Lecture 2:

Using networks to explore social niche construction

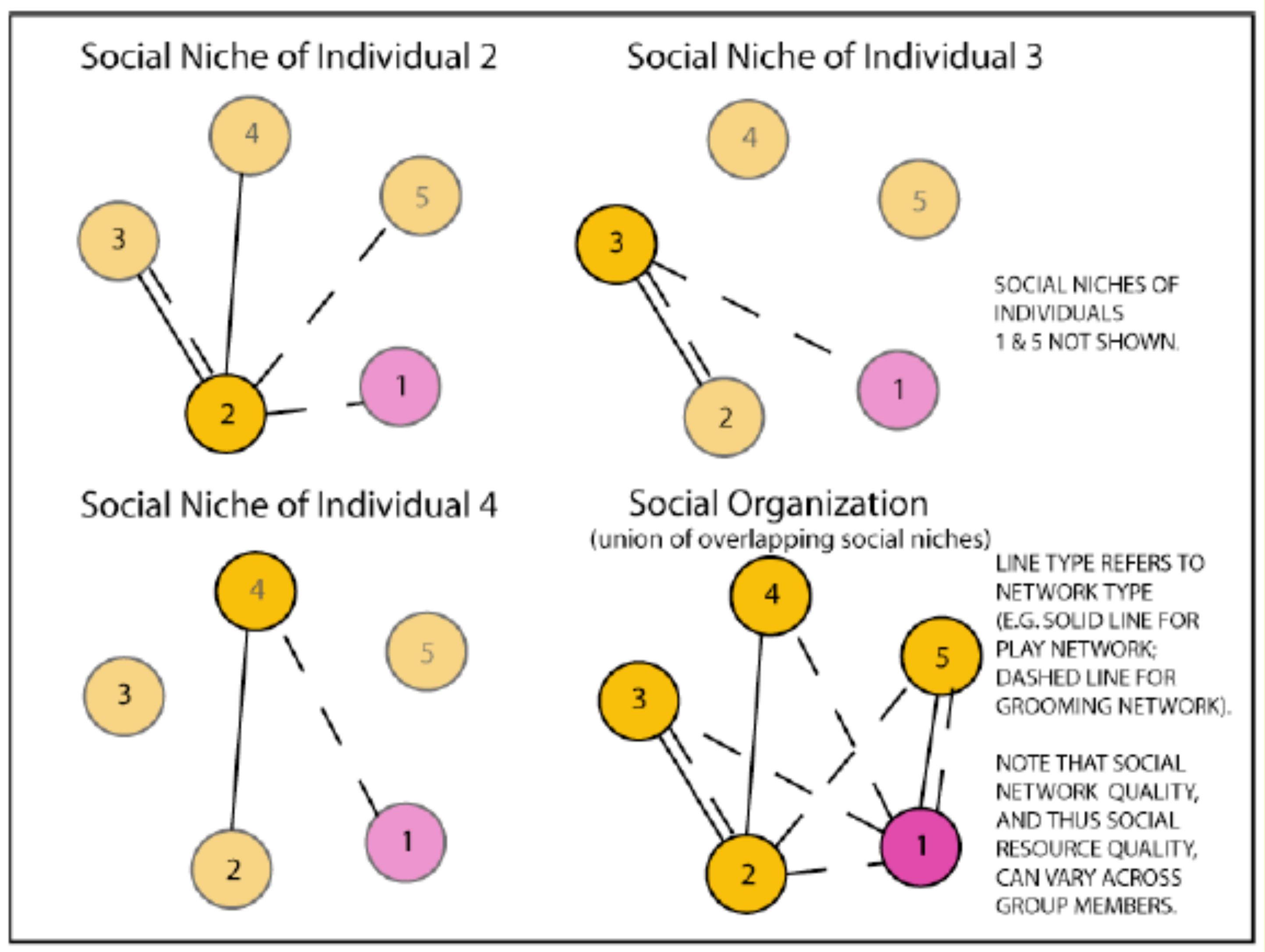
and

Outlook for the field of networks

