

Networks and stability

Part 2B. – Network dynamics

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1. network topology (II.20-27.)

2. network dynamics (III.6.-13.)

(III.20.-27. no lectures)

3. examples for networks (IV.3.-10.)

(IV.17. Easter)

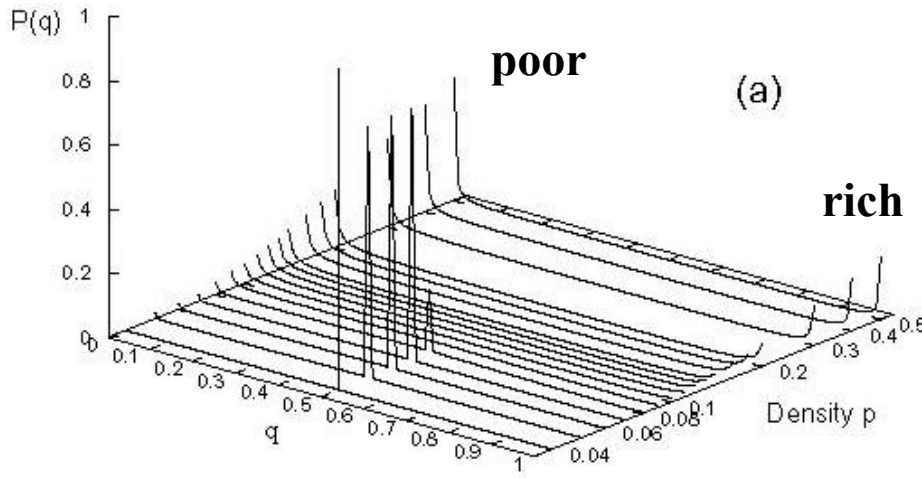
4. synthesis (IV.24., V.1. holiday, V.8.)

(V.13. consultation)

Network dynamics

- perturbations, signal and noise
- relaxation, self-organized criticality
- cascading failures
- **topological phase transitions**
- sync
- synthesis: engineering vs. tinkering

„Simple” phase transitions – percolation, society

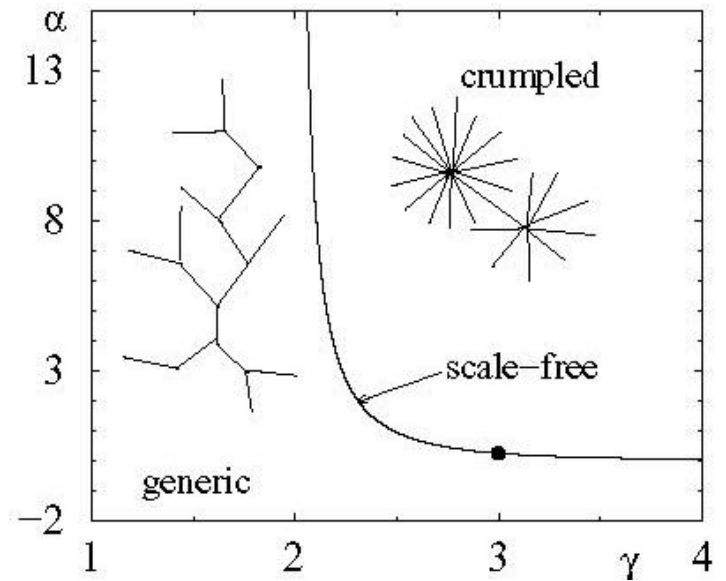
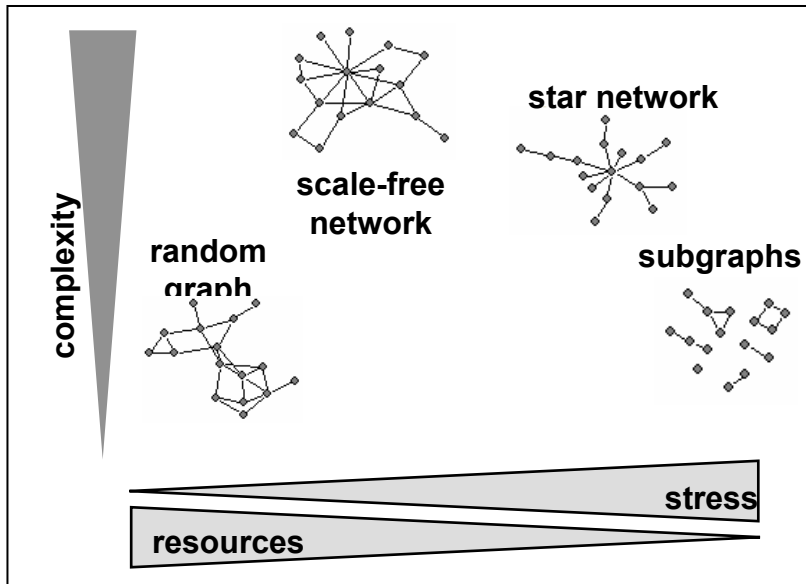


