Part II: Synthesis of Concepts from the Complexity Sciences

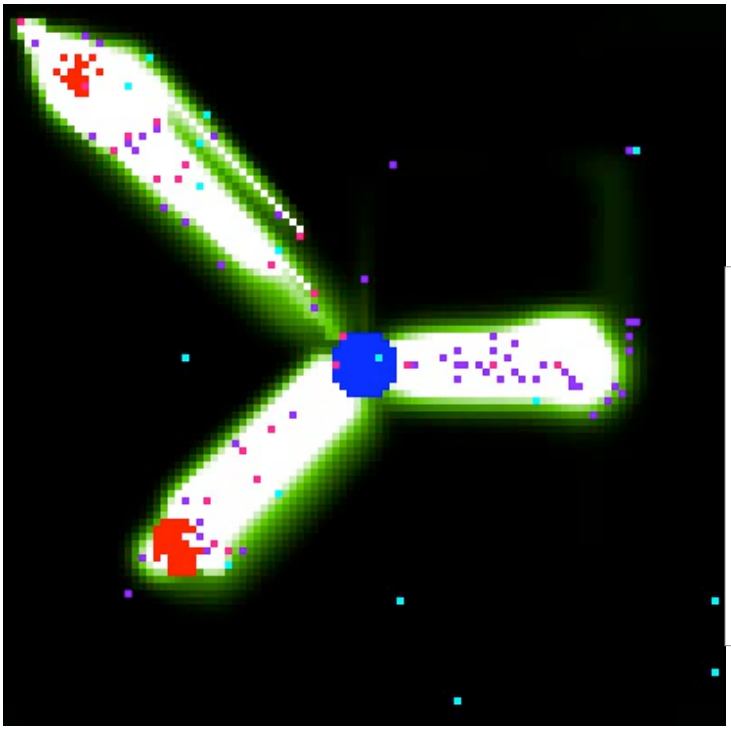
Strategies in Ecosystems

Norman Johnson presented a second talk in which he reported on his research with ant collectives and their strategies for finding food, and the implications of this work for organization design and governance.

We're going to use a simulation about ants to examine strategies in ecological systems.

When we simulate ants foraging for food with two food positions, close and far away, the closer food source is exploited first. Why would ants exploit the closer food source? They don't have any rules that tell them to do this. They only have three rules: take food to the nest if you have it and lay a pheromone trail, search for food using the collective pheromones if present, otherwise search randomly. How does this happen?

The answer discovered from the group is that closer food sources have stronger collective pheromone trails and it takes less time to exploit a food source. Hence the simple individual rules create a collective process between their interactions that is greater than the simple rules.



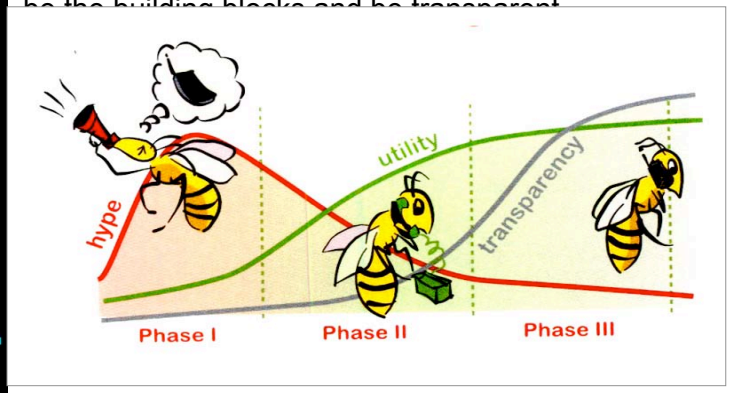
This exploitation of the closer food source is an emergent property of the collective – it's only observable in the whole and you can't predict it from knowledge of the individuals.

This just doesn't happen for ants. Many social phenomena that we rely on are emergent properties.

What if I had a food source that is really far away and the pheromones evaporate? The collective will fail, because they lose their communication system.

Suppose all the ants initially took the same path in searching for the food? There would be no diversity. Could they find the shortest path to the food then? No! The shortest path solution only happens because there is diversity in the ant colony. This is a major observation of how the synergy (rather than selection) of diversity leads to better solutions.

This chart introduces the idea that there are different stages in a self-organizing system – here, specifically technology adaptation: hype/discovery stage, utility stage, and transparency stage. The transparency stage is where the technology becomes transparent in its use – like phones today. This development process very much applies to your undertaking. You are struggling to develop a movement that influences 100s of organizations. You are asking about developing new and different ways of producing utility. You would like utilities to



An example of this is telephones. Telephones started in rural America. There was a point they became useful but not so easy to use - they weren't transparent.

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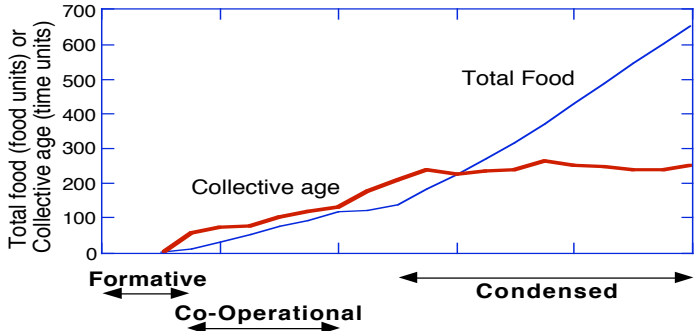
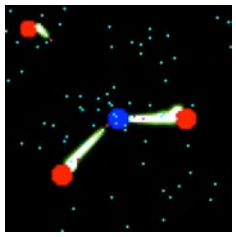
Let's connect some ideas. When there is an infinite food supply and more and more agents get into the collective process, if you plot the total amount of food obtained over time there are a couple of break points in the shape and these correspond to stages that develop. At the end there is a long tail of constant production, a less productive time in the middle and an early random time.

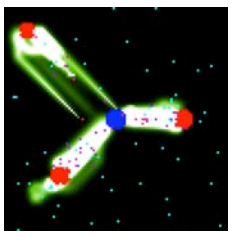


The first stage is about individuals discovering things and discovering new structure. The second stage is the structure starts to overlay - no one ant finds the shortest path – but the collective does. The last stage is an optimized system where almost all of the individuals are exploiting the emergent solution, the shortest path, and it's now transparent.

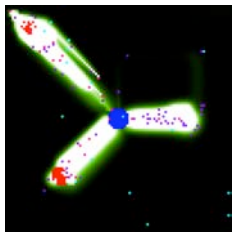
This slide summarizes the three different stages of self-organizing systems: formative, synergy, optimize. If you look at the individual actions in each stage, they are very chaotic in the beginning but predictable in the end. Early on performance is due to diversity, but it starts to change as you get later in the cycle, and the last phase is all due to the optimized collective. Diversity grows, but at the end there are few options and they aren't changing very much.



Formative
Forming structure

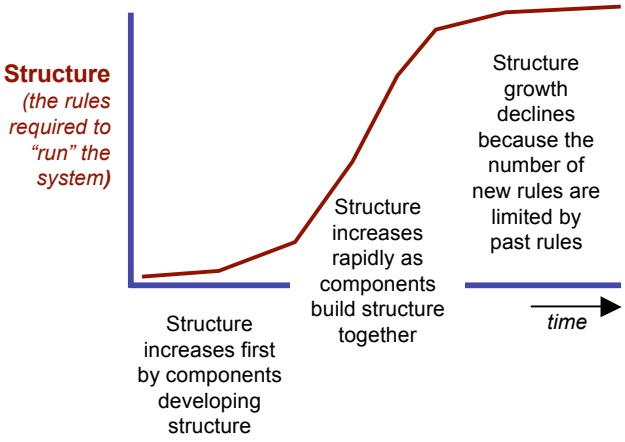


Synergistic
Synergy of Individuals



Optimized
System optimization

This is a plot of how structure increases over time. For example, the pheromone trail is a structure and it grows little in structure at the beginning when all the ants are just wandering around. Then it increases rapidly as the collective finds synergy, and then the structure levels off. There is a limit to how many individual paths you can put on top of each other and create new structure.



As an ecosystem gets older there is no more room for more restrictions. At a certain point you would break the system if you put in a bunch more rules. Think of what would happen if you added more and more rules to a chess game? At some point it would be unplayable.

The rate of structure development declines towards the end – even though there might be a lot of structure in the end. In nature, this structure can be related to diversity. In Australia – the most stable ecosystem in the world (until recently because of climate change) - there might be one type of butterfly that only pollinates one type of flower – making for loss of apparent diversity, but that means there are no other options for that butterfly. Hence not only do you have to have diversity, but it must be expressed and they must be flexibility such

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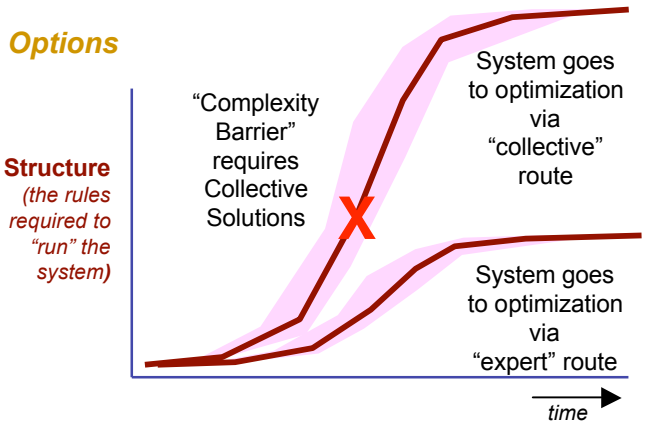
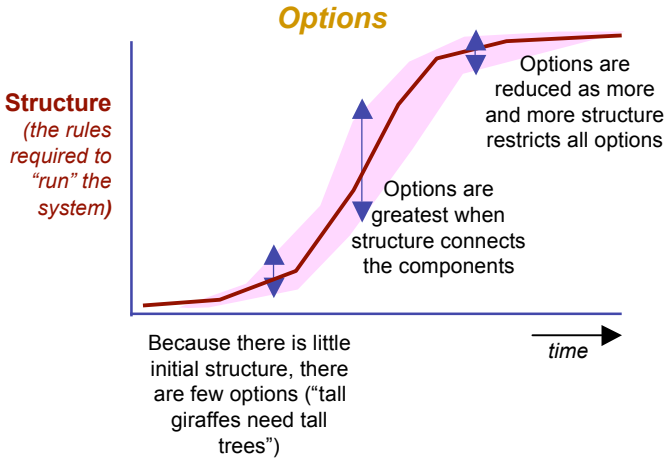
Now let's add the options onto the structure. Initially structure creates options (tall plants mean tall animals – giraffes). Then there is an explosion of options at a certain level of structure. There is a sweet spot for options in the middle and then as you put more structure on it you get less options. Where is your system? How many options and how much structure do you have? (Answer: there is lots of structure – maybe too much and too few options.) Robustness comes in the middle. The end is not robust and the beginning is fairly fragile.



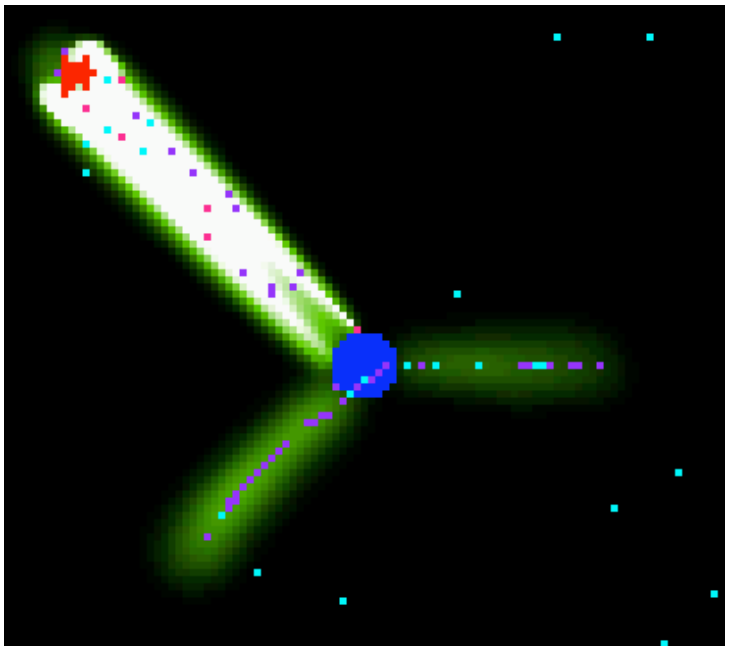


Options are the free choices both created and limited by the structure (example: the rules of chess create an "environment" where many options are possible- while also limiting what choices are available)

These ideas are captured by researchers studying "infodynamics"

Let's look at what can go wrong when the system is changing – which really is the world we live in– more change very day, and it's only going to get worse.

Before we saw that the system exploits the closer food source, but now – because of the prior structure - they are enamored with the food source that is further away and the emergent property is not an option. This is an example of how structure can be mal-adapted in changing times, so it takes the solution away from what is more optimal.



A plot of the utility of an expert as a system becomes more complex looks like this. At very low complexity, everyone can solve the problem and you don't need an expert – they have no utility here. While more complexity you can hire an expert to tell you how to optimize it. But if the problem becomes too hard, even experts fail – such as in the stock market.

Now add the utility of the collective to the figure. What we are finding is that if the problem is too complex you need the collective to solve the harder

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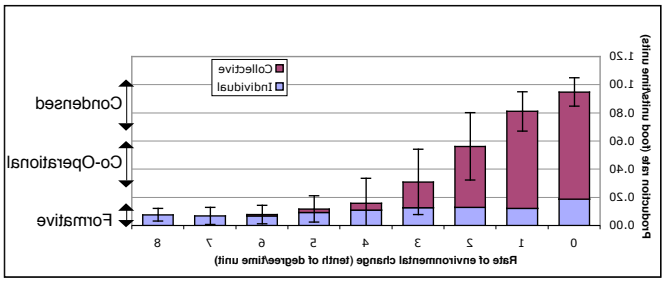
We are going to take a source of food and move it in a circle. What happens when it moves slowly? The colony does a fairly good job of adapting. Before, the scouts (innovators) didn't really do much, but now they play a very important role in finding the new food source, so that the collective can exploit the resource. If you graph this you can see the production in the collective versus the individual.



What if we move it 50% faster? What happens? This amount of change creates a boom and a bust cycle. Look how the productivity collapsed.

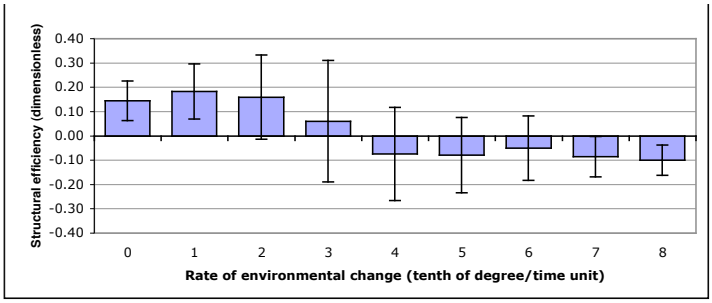
How can you reduce the bust? Make more scouts! You can increase the performance by 40%: If you reduce the strength of the pheromones by making it evaporate faster, you can create more scouts. Hence, there is a tradeoff between performance and robustness. A major lesson to learn is that busts are so bad that removing busts from the system by lowering your performance during good times can greatly increase the time-averaged performance – 40% in the above example.

If we move the food really quickly all the productivity is happening from the innovators. What about the collective? Does it help or hinder? The collective never gets food in this case. It takes up valuable potential innovators.

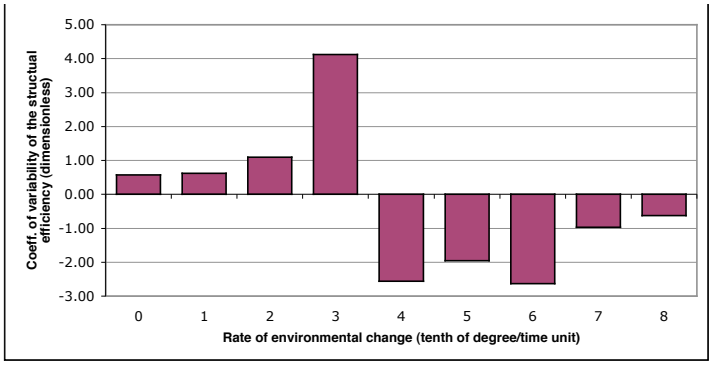
Here's a graph that summarizes everything we just learned. If systems change slowly, they go to an optimized developmental stage. But as change happens faster, the final development stage pushes to less developed systems. Also you conclude that you force the system to go back to earlier stages of development by increasing the rate of change

Can you make observations about your system as the rate of change increases?

In times of fast change, the self-organizing collective must be carefully managed so that it doesn't reduce system productivity.



Let's quantify the effect of the collective on responding to change. Structural efficiency is how well the collective produces food. What we see is that for low rates of change the structural efficiency is positive and large, but as change increase, the structural efficiency declines and goes negative. The collective is actually hurting the efficiency. Hence in times of fast change, the self-organizing collective must be carefully managed so that it doesn't reduce system productivity.



Social trends can stress the development of resources (remember the comment earlier about professionalism), reduce diversity and make you more susceptible to tragedy. The Fed's goal under Greenspan was to keep robustness in the system and not necessarily to optimize the system.

Conclusions: You are much better off keeping a

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Mass communication is the ultimate pheromone trail for humans. While the collective might be able to prevent the bust cycle through diversity, the downside is that if mass communication results in a fad (reducing diversity) it could make the system more susceptible to boom and bust – lowering overall performance.

Summary - if there is no change in the environment you go from formative to synergistic to optimized stages – each with its own dynamics and performance process. If you have a slower change innovators become more important but production is similar. If you change more quickly you will never get to be optimized. If you change faster than the individual can adapt you get force the systems to a formative stage.

Structures come in different types. Because we have options to change structures, it's good to know the flavors they come in. They can be superficial and not really effect outcomes (some say many of the colors in nature are of this type – diversity not for a purpose but because the diversity generation engine just didn't know when to stop) or they can be something like hydrogen bonding – which will always be present – no matter how many times you replay the tape, even if you tried to change it. And then there are structures in between. Would we get the same specific DNA coding if we played the tape of evolution again? Likely not, but we still would get some type of digital coding.

Conclusion: Don't focus on structures in the system you can't change. Don't focus on structures that don't influence the outcomes.

What would happen we made the strongest pheromone structure permanent? This is like saying, "Lets take our best ideas and make them law, never to change again." If we have a little change in the system it drops production and there would be death. The environment is changing and they aren't adapting.

It turns out that largest companies (with a few exceptions) are not the best performers because they cannot adapt. There is no Creative Destruction. Any system has to creatively destroy part of itself in order to keep alive and evolving. Capitalism is like that. Recommend the book Creative Destruction by Foster.

Conclusions. Lauren talked about competitive strategies but it's also important to talk about synergistic strategies – these are more common in mature systems you deal with. Busts are catastrophic, and you should focus on robustness before performance. Different types of structures have different reproducibility – so pick your battles against structure wisely. You need to learn about creative destruction. Focus on process not product in times of fast change – a good process will never become obsolete, where product (or specific rules) will always become obsolete. Emergent solutions cannot be planned (we don't understand these system well enough yet) but they can be enabled by diversity.

There needs to be a balance between performance and structure. And there needs to be a balance between performance and structure. The formative stage is good for building structure but it's a fragile time.

Summary

- √ Consider both competitive and synergistic strategies
- √ "Busts" are worse than lower average performance
- √ Different types of structures have different reproducibility
- √ How to evolve an overly-constrained system?
  - – Either "creatively destroy" structure or build on structure
  - – Seek diverse strategies
  - – Focus on process, instead of product (KISS)
  - – Emergent solutions can't be planned but can be enabled by diversity
- √ Optimize structure (rules) and options based on:
  - – Required performance and robustness
  - – Stage of development
  - – Rate of change (internally or externally)
- √ Use stages of development as guideposts
  - – Formative: lots of building of structure, fragile
  - – Synergistic: sweet spot for resilience and change
  - – Optimized: only for slowly changing or stable