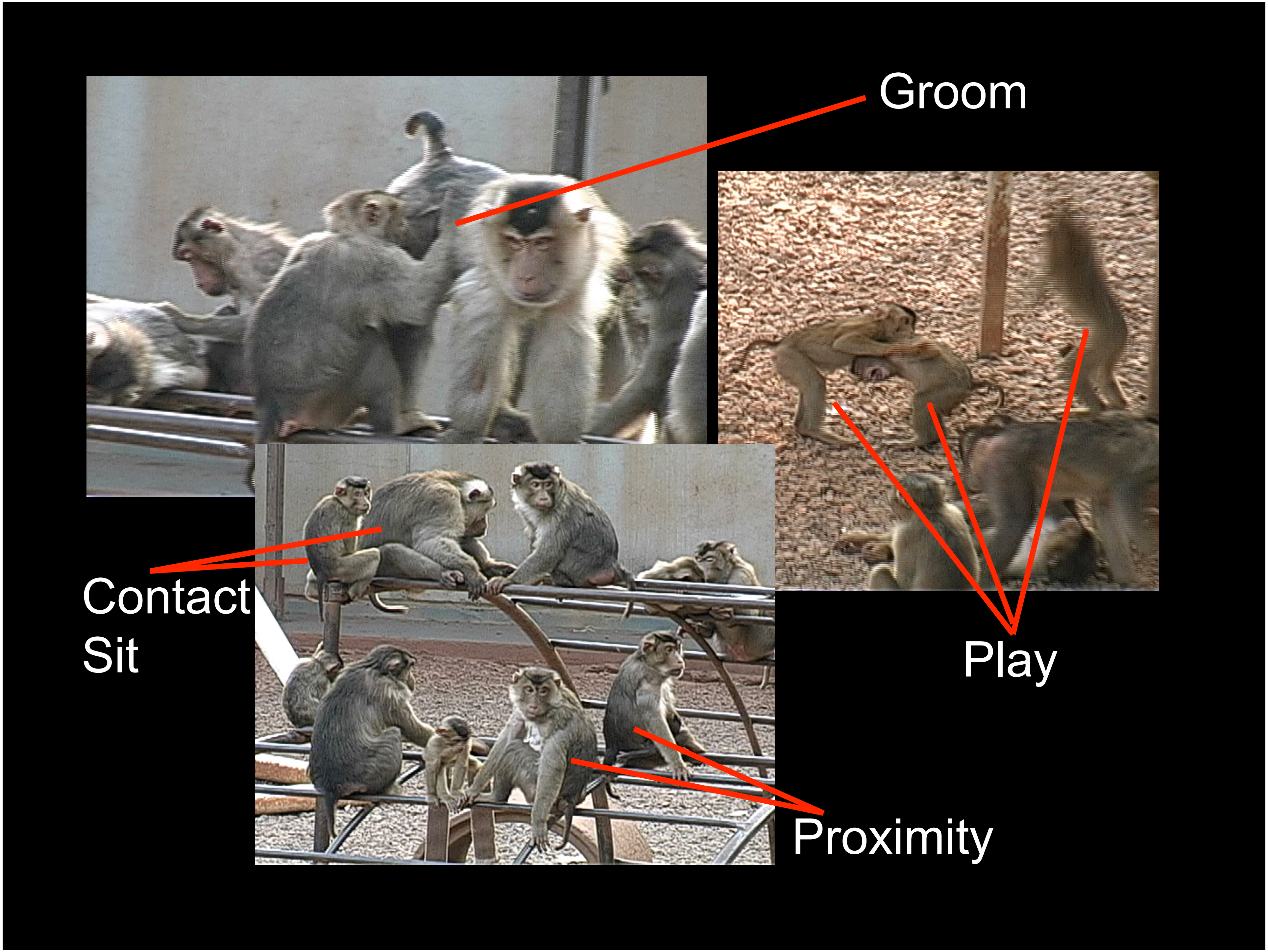
Policing Stabilizes the Construction of Social Niches in Social Primates

A Network Study

What is a social niche?

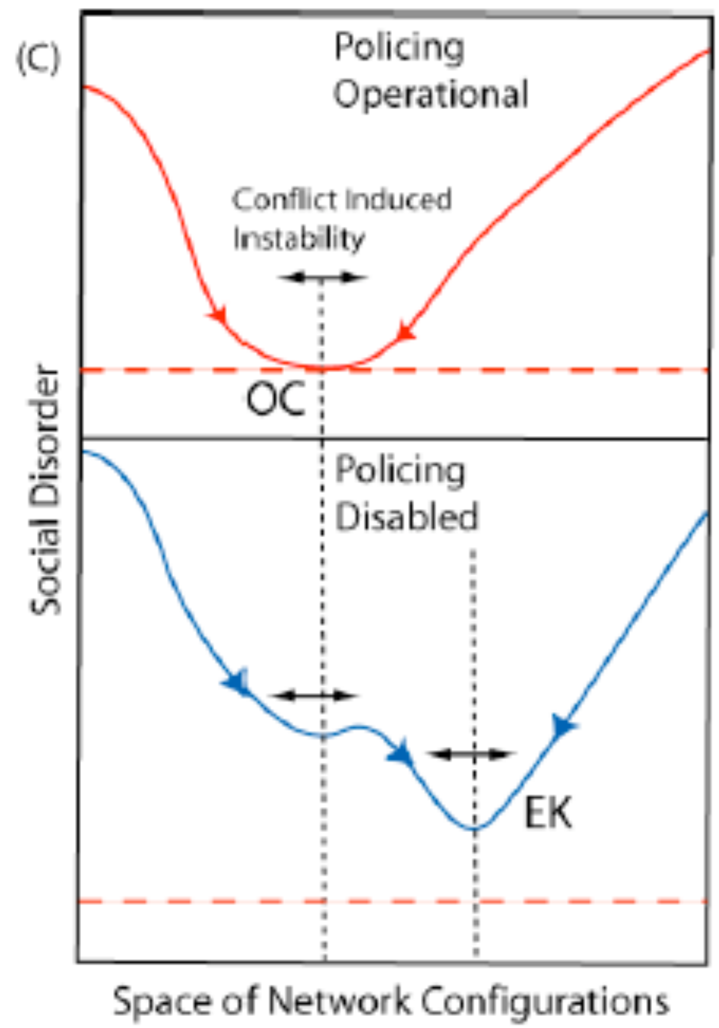


Overlapping Social Networks

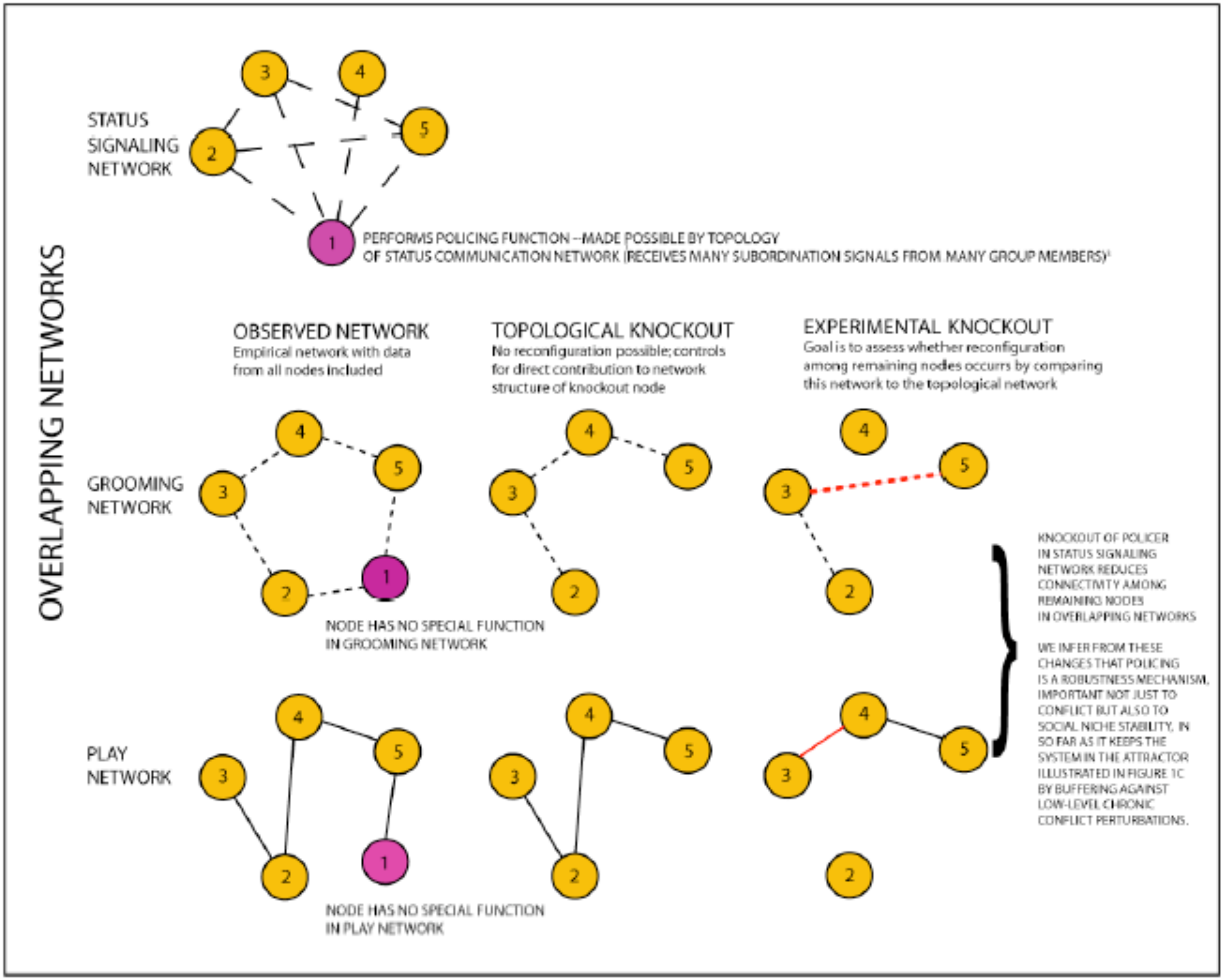


Groom
Contact
Sit
Play
Proximity

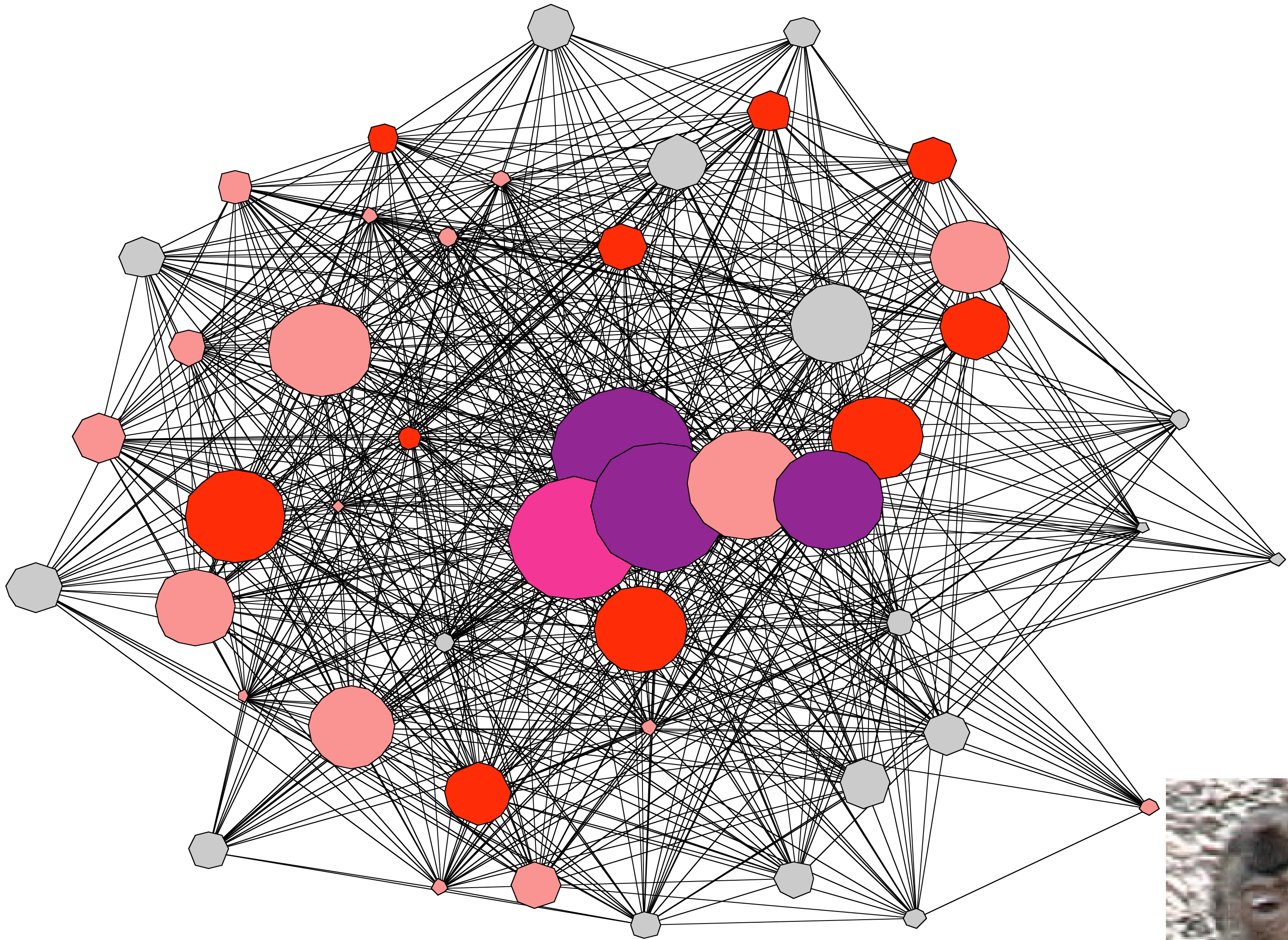
Conceptual Framework

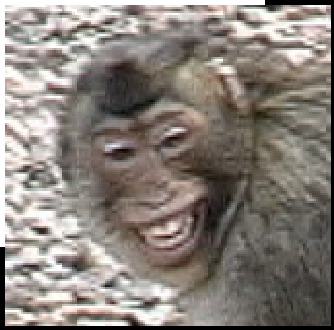


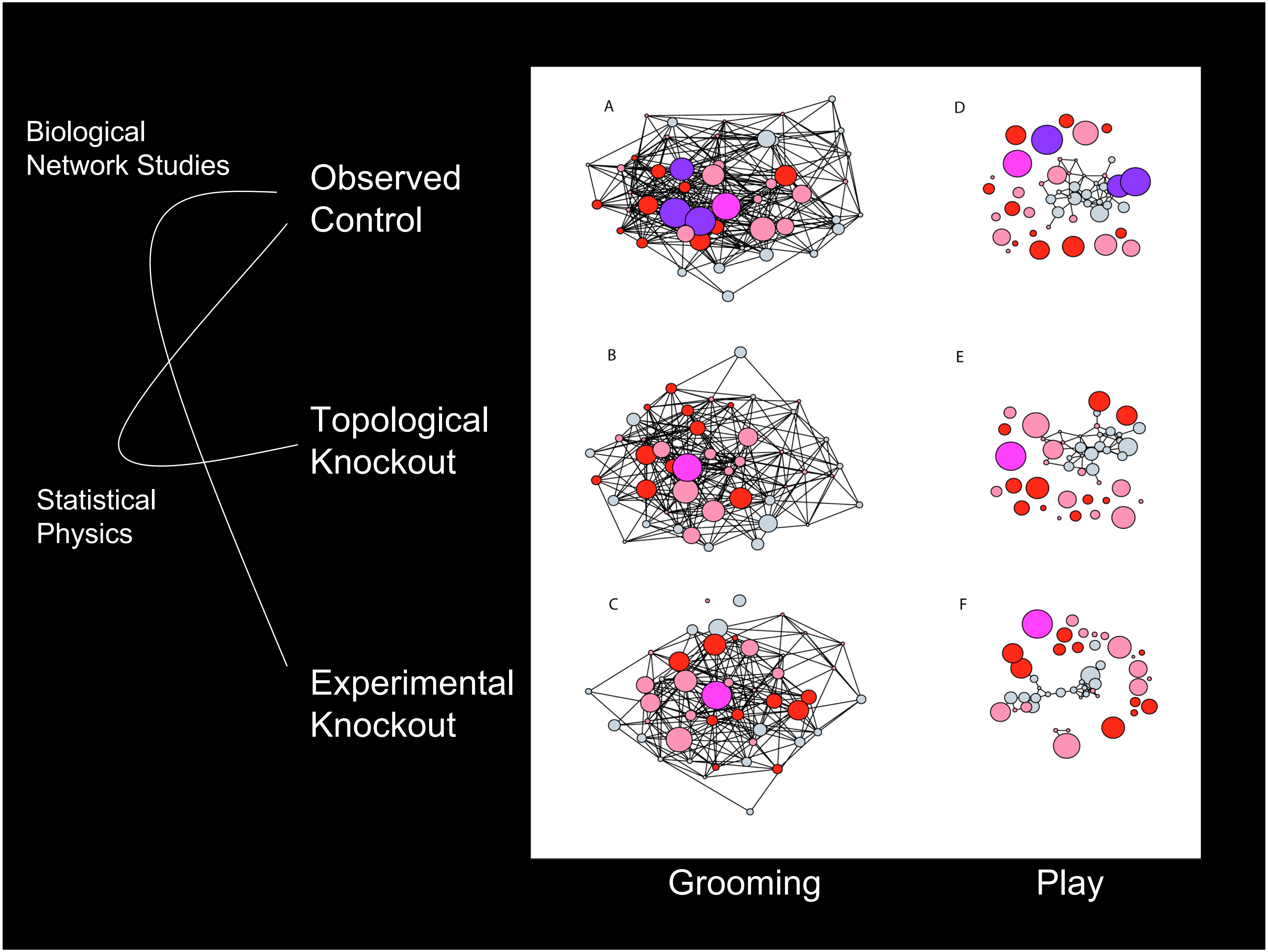
How is the study performed?



Status Communication Network






Biological Network Studies
Statistical Physics
Observed Control
Topological Knockout
Experimental Knockout
A
B
C
D
E
F
Grooming
Play

Findings

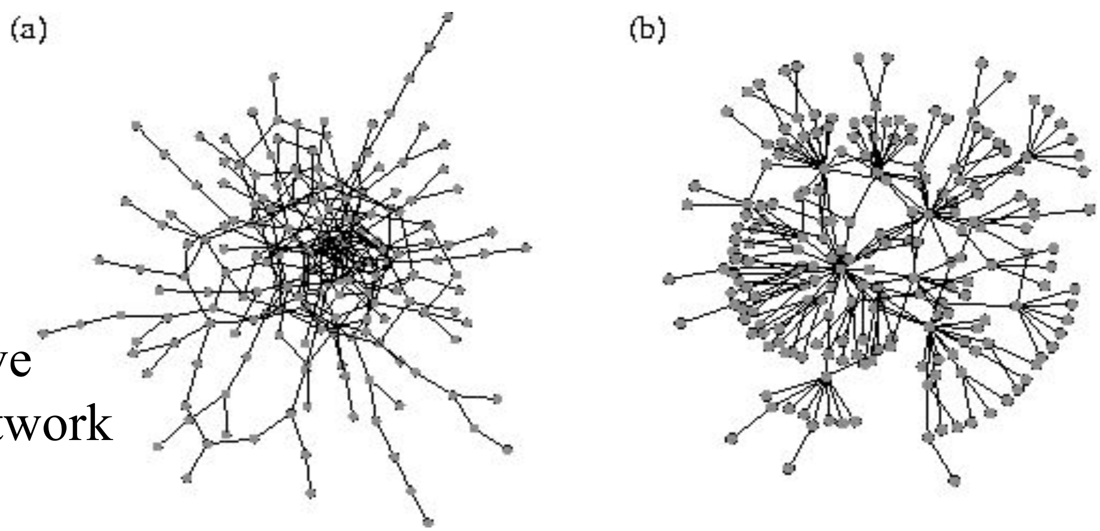
- Clustering increases when the policers are removed.
- Mean degree is higher in the presence of policers.
- Play and grooming networks are more strongly affected than contact sitting and proximity networks.
- Comparing the OC, TK, and EK conditions shows us the system is partially restorative.