population
density

winning
chance

arxiv.org/cond-mat/0503004

Topological phase transitions



Physica A 334, 583; PRE 69, 046117

Topological phase transitions – examples: animal communities

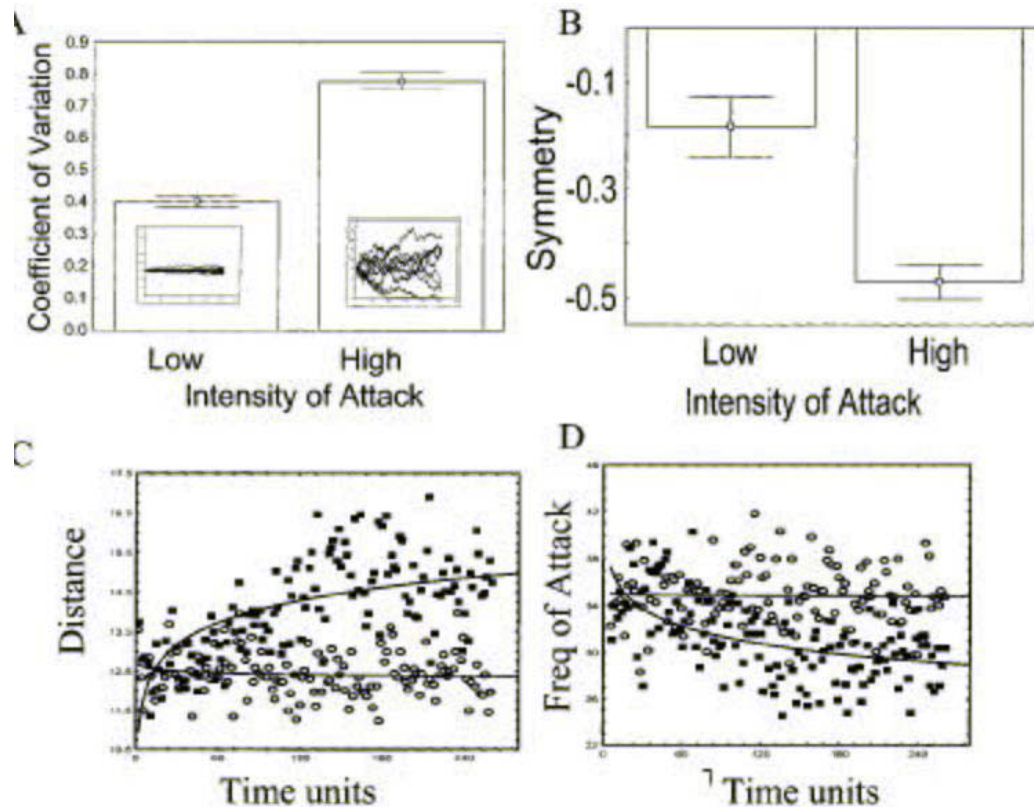
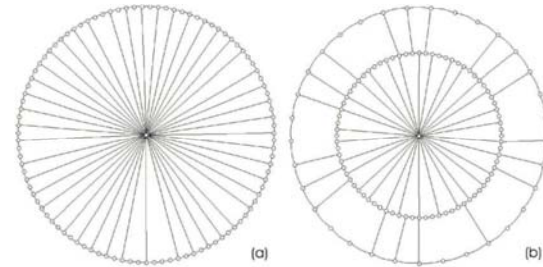
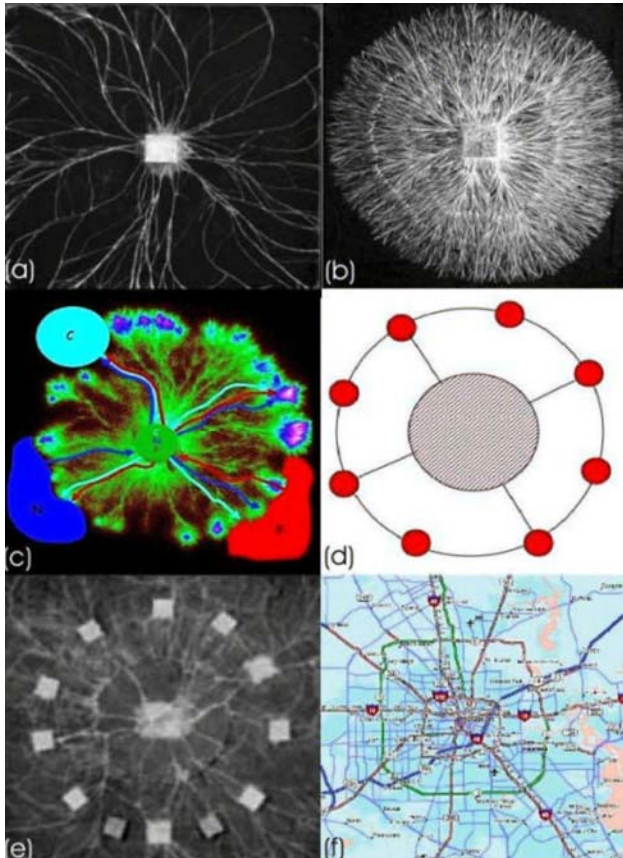


Figure 2. Effects of different intensities of aggression. (A) Gradient of the hierarchy as measured by the coefficient of variation of dominance values. (B) Symmetry of aggression measured as a τ_{KR} -correlation between an actor- and receiver-matrix of aggression. (C) Average distances among all individuals over time. (D) Average frequency of aggression over time. Open circles: low intensity of aggression, closed boxes: high intensity of aggression.

Topological phase transitions – other examples

- cells scale-free \rightarrow star \rightarrow apