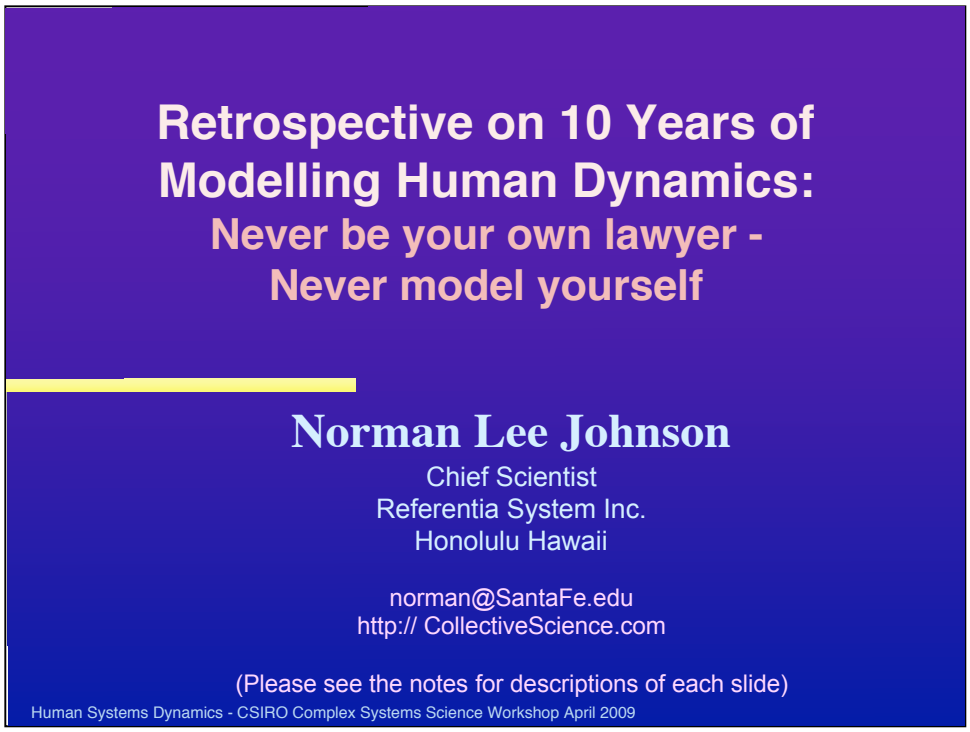
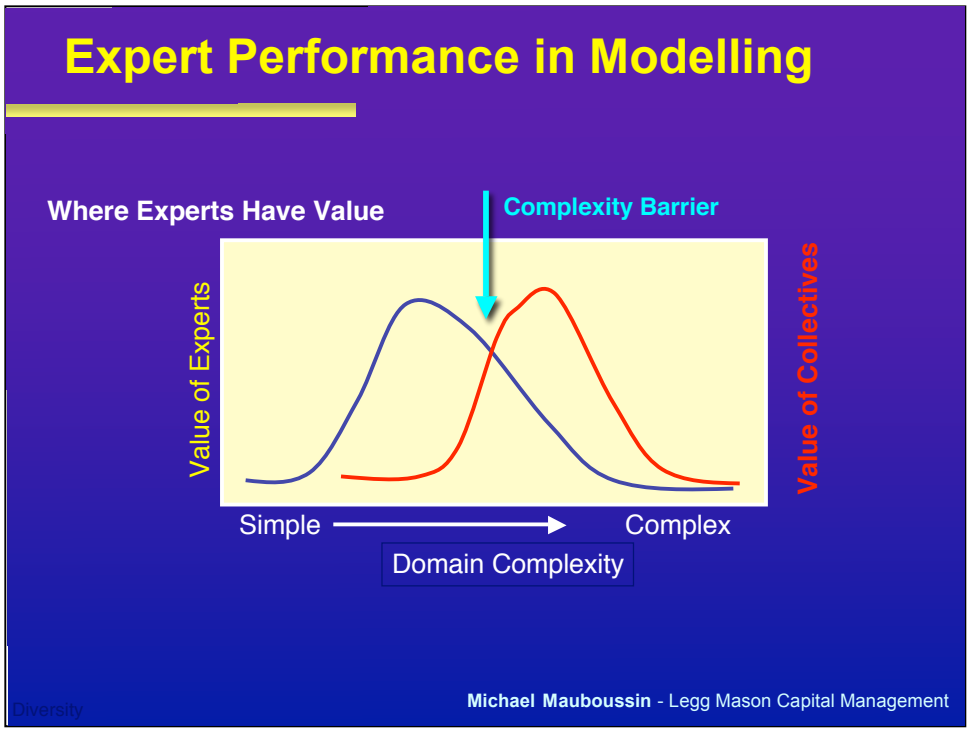


Originally I had “Never be your own Barrister”to reach out to the local Brisbane community, but Danielle advised me that Barristers are going away for the more western model. So the best I could do was spell modeling modelling.



I've reached my complexity barrier in individual modeling -

Therefore the best I can do in this talk is to enable the "wisdom of this crowd" by:

-provide awareness of our biases - making us more open to innovation

-Setting up a common "world view: for exchange of ideas - so synergy can happen

-Identifying areas of opportunity

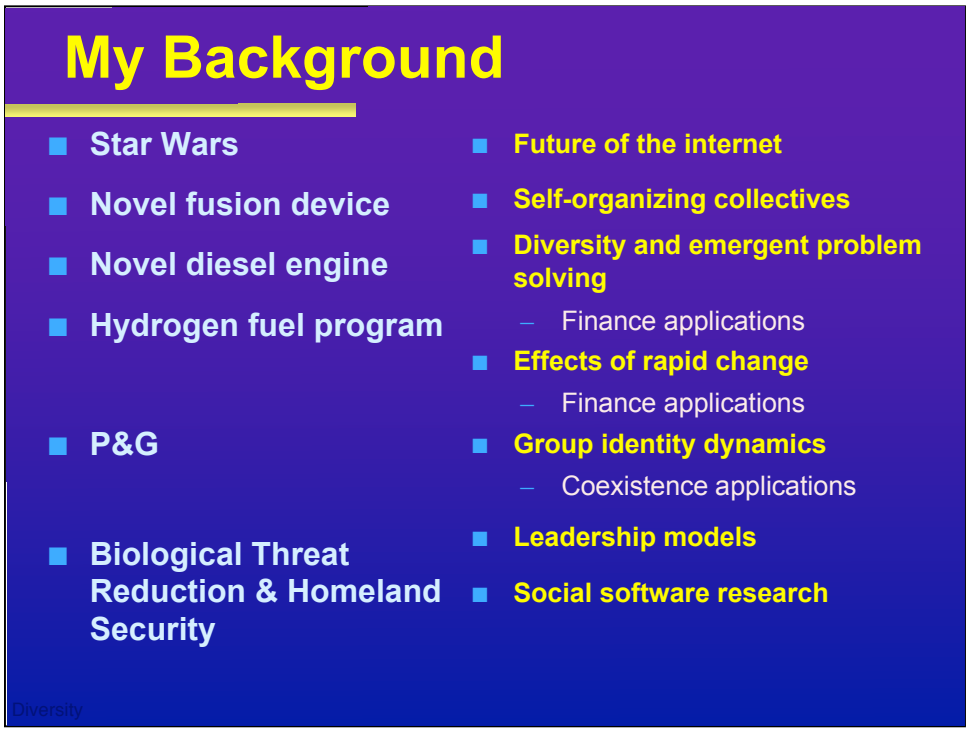
Questions (with Plausible Deniability)

- Are you using "human dynamic" models?
- Academic? Government? Company?
- Are you a developer?
- Is habitual behavior included?
- Does the behavior change with need?
- Does the behavior change with stress?
- Is leadership included?
- Does the model include emergent behavior?
- Uniquely innovative behavior?
- Are you satisfied with your model? Is it working for your application?
- Is your model validated?
- Do your agents behave like you? Are you unnaturally attached to them?

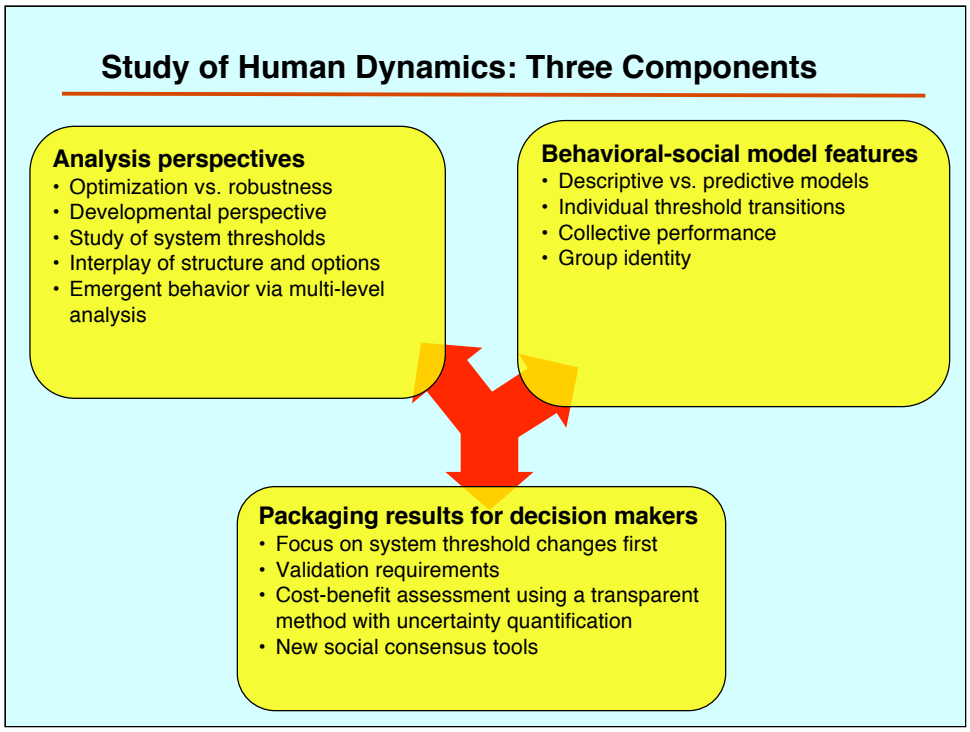
Diversity

The point of these questions is to find out who you are, and to get you to listen and thinking about how the material applies to you. But also to highlight where I think there are some missing pieces in the work the community has done - for example addressing threshold changes of behavior.

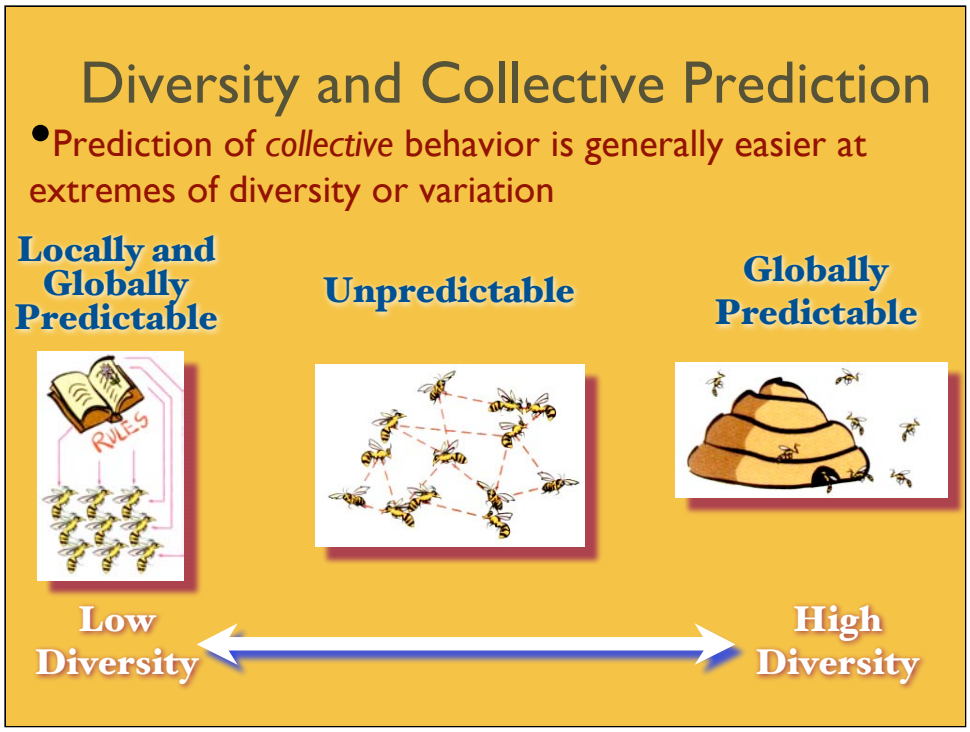
Interestingly there were mostly academics - say 90%, and the rest government. And not companies represented.



This illustrates how we even capture diversity in our jobs. On the left is what I did officially for 25 years at Los Alamos National Labs. At the right was what I did in my spare time and passion - which is what this talk is about. That said, there was a convergence at the end when I worked on Epidemiological simulations - which bought social behavior into the core science side on the left.



THis is the table of contents for the talk. I spent quite a bit of time trying to figure out how to organize the different topics and how to show where the challenges and opportunities are. This is what I came up with. The Analysis Perspectives are aspects of complex systems. The Behavioral-Social Models is self-explanatory. The Packaging for Decision Makers is how I think we have to package the results of the two boxes at the top. It is not enough to understand or model the systems. You also have to package them in useful forms.

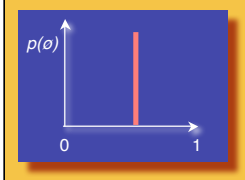


The major "ah-ah" I had about social behavior was seen through the perspective of diversity: which can be technically viewed as distributions and how these enable prediction – with respect to diversity or heterogeneity of the system. The above is one view of this perspective. Turns out that a little or a lot of diversity (that is well sampled) is good for prediction. The qualifier "well-sampled" diversity is required because some systems have lots of diversity that is poorly interconnected (or rigidly connected) and therefore the diversity really doesn't really get sampled, which has a major effect on the dynamics or robustness of the system – a prime example is a senescent ecosystem: lots of diversity but very restrained interactions. Same is true for old economies.

Diversity and Collective Prediction

- How does this translate to distribution functions?

Locally and Globally Predictable



Unpredictable

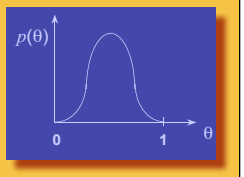
Problem distributions:

- Discrete distributions
- Multi-modal distributions
- Long-tailed distributions

(e.g., power law,

instead of Gaussian statistics)

Globally Predictable



Low Diversity ⟷ **High Diversity**

So what causes distributions to be not "nice"? One list is given above. You can read lots on this looking at the work by Tsallis (more on this in a bit).

Predictability is challenging when:

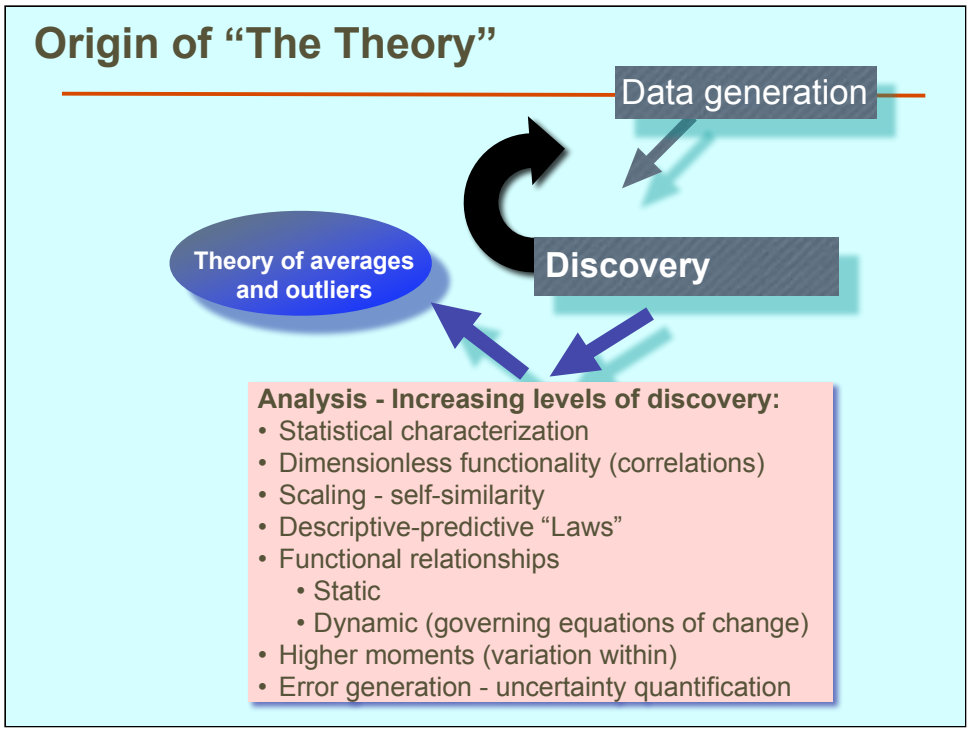
- The complexity barrier was passed - strategies may not lead to desired outcomes
- Subjective or emotional evaluation dominates rather than objective evaluation (often a consequence of complexity)
- The system has “calcified” - internal or external structures lead to lack of robustness if change present.
- New structures (e.g., technology changes) introduce new options
- New environment causes system to explore uncharted responses

This is just an empirical list of how predictability breaks down. Some of the items show how distribution as limited or changed by structure are a useful viewpoint into prediction.

Evolvability is challenged when:

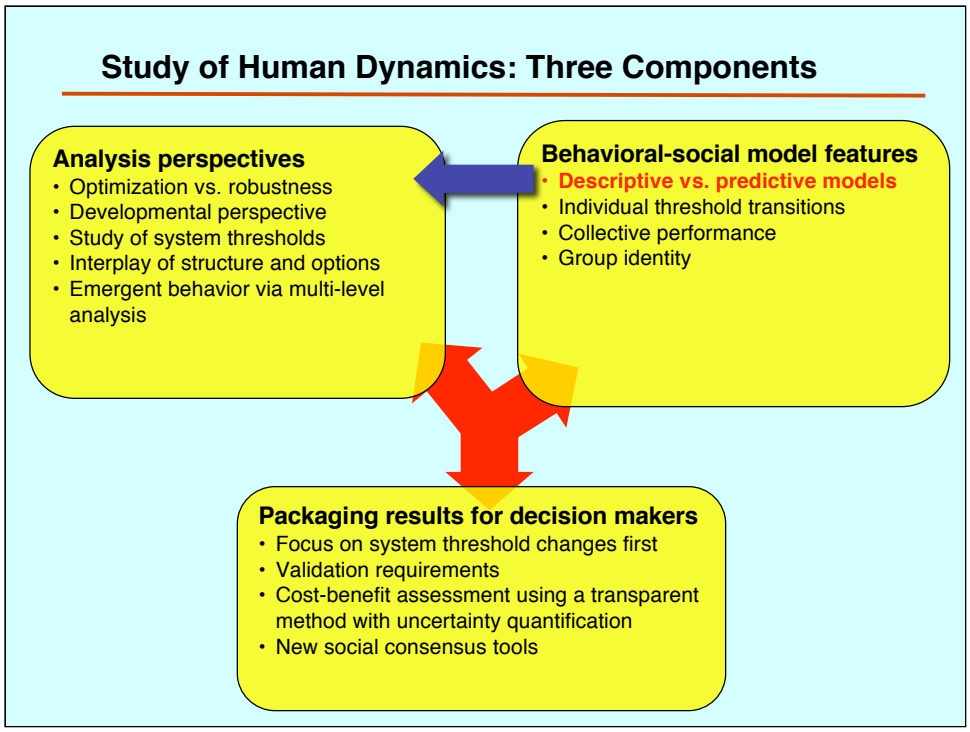
- The system has “calcified” - internal or external structures lead to lack of robustness.
- The complexity barrier was passed - strategies may not lead to desired outcomes
- Subjective evaluation dominates rather than objective evaluation (often a consequence of complexity)
- Habitual or peer-copying behavior dominates rational choices
- Low diversity limits exploration
- Limited synergy between existing diversity limits innovation

The other side of the coin of prediction is evolvability.

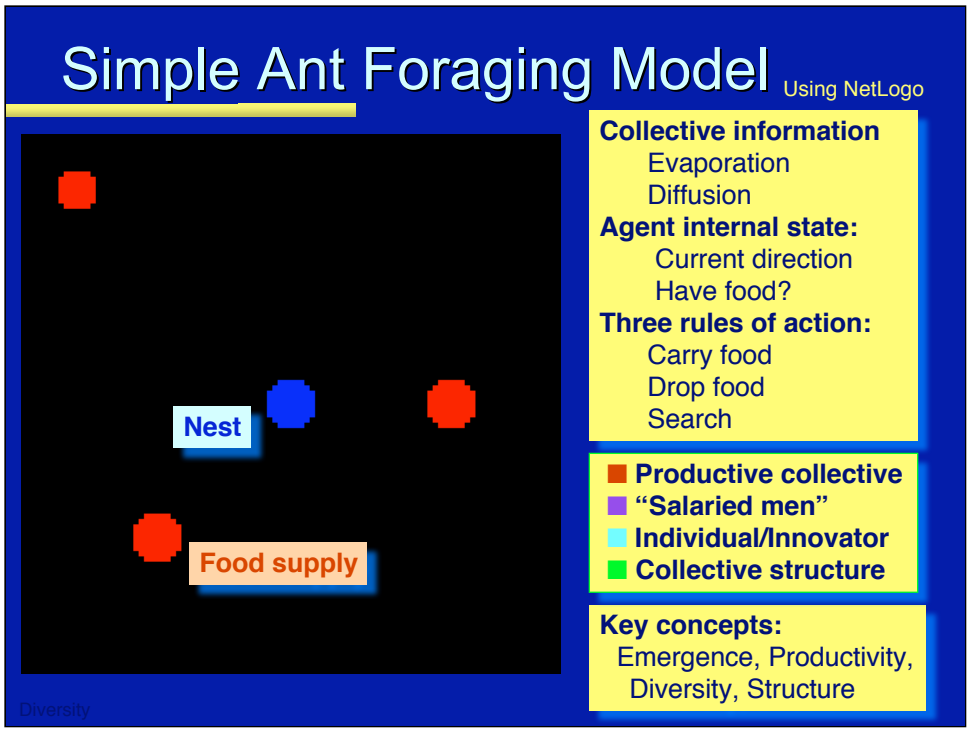


This viewgraph illustrates the context and role of scaling or power laws in science (and business).
Observations:
•Most businesses stop at correlations in dealing with large amounts of data. The challenge and big payoffs are from driving further down in the list. My view is that this is why we are all here today.
•The last two items are rarely touched even in well developed sciences, but are proving to be the real resources needed for decision makers in dealing with complex systems with potentially severe unintended consequences of decisions. Much of this can be captured under the rubric of UNCERTAINTY MANAGEMENT.
•Higher moments refer to the variation of the data around the mean
•Error generation refers to the tracking of uncertainty in systems or of the noise in a system. (search on "infodynamics" on the web for background)

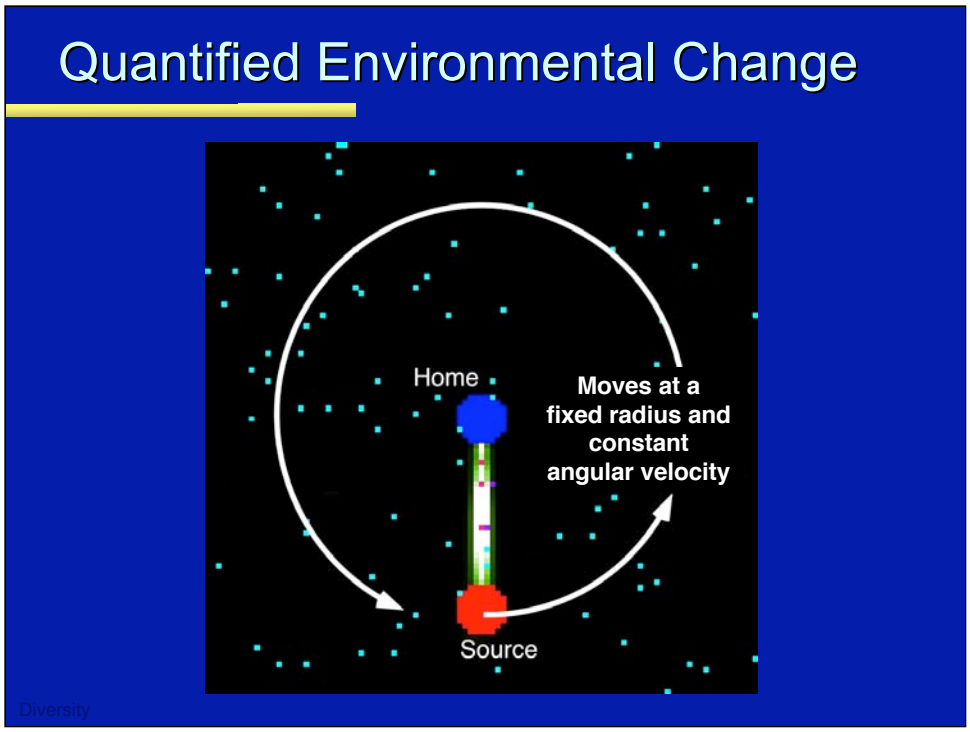
(See Doyne Farmer's chapter on Power-Law distributions for more details on this viewpoint)



The last slides targeted prediction vs. description. Let's push these over to system behavior.

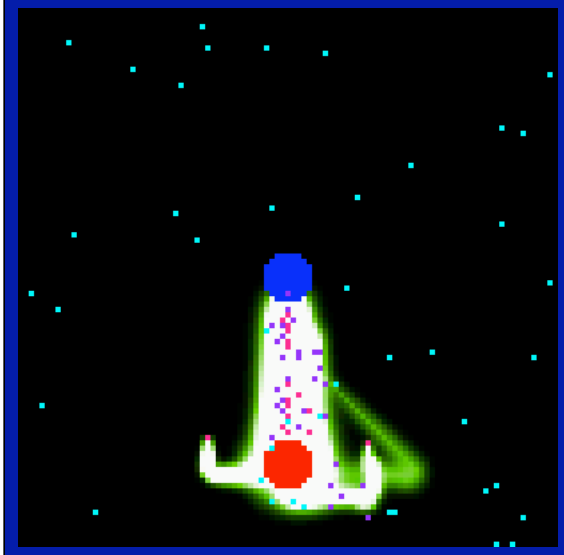


Contact me for movies a paper that describes these simulations, movies for these slides, and the NetLogo program that is used to generate the movies and results.



Most studies examine steady-state systems. But most real systems are undergoing change and now as drastically different rate of change. So we must understand how to model variable rates of environmental change and what type of behavior is exhibited. This is just a simple example. Contact Norman for a paper that describes this study in detail.

Slowly changing environment



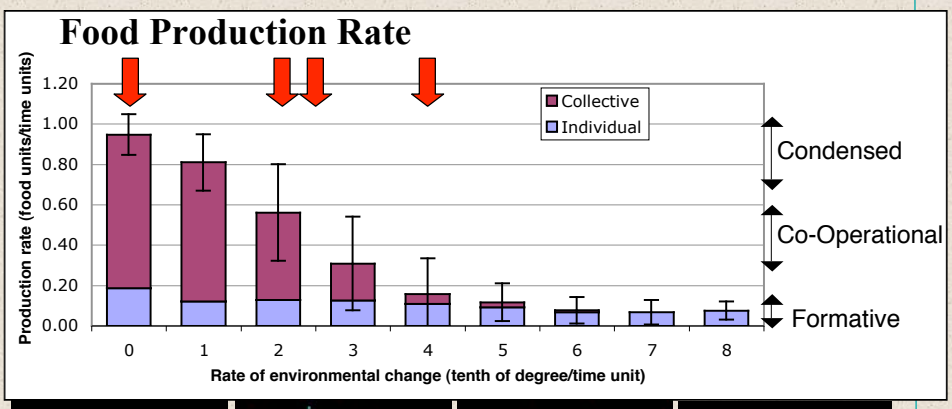
Diversity

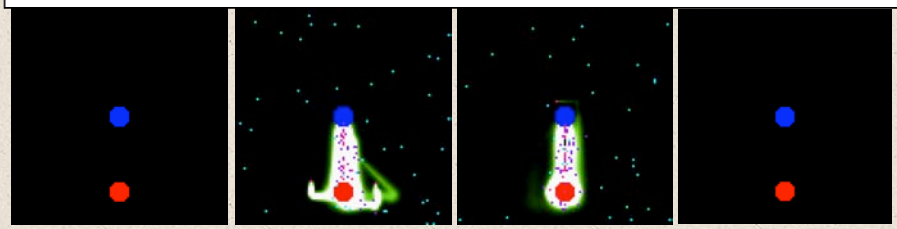
Productivity is only slightly less than an unchanging source

Herd effect allows for quick utilization of new resource location

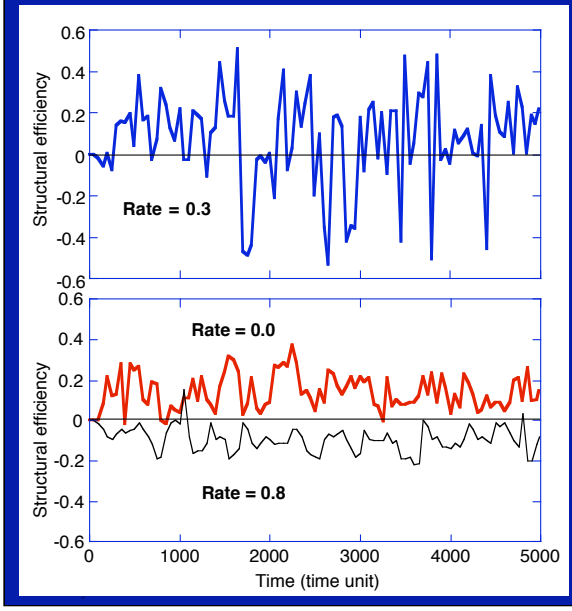
Innovators become important (again) by sustaining optimal performance of the collective

Effect of Rate of Change on System Development





Structural Efficiency - Boom and Bust

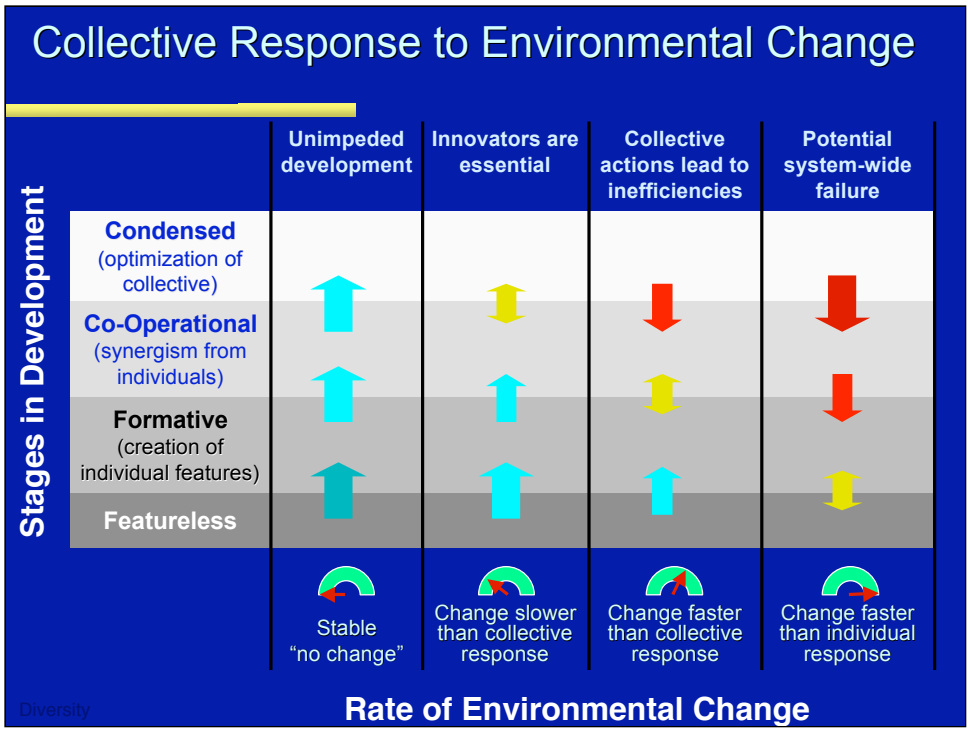


Lower average production -> crash avoidance

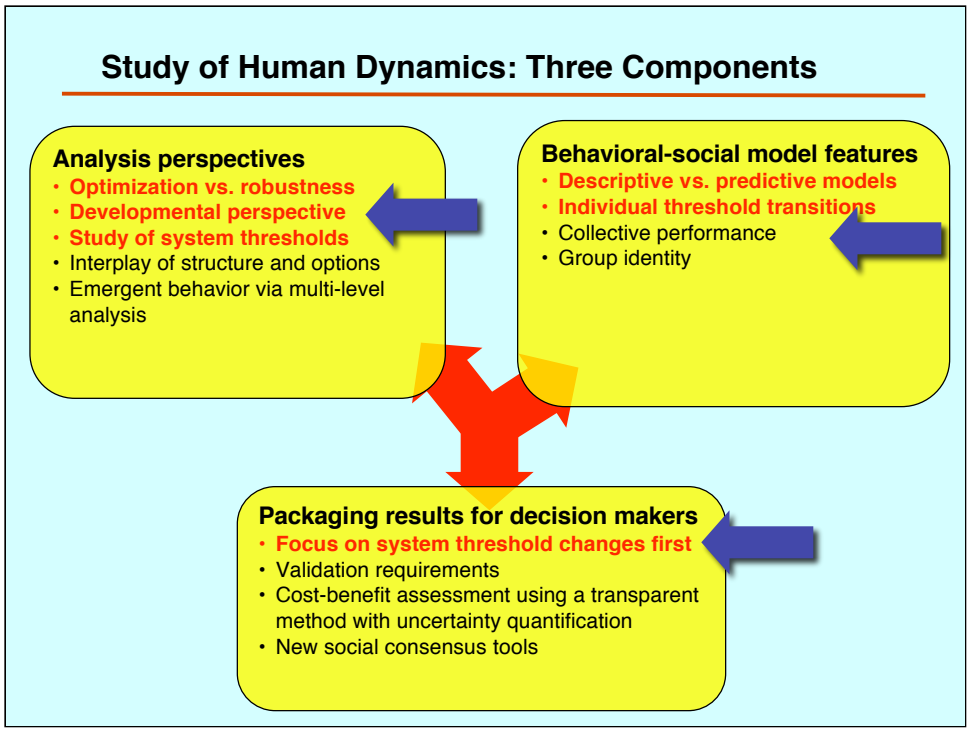
Greater minimums and maximum when compared to extreme rates!

Bust is proceeded by increased production

The structural efficiency is defined as how much the pheromone cloud contributes to the foraging supply. It can be positive or negative.



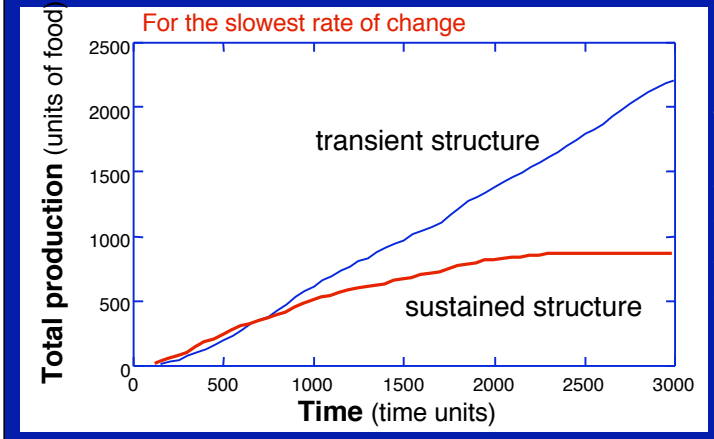
This is a summary of how this simple problem goes through different stages of development. And how increases in the rate of change forces the system to more immature states of development. Contact Norman for papers on this discussion, particularly how it related to the different process of selection and synergy in collective performance.



This summarizes what we just saw. We saw that looking at diversity leads to an understanding of optimization versus robustness. Looking at the system processes introduce a useful perspective that system develop and aren't just random - even for evolutionary system that are considered to be driven by random processes. Because a development perspective leads to transitions in different processes, system threshold are observed and become an essential consideration for decision makers. And excellent example is the threshold changes we are seeing with CO2 levels at "350" - our climate appear fairly stable until this threshold was reached. Now changes are happening rapidly.

Combination of Sustained Structure and Change

How does the retention of structure change the collective response?



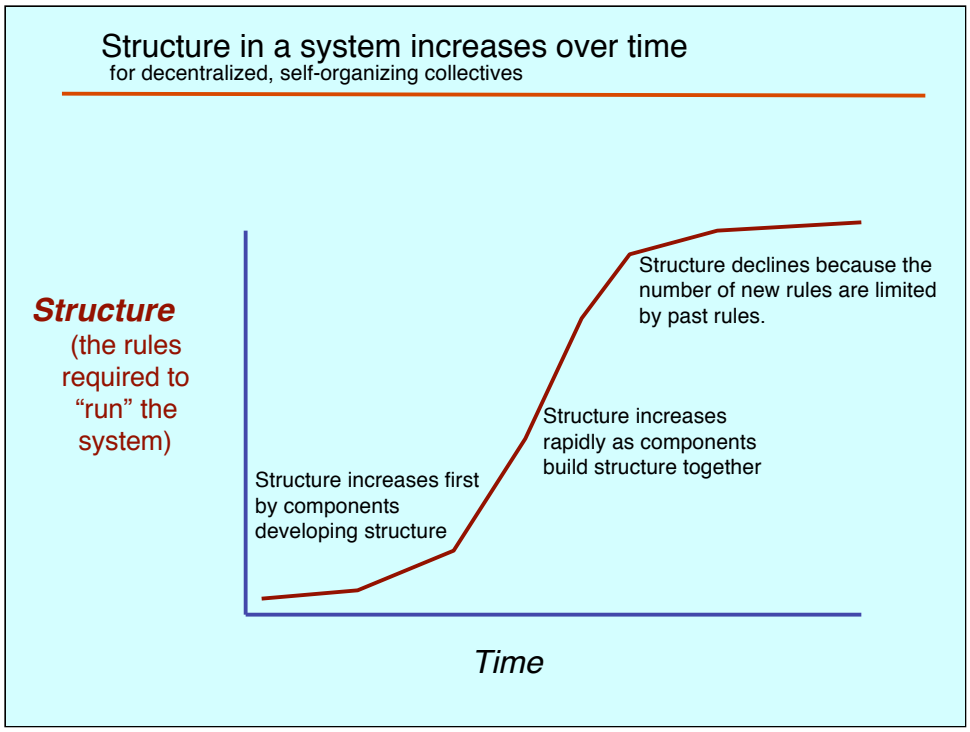
Suggests that fixed evolutionary adaptations lead to inefficiencies in the presence of even small rates of change

What would be the effect of a faster ant?

What would be the effect of mass communication?

Diversity

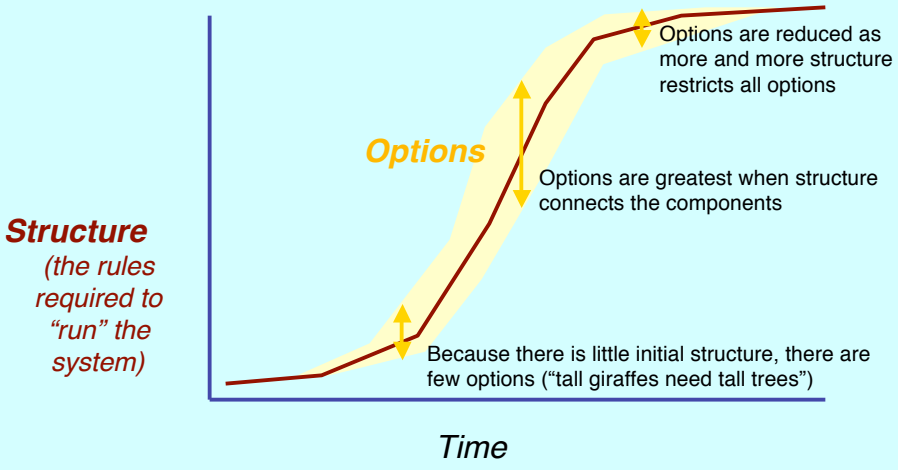
The previous foraging example was an illustration of a transient pheromone structure. What would happen in the simulations if the pheromones persisted above a threshold concentration? The above figure shows the result for even the slowest rate of change. This illustrate how structures can strongly inhibit adaptation in a system - and results in the need for creative destruction (Google this phrase and Foster's book by the same name).



Here's a summary of an evolution of a system and how structure first creates options and then limits adaptivity. With a sweet spot in between.

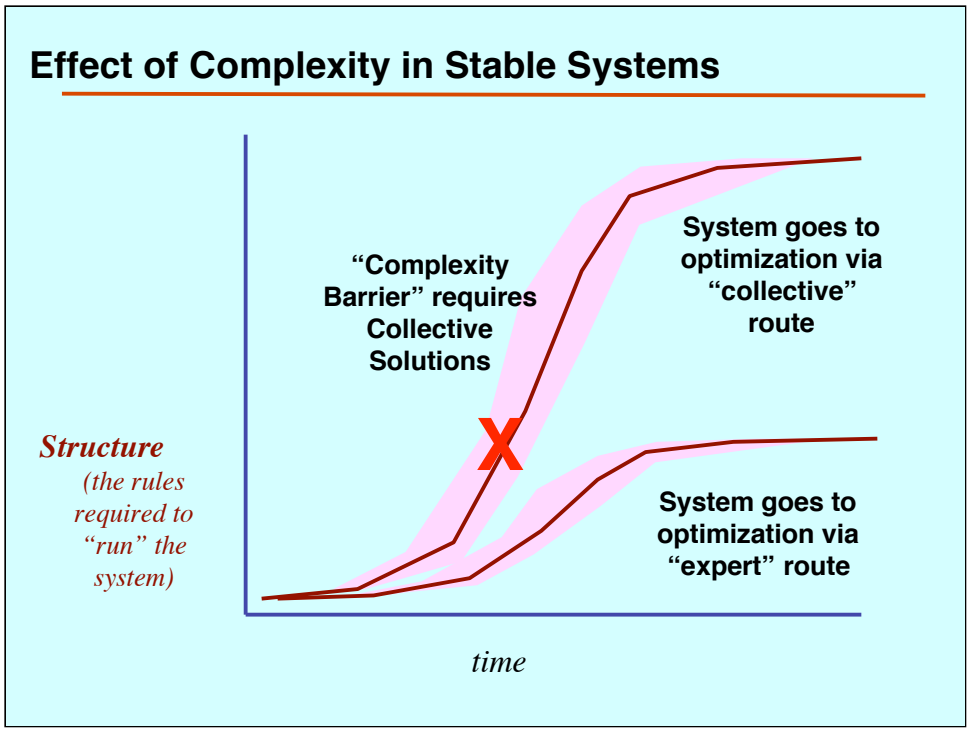
Options around Structure also change

Options are the free choices both created and limited by the structure
(example: the rules of chess create an "environment" where many options are possible- while also limiting what choices are available)



These ideas are captured by researchers studying "infodynamics"

The best way to understand how structure affects a systems is by how it changes options during the evolution. Google infodynamics. And ask Norman for a paper on this topic.



This illustrates how in systems with lower complexity, the synergistic state can be bypassed - as is often the case when a "expert" or most fit performer is present. Hence the utility of the collective in the low in the second slide until the complexity increases sufficiently to confound the "expert".

Why Care about Structure-Options?

Studies of thresholds in structure:

How structure controls change, innovation and evolution

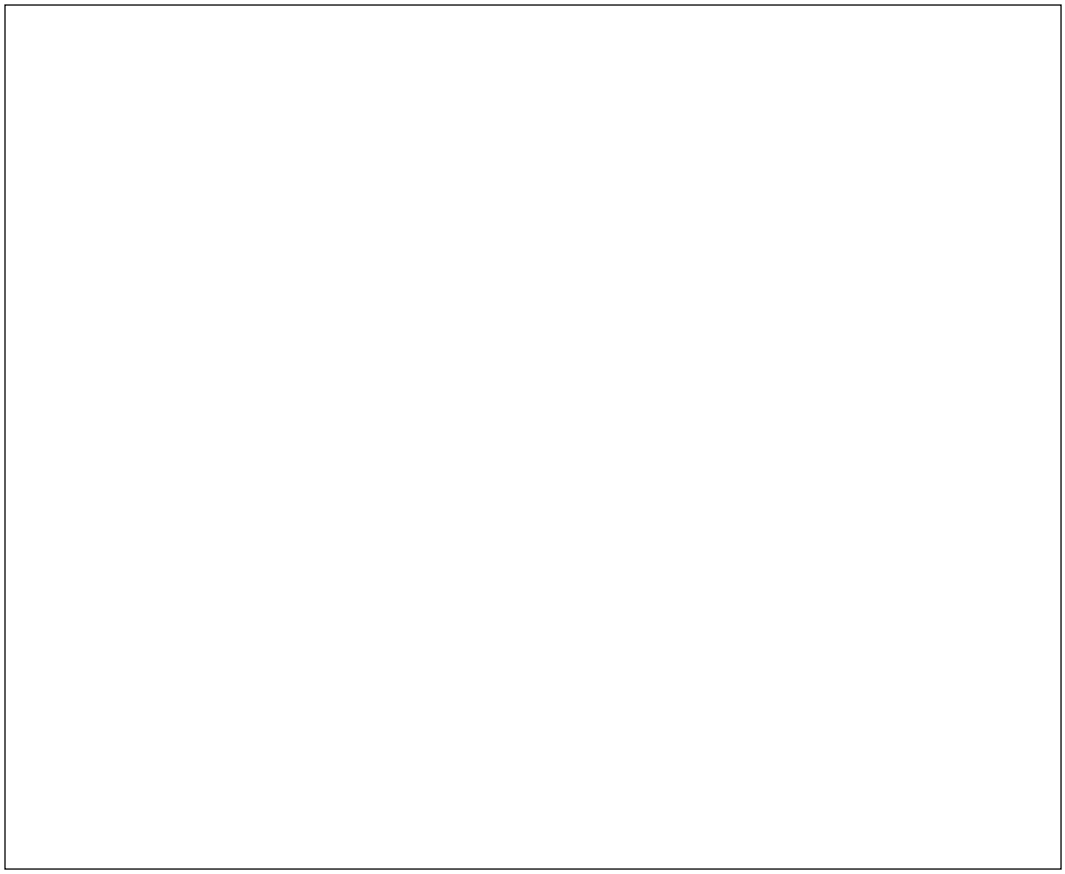
- Prigogine's Laws of Stasis, Change and Evolution
- Joseph Schumpeter's Creative Destruction
- Foster and Kaplan "*Creative Destruction: Why Companies that are Built to Last Underperform the Market - And how to Successfully Transform Them*", 2001
- John Padgett life's work on innovation in the Florentine (and world) finance system
- Johnson and Watkins - on the study of selection vs. synergy - particularly for information systems

- **Dynamic "structural" thresholds do the same**

Contact Norman for the Johnson/Watkins paper.

Prigogine's Laws of stasis, change and evolution:

- System near equilibrium cannot evolve spontaneously to generate spatial–temporal (dissipative) structures
- As the system is driven far from equilibrium, it may become unstable and generate spatial–temporal structures
- Near-equilibrium temporal evolution typically destroys structure
- Far from equilibrium, beyond the limit of stability of the near-equilibrium behavior, nonlinear kinetic processes associated with flows of matter and energy can generate structure



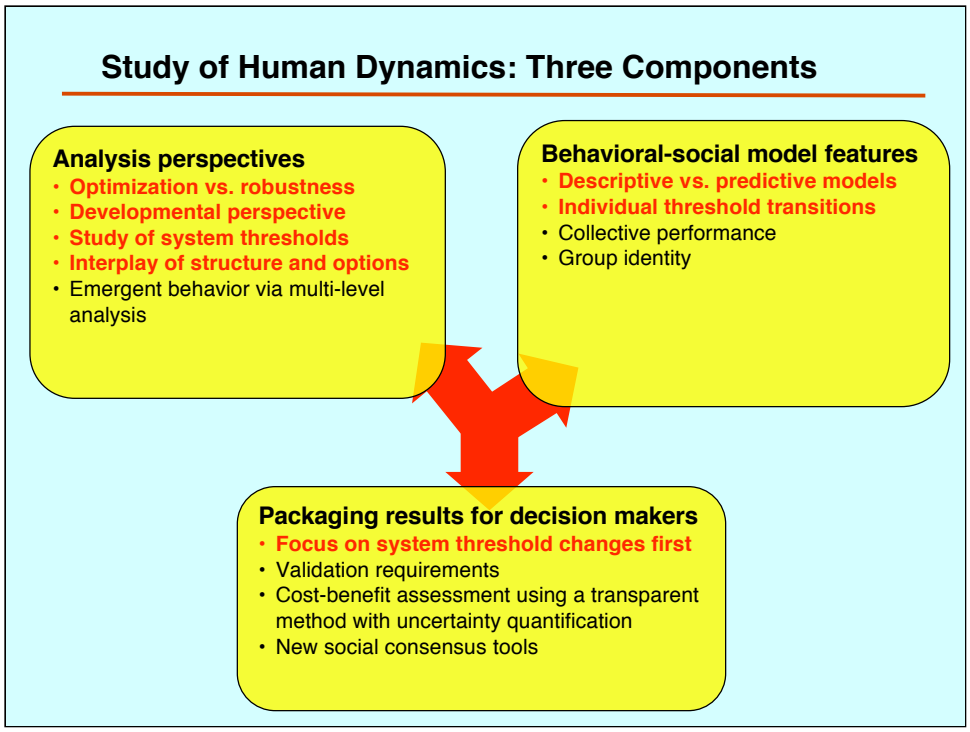
The Structure of **Structures**

Structures direct the evolution of the system by creating and limiting potential options
Their definition depends on the time constant of exogenous/endogenous change.

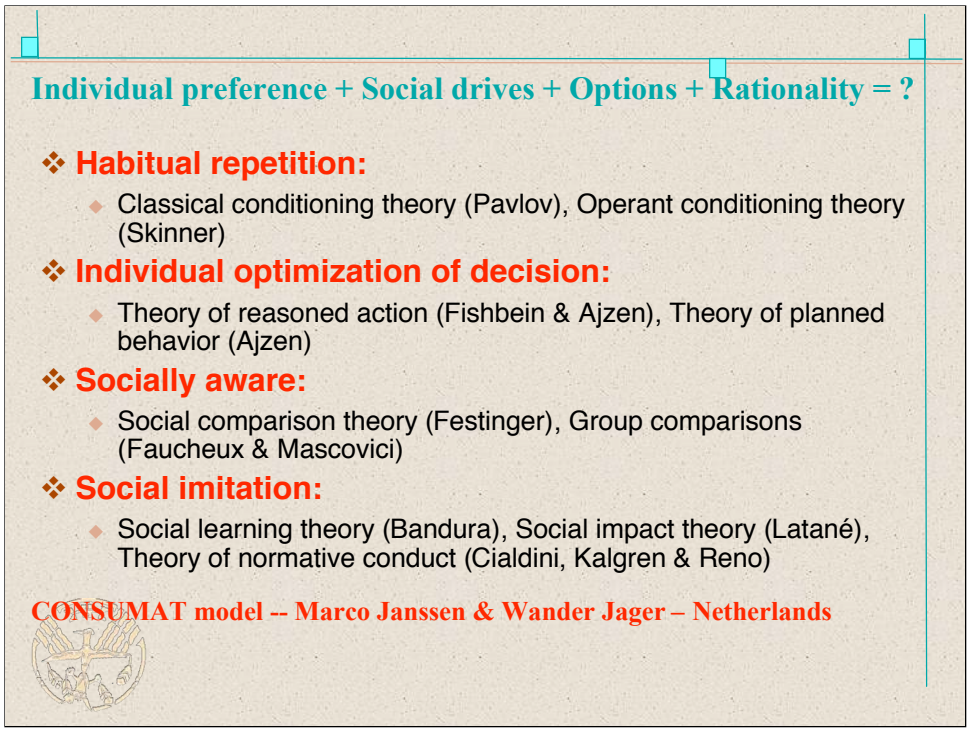
Description	Determines evolutionary path directly	Retained once expressed	Always expressed	Origins: Random, Direct, Emergent
Experiential or transient features Learning – Ant position				R
Shallow surface features Coloring – Collective solution		X		R
Deep surface structures (frozen ``accidents'') Specific DNA coding	X	X		D,E,R
Deep system structures (frozen organization) Digital coding, nucleus formation	X	X	X	D,E
Features reflecting fundamental laws Hydrogen bonding	X	X	X	D

Diversity

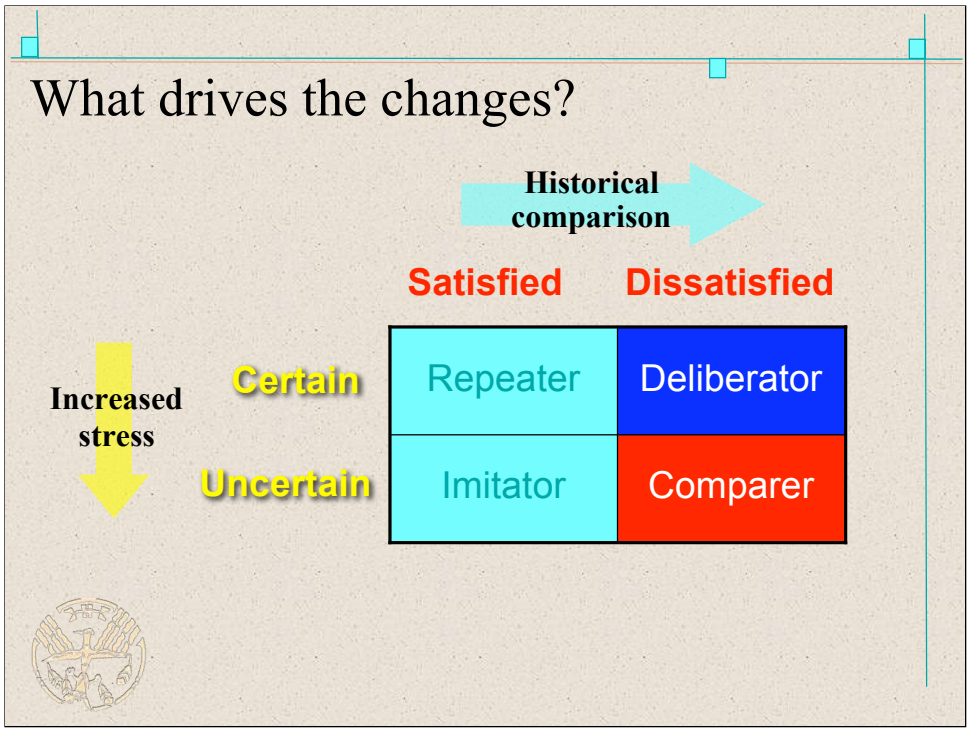
This is a challenging slide but very important - shows how there are different structures, defined by different properties or origins. Contact Norman for this unpublished work. The properties are the ones used in **Wonderful Life** (Stephen **Jay Gould**), when the "tape" is played again.



The interplay for structures and options is often missed in the analysis of systems and are critical to prediction.

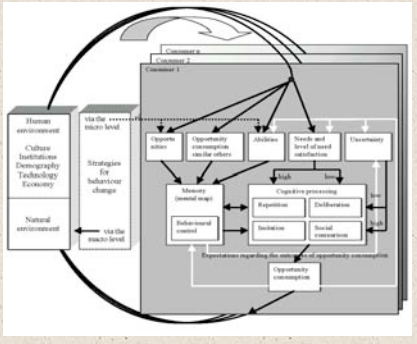


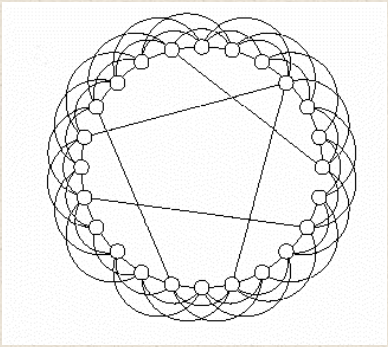
Let's return to social and behavioral models. This is a quick summary of the most complete model in my judgment - Google CONSUMAT. The developers asked the question how can we integrate the validated and accepted models into one consumer behavior model, listed above.



They observed that the critical integration step was to introduce two drivers for behavior change - as above. When either of these drivers are small, there behavior is habitual - you do what you did before. This is an often ignored state of behavior. And this approach captures how the different models can be integrated into a single model. Threshold transition are essential!!

Individual Behavior + Network = Global Dynamics



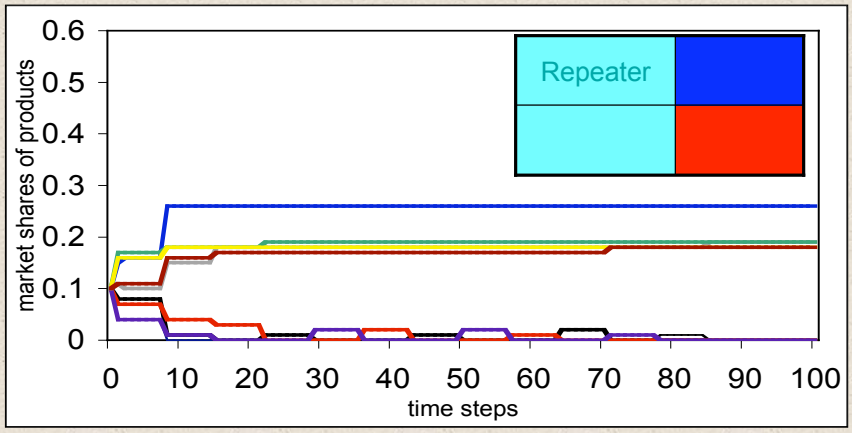


1000 Consumers with the same behavioral tendency buying 10 products on a small-world network

The following example is available in a publication online. And shows how different states of individual behavior lead to very different global behavior - for a specified network. Note that the network changes transition points, but realistic networks all have the same global states.

Population of "Repeaters" - satisfied and certain

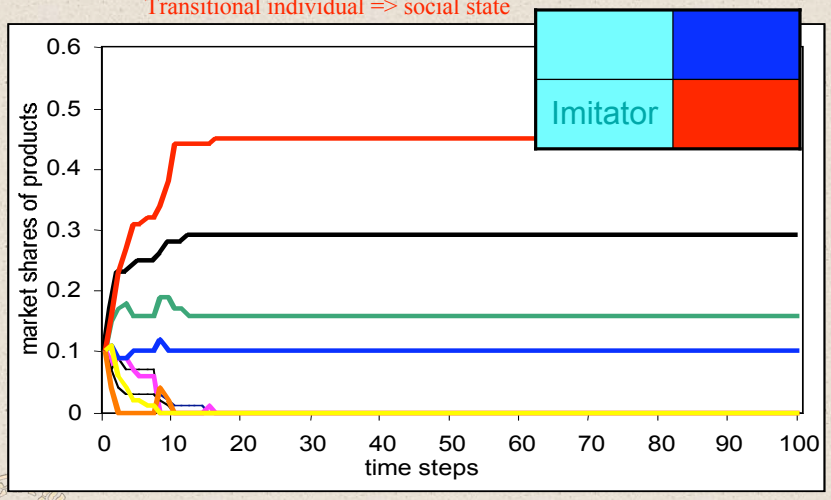
Closest to "Rest state"



Few products of equal distribution - highly stable

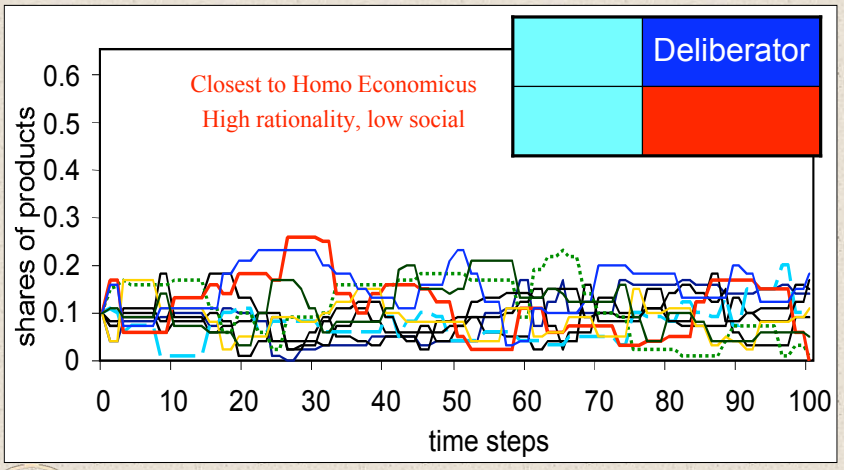
Population of "Imitators" - satisfied but uncertain

Transitional individual => social state



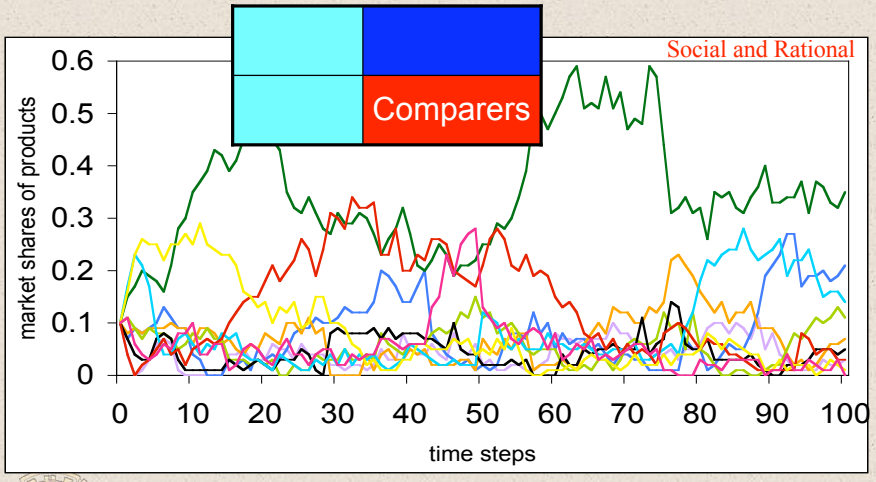
Few products of unequal distribution - highly stable

Population of "Deliberators" - dissatisfied but certain



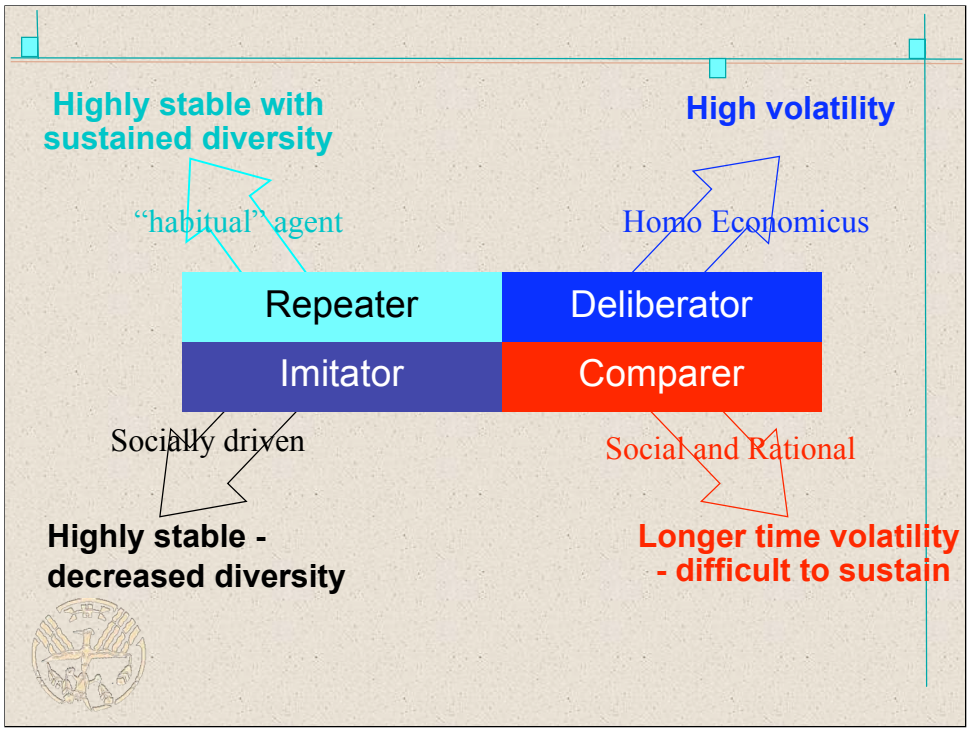
High volatility on all products

Population of "Comparers" - dissatisfied & uncertain

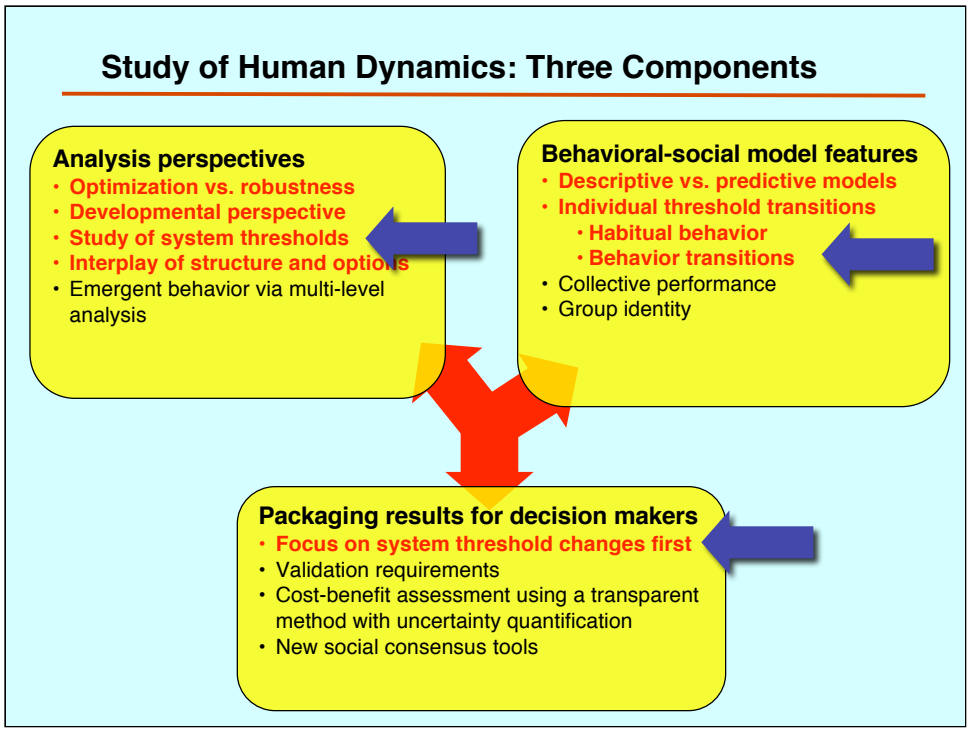


Volatility over long times on few products

But difficult to maintain - high energy state



THis summarizes the last results and how individual behavior leads to different global dynamics or states.



We now show how individual states can effect global states and systems change change abruptly when thresholds are passes. We saw this ealier in the ant foraging. Now we also see it for realistic human behavior models.

Expert Performance in Finance

Why can't financial experts outperform the S&P 500 "collective" – good + bad – consistently?

- Professional money managers fail to beat the S&P 500 at an average rate of 70% per year.
- 90% trail the S&P over a 10-year period.
- Over decades are only a few – Soros, Miller, ….

"These are the people who have more knowledge and more training than the vast majority of investors. And yet, neither the superior knowledge nor the superior experience helps them in the long run."

Bill Mann, TMFOtter

Diversity

Now let us turn to collective decision making. Here's a realistic example.

Prediction

LEGG MASON
CAPITAL MANAGEMENT

Academy Awards

12 categories
Not a poll, a prediction

2007

Consensus:	11 out of 12 correct
Best student:	9 out of 12 correct
Average student:	5 out of 12 correct

From a workshop on Complex Science for the Physician's Alliance

Source: www.turbosquid.com.

Here's another. For the full text and slides of this talk Google the workshop above.

Diversity Prediction Theorem

LEGG MASON
CAPITAL MANAGEMENT

Scott Page's
Diversity Prediction Theorem

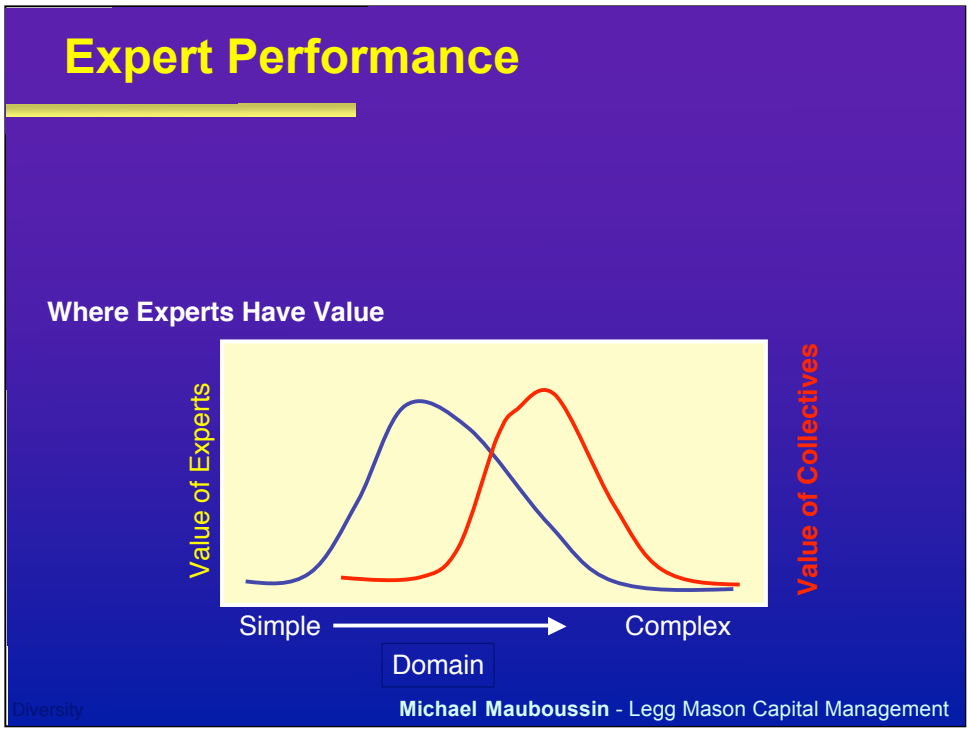
Collective Error =

Average Individual error
minus
Prediction Diversity

Source: http://polisci.lsa.umich.edu/faculty/spage.html.

"The Difference: How the Power of Diversity Creates Better Groups, Firms, Schools, and Societies"

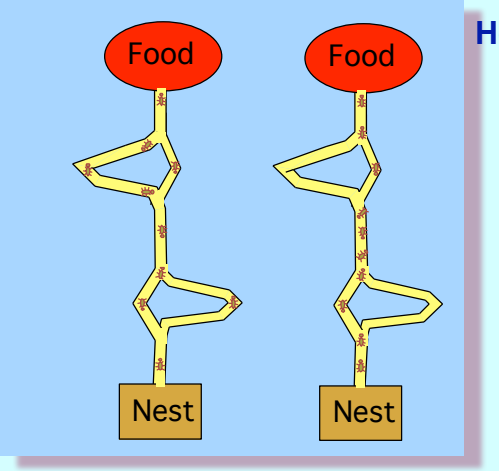
This rearrangement of the common standard deviation definition explains much of what we've observe in collective systems.



Applying the theorem: When the individual error starts to get large because the complexity of the system is too great for the individual to understand, the collective performance drops, independent of high diversity. See the CollectiveScience.com website for the paper on this topic in greater detail or contact Norman.

Ants Solving “HARD” problems

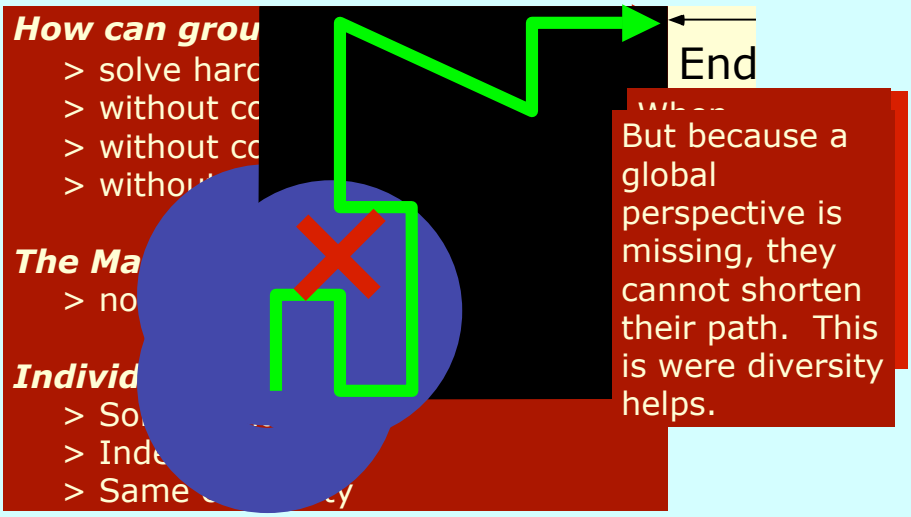
The ant colony (and individuals) finds the shortest path



How does it work?