Summary of Clustering and Degree Results

	OC-TK		OC-EK		**TK-EK**	
Network	Degree	Clustering	Degree	Clustering	**Degree**	**Clustering**
Grooming	SIG D	SIG D	SIG D	SIG D	**SIG D**	**D**
n = 45	p<.001	p<.001	p<.001	p=.008	**p=.009**	**p=.36**
Play	D	EQUAL	SIG D	D	**SIG D**	**D**
n = 29	p=.08	p=.94	p=.016	p=.87	**p=.027**	**p=.86**
Contact-sitting	SIG D	I	D	D	**D**	**D**
n = 45	p<.001	p=.028	p=.16	p=.99	**p=1.0**	**p=.70**
Proximity	SIG D	SIG D	D	D		**SIG I**
n = 45	p<.001	p<.001	p=.051	p=1.0	**I p=.51**	**p=.03**

Assortative Mixing by Degree

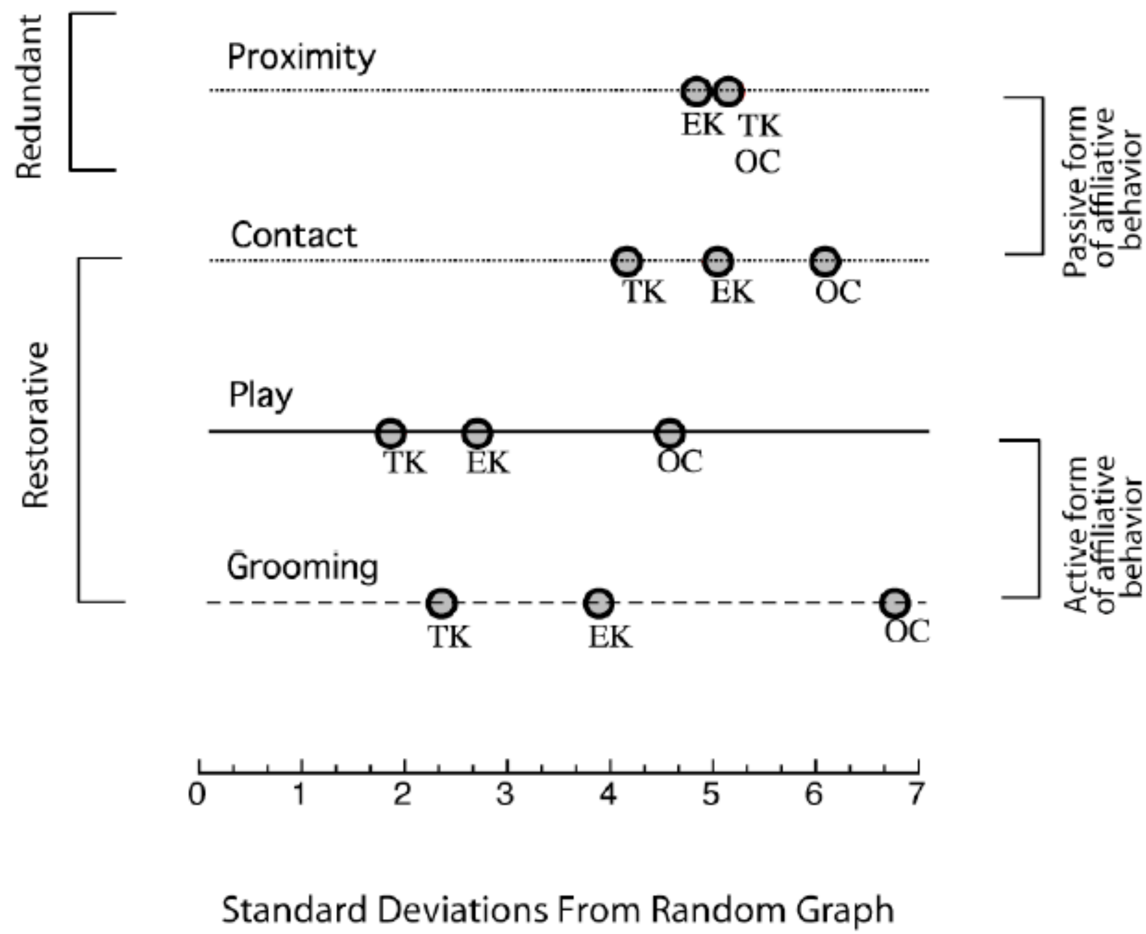
- A network is said to be assortatively mixed by degree if high degree vertices tend to connect to other high degree vertices
- A network is disassortatively mixed by degree if high degree vertices tend to connect to low degree vertices.