This is a well known example. But one major ‘ah-ha” is that if the ants have no diversity to begin with they won’t every find a shorter path. This is NOT the same as Darwinian diversity leading to better performance - because synergy of diversity is required, not selection from diversity: when the shortest path is found by the collective there is no one ant (in a complex system) that is actually taking the shortest path!!

A Model for Solving *Hard* Problems



To view this slide, you must use the presentation mode.

Let's look at the idealized simulations that I did. (Ask Norman for the paper or see CollectiveScience.com)

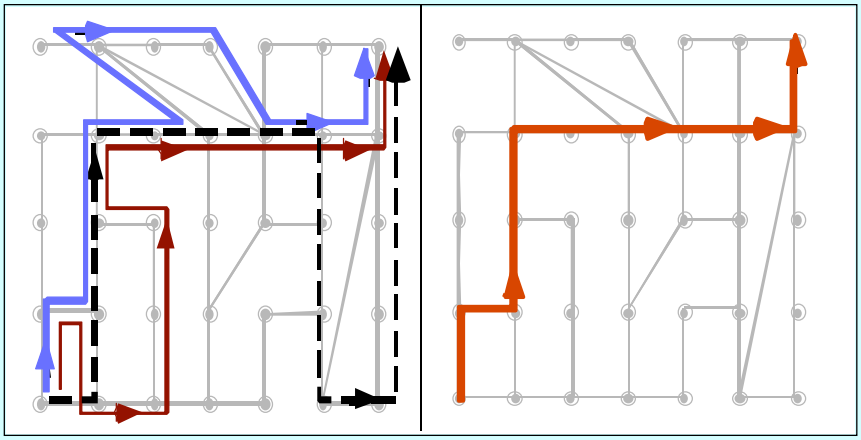
I asked the question: How can groups solve problems better - without coordination, cooperation or selection? What I did was to have many individuals solve a maze - independently and with the identical capability.

And they solved it without having a global perspective of the problem. For example, at the beginning an individual has two choices - not knowing where the goal is, they randomly pick one path. Then at the next junction, they pick from 3 paths, and so on. Until they find the goal.

This is an example of a path of an individual. Note that in repeating the solution, the individual will cut off extra loops - remember the last time you went to a new restaurant again, you did not randomly drive like you did the first time - you optimized your solution, based on your learned information.

We see that the individual could improve their solution even more, but because they don't have a global perspective, they cannot see how to make a shorter path. One individual cannot know everything. Filling this gap is one way how diversity can help.

How collectives find the Shortest path



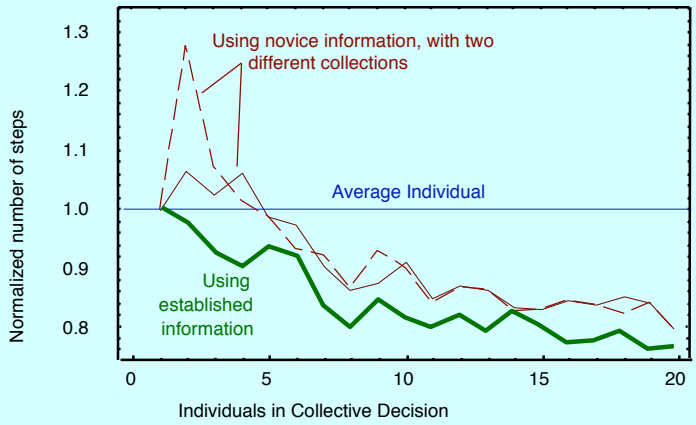
Paths of three ants

Collective path

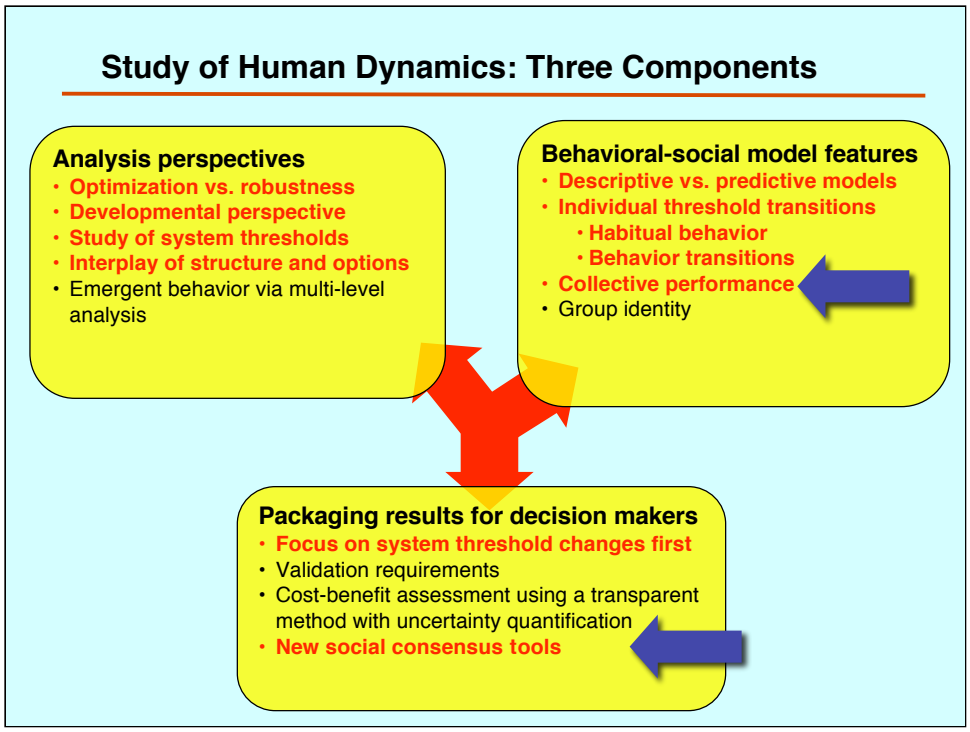
Unlike in natural selection, no one individual is the fittest!

No global perspective, but results in short path - a global property. Therefore, and emergent property of the problem.

Ensemble (Averaged) Behavior



Performance correlates with high *unique* diversity



These observation of emergent collective performance (sometimes called collective intelligence or swarm intelligence or wisdom of the crowds), has lead to new social collaboration and consensus tools. Contact Jen Watkins for a summary paper on these tools.

Diversity - source of conflict or synergy?

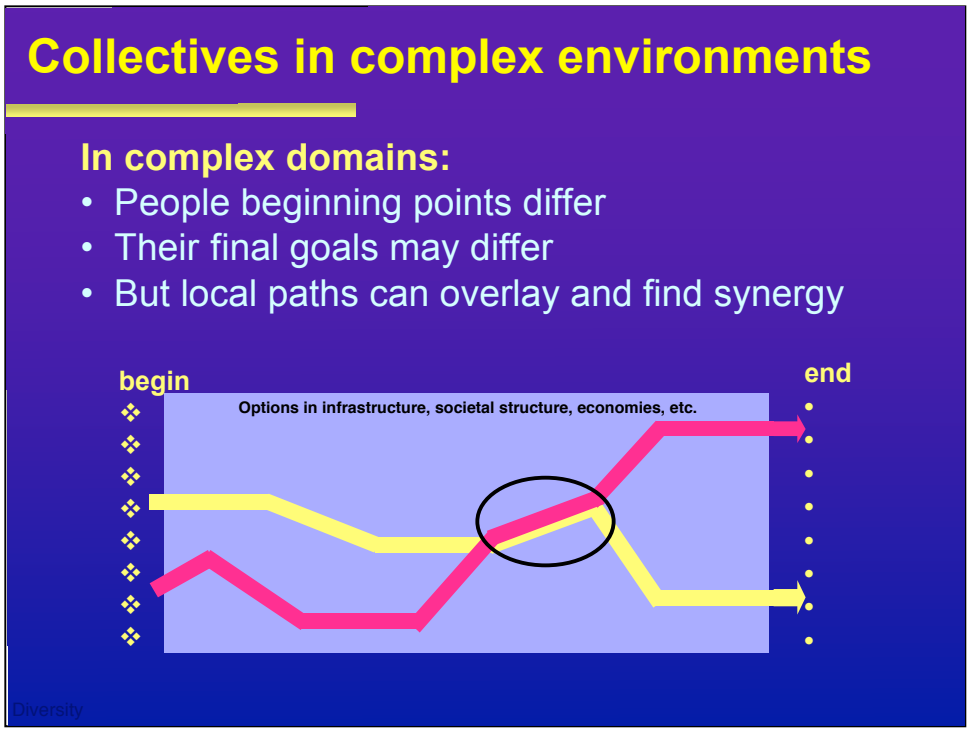
Diversity can lead to synergy when collectives have:

More restrictive

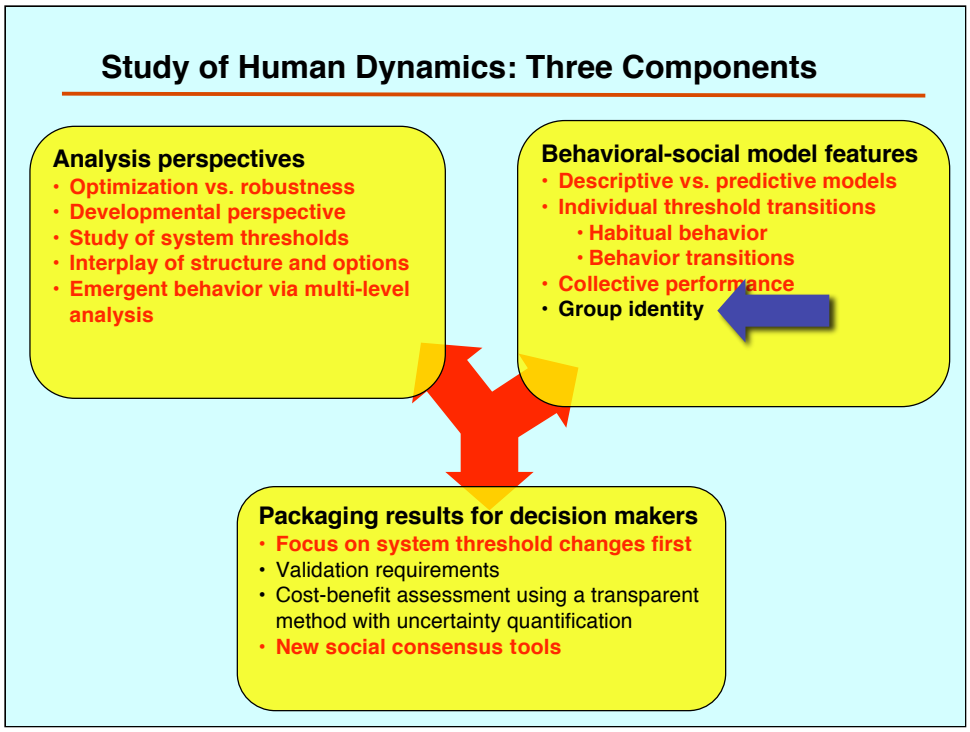
- **Common goals**
- **Common group identity**
- **Common worldview (agreement on options), but with different preferences or goals**

Otherwise, diversity can lead to competition and conflict

A major question that arises is when does diversity lead to conflict (which was what was observed in most selective systems) versus synergy and ultimately cooperation. This is my view on the topic. Ask Norman for papers for more discussion.



This is just an illustration how in a complex world, you don't have to have the same beginning point or goals to have synergy in diversity - you just have to have "paths" that overlap.



We now see that global emergent behavior is the key perspective to understand collective performance. What about the dark side of Collective systems - as observed in groups with a common identity?

Why Care about Group Identity?

Social organisms have a strong drive to form group identity:

"... experiments show that competition is not necessary for group identification and even the most minimal group assignment can affect behavior. 'Groups' form by nothing more than random assignment of subjects to labels, such as even or odd."