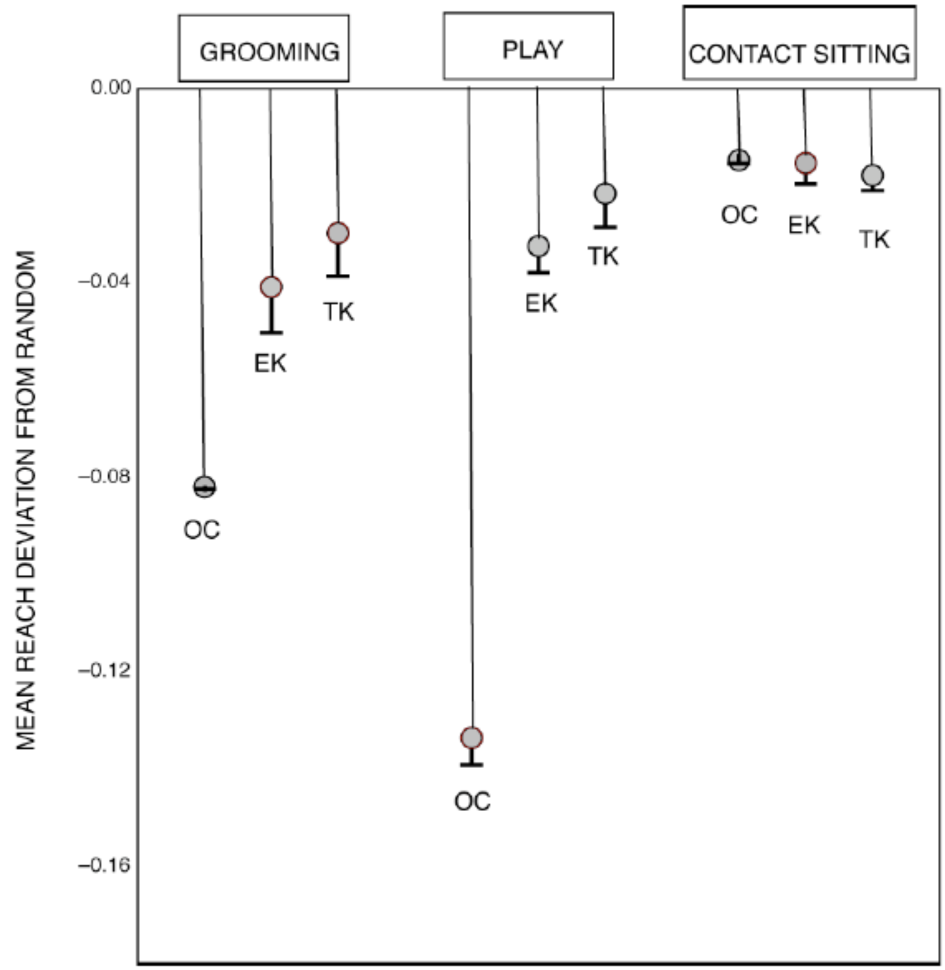
Assortative Scale-free network

Disassortative Scale-free network

Assortativity Results



Reach of a node measures its *indirect* connectedness to other nodes in the graph.



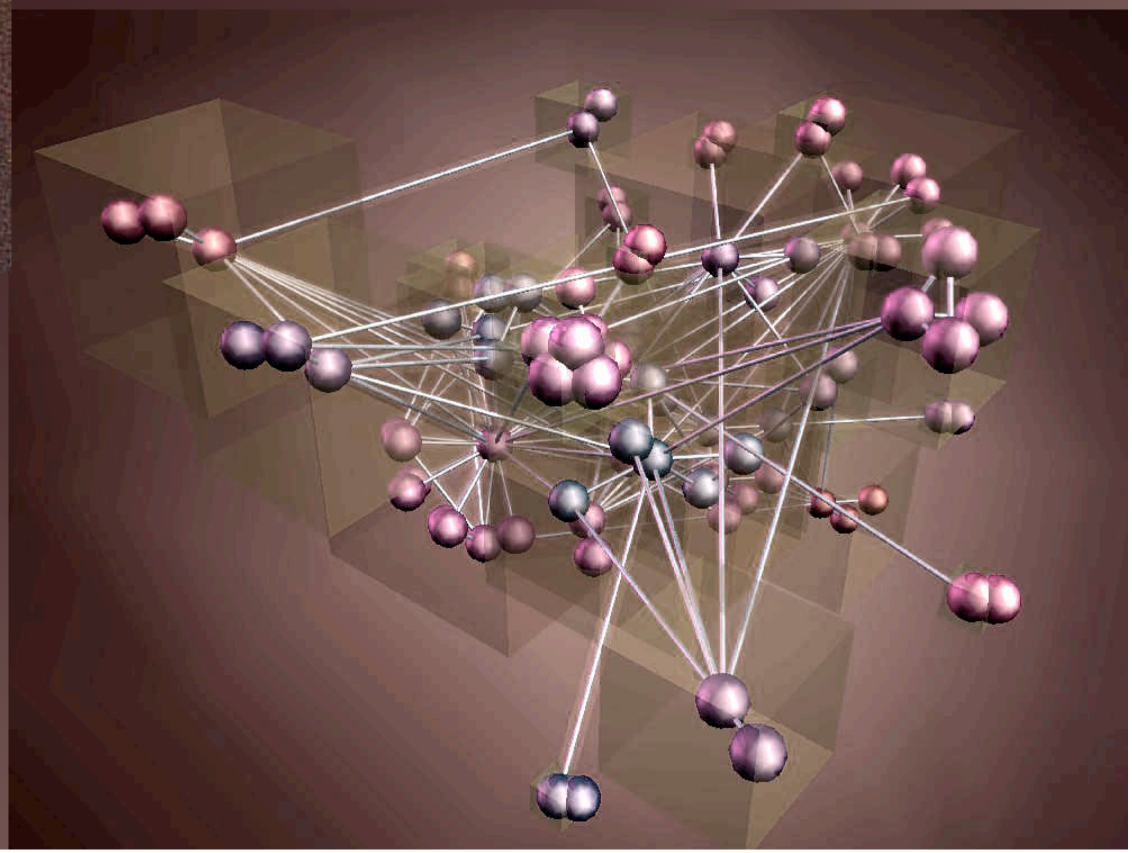
Conclusions

- The presence of policing allows for partner diversity.
- In the absence of policing, individuals form conservative social relationships.
- The social niche is partially restorative.

Future Directions

- Can these kinds of perturbations lead to switching in the organizational structure?
- What are the rules by which individuals choose their interaction partners in the various networks? How do these rules determine the social structure? How are they constrained by the social structure?

Critique of Pure Networks



Where do we go from here?

The current state of complex networks

- Are networks a fad?
- What are we doing wrong in the field of complex networks?
- Where do we go from here?

Scientific “fads” from statistical physics

- Self-organized criticality (SOC)- a proposed explanation for why we see power laws in so many natural systems when power laws in physics are only seen at critical points.
- Econophysics - the application of statistical physics toward the understanding of market patterns.
- Fractals - self-similar patterns observed in a variety of natural systems – snowflakes, river networks, forest fires…
- The application of statistical physics to evolutionary biology.
- Highly-optimized tolerance (HOT) see Newman, Girvan & Farmer’s response, COLD
- Spin glasses (or spin systems generally) applied to neural networks, gene regulation, economy, opinion formation, war, …
- The edge of chaos (EOC)
- Tsallis entropy
- And networks?

But networks can still be useful with…

- A problem naturally calls for a network-based approach. Complex networks should not be the answer in search of a problem (although this approach may be the easiest way to get publications in high-profile journals).
- An understanding that just considering the topology of system interactions will provide insights into the system's constraints, and will not offer a complete solution to the system if dynamics are not included.

Some cautionary tales of complex networks…

Barabasi et al. showed that the internet was fragile to a targeted attack of high degree nodes. This is true, but slightly misleading. The network they looked at was on the level of autonomous systems, groups of singly managed computers each consisting of thousands of machines. The cost of disabling high degree nodes in the network is expected to be much higher than the cost of disabling a random node.

Poor sampling approaches can also give us misleading results

Traceroute sampling makes random graphs appear to have power law degree distributions

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(Dated: June 13, 2005)

The topology of the Internet has typically been measured by sampling *traceroutes*, which are roughly shortest paths from sources to destinations. The resulting measurements have been used to infer that the Internet's degree distribution is scale-free; however, many of these measurements have relied on sampling traceroutes from a small number of sources. It was recently argued that sampling in this way can introduce a fundamental bias in the degree distribution, for instance, causing random (Erdős-Rényi) graphs to appear to have power law degree distributions. We explain this phenomenon analytically using differential equations to model the growth of a breadth-first tree in a random graph $G(n, p = c/n)$ of average degree c, and show that sampling from a single source gives an apparent power law degree distribution $P(k) \sim 1/k$ for $k \lesssim c$.

A **Clauset**, C **Moore**, - Arxiv preprint cond-mat/0312674, 2003 - arxiv.org

Be cautious when attributing a system's features to topology alone

The segment polarity network is a robust developmental module

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All insects possess homologous segments, but segment specification differs radically among insect orders. In Drosophila, maternal morphogens control the patterned activation of gap genes, which encode transcriptional regulators that shape the patterned expression of pair-rule genes. This patterning cascade takes place before cellularization. Pair-rule gene products subsequently 'imprint' segment polarity genes with reiterated patterns, thus defining the primordial segments. This mechanism must be greatly modified in insect groups in which many segments emerge only after cellularization. In beetles and parasitic wasps, for instance, pair-rule homologues are expressed in patterns consistent with roles during segmentation, but these patterns emerge within cellular fields. In contrast, although in locusts pair-rule homologues may not control segmentation, some segment polarity genes and their interactions are conserved. Perhaps segmentation is modular, with each module autonomously expressing a characteristic intrinsic behaviour in response to transient stimuli. If so, evolution could rearrange inputs to modules without changing their intrinsic behaviours. Here we suggest, using computer simulations, that the Drosophila segment polarity genes constitute such a module, and that this module is resistant to variations in the kinetic constants that govern its behaviour.

Nature. 2000 Jul 13;406(6792):188-92

Outlook for the Field

- We’ve developed useful measures to characterized networks, but we need to create a more unified theory.
- We need to think more about the interplay between topology and dynamics. Can we find ‘universality classes’ with respect to topology and dynamics? Can we determine which topological features are most important to different types of dynamics?

Collaborators

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