Group Identity can be the dominant factor of behavior:

"Subjects are more likely to give rewards to those with the same label than to those with other labels, even when choices are anonymous and have no impact on their own payoffs. Subjects also have higher opinions of members of their own group."

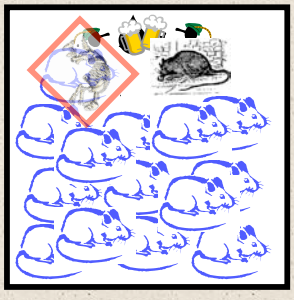
Ethnicity question on IQ tests

Akerlof, G. A. and R. E. Kranton (2000). "Economics and Identity." Quarterly Journal of Economics 115(3): 715-753.

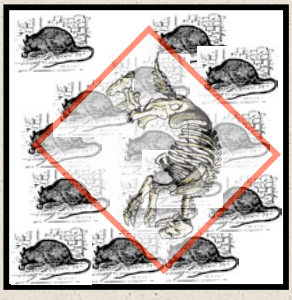
Diversity

Rat Studies of Maximum Carrying Capacity

One "social" rule =>
Cooperative social structure



Control group - no "rules" =>
Your worst nightmare



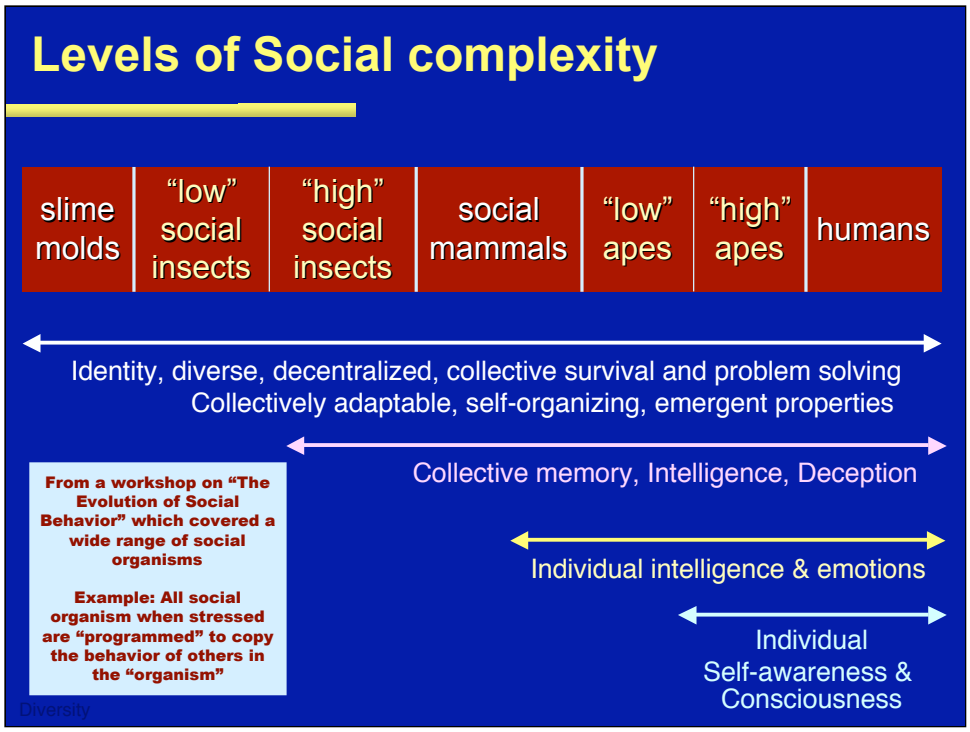
NIMH psychologist John B. Calhoun, 1971

Both systems loaded to 2 1/2 times the optimal capacity.

Social order system can carry 8 times the optimal capacity before going over the threshold.

This experiment shows how a simple change (requiring two rats to get a drink of water) cause major changes in global societal stability. But the real story was when one of the control rats on the left go loose in the "ideal" system: One of the ideal rats tried to help the control rat get water, which the control rat took as aggression and attacked and hurt the helping rat. The helping rat continue to try to help even though attacked - until it died.

Contact Norman for the Calhoun paper on this topic. THis illustrates that even "simple" social organism can exhibit complex behavior of individual suicide for not logical reason, except sustaining group identity.



The different qualities associated with different social organism are just a guess by Norman - But this viewpoint appears to be supported by researchers in the field. It is a major reason to be optimistic about modeling human behavior is a useful way. The lesson is that we tend to focus on what's unique in humans, but the most successful models - like CONSUMAT - focus on what common to all social organism!!

Group Identity as the missing piece

Suicide bombers – War heroes – Defensive mothers

All about sacrifice of self to the "greater self"

What can we say about group identity and behavior and system dynamics. Note that this type of social behavior was not specifically captured in the CONSUMAT model.

Identity: Assertions and Definitions

Identity

Despite the long-standing recognition of the importance of identity in social systems, most studies of identity are observations of identity's influence on individual and group behavior, rather than understanding the processes by which identity forms and modifies behaviors.

Group Identity == Mechanism of Group Immunity

Common definition: if someone does something to a person in your identity group, it is the same as if they did it to you.

Working definition: Identity is the individual behavioral bond/process that creates a "group self" that has all of properties of an individual self.

Assert: Group identity in higher social organisms can be an abstraction that detaches from the origin of the identity group.

An example of abstraction of identity is the Muslim fundamentalist groups that now behave is a manner that is in direct conflict with their religion.

Questions from an Identity Perspective

Identity

Answers, or at least a beginning of an understanding, of questions like these will help to inform policy regarding intra and international negotiations and other actions designed to bring about the resolution of conflict. It will aid them in identifying unintended consequences of hasty actions, such as the use of extreme force. Or, how to prevent violent conflict and grow the conditions for peace.

What are the characteristics of identity groups?

What are their dynamics? **Formation, stability, coalescence, expression, polarization, influence, dissolution**

How does group identity affect the acceptance, adaptation, spread and exploitation of an idea?

Does the rapid spread of an infectious idea (e.g., a fad) require a common group identity?

What are the conditions that cause identity groups to become destructive to other groups or to factions within a group?

How does a "leaderless group" group use identity to self-organize?

How does insurgent news/press of "violence on self" polarize the "self"?

How does diversity affect identity formation? Performance? Stability? As diversity decreases, will tolerance decrease?

What are the conditions necessary for coexistence to emerge between identity groups?

How does one really build a democratic nation from fractionalized groups?

An example of abstraction of identity is the Muslim fundamentalist groups that now behave is a manner that is in direct conflict with their religion.

Characteristics of Identity Groups

Identity Groups (IDGs) express a common worldview – an understanding of how the world works: what are options and what is forbidden

IDGs have a shared, unspoken knowledge that is typically unknowable outside the IDG

IDGs often have symbols of association such as dress or language differences, often unobserved by others

IDGs – when in larger and sustained groups – develop culture and civilizations

While most of us are born or develop within existing IDGs, we also form many identity groups during our lives.

Identity Groups under Stress

Stress – a heightened state of anxiety about one's current state that might originate from outside the IDG (e.g., oppression) or from within (e.g., internal dissension) **– can cause the IDG to act as a single organism** ("circling up the wagons")

Stressed Identity Groups:

Are more likely to reject ideas coming from outside the IDG

Oppress, reduce, or prohibit expression of diverse ideas within the IDG

Make irrational actions that are potentially self-destructive

Can "dehumanize" individuals and groups that represent opposition IDGs

Are in a state that can lead to polarization, particularly if "outside" IDGs are well defined, are in opposition and are creating the stress

Can be strongly influenced by a leader (or idea!) that represents the IDG, particularly potential "martyrs" that have received the brunt of the oppression or violence from the opposing IDGs.

Diversity and Identity

Self-Organizing Decentralized IDGs (SODIDs) can have sophisticated information gathering, complex problem solving, collectively organized action, and high performance, predictability and system-wide stability.

SODIDs with high expressed diversity typically exhibit these desirable collective attributes – Identity is the mechanism that provides coordination of diversity in social organisms.

SODIDs with low expressed diversity often exhibit negative attributes of oscillating performance (boom and bust cycles), failures due to an excessive dominance of one component of the system and unpredictability.

The tendency of Identity Groups under stress to repress diversity can results in negative global outcomes.

Identity can both enable the quick adaptation of a life-preserving idea or reinforcement of a destructive idea that leads to failure of the system as a whole – which path is taken is dependent on diversity of the group.

Application - Tipping Point

Law of the Few

- **Identity largely determines the social network**
- **Identity coherence determines the success of trendsetters to represent the the group and the sticky idea**
- **Trendsetters often span multiple identity groups**

Stickiness Factor

- **The "stickiness" strongly correlates with the resonance with identity**
- **Ability to jump across multiple identity groups determines widespread propagation**
- **An idea that is sticky to an opposing identity group will be aborted and demonized.**

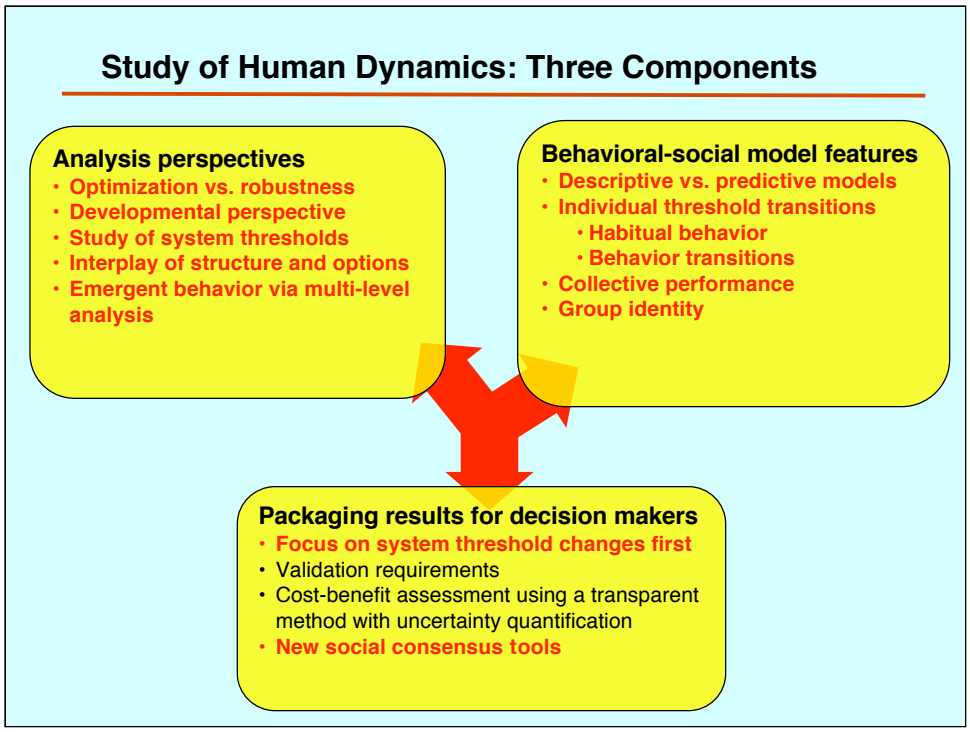
What we conclude is that many researcher have made conclusions about the herd effect in collectives, but they have not identified that this only happens in identity groups. Therefore a study of identity groups is essential to understanding group behavior.

Why Care about Group Identity?

Studies on group identity as the missing link:

- Mary Douglas Grid-Group Theory of culture **
- Akrtlog & Kranton modify the "rational choice utility model" to include identity *
- Sun-Ki Chai's Coherence model for predictable cultural change

* Akerlof, G. A. and R. E. Kranton (2000). "Economics and Identity." Quarterly Journal of Economics 115(3): 715-753.
** Douglas 1970, 1978; Douglas and Wildavsky 1982; Wildavsky et al. 1990. Adapted for choice-theoretic models in Chai and Wildavsky 1993; Chai and Swedlow 1998.



Here's as summary of all the points we've covered. I did not cover validation or tools used for cost-benefit analysis - which must be essential components of any application of behavioral models.

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For exceptional talks on Complexity in financial systems, see the Thought Leaders Forums:

- http://www.leggmason.com/thoughtleaderforum/2006/index.asp for 2003-2006
- http://www.capatcolumbia.com/CSFB%20Thought%20Leader%20Forum.htm for 2000-2003

Here are additional references relative to dynamics of complex systems. Contact Norman for additional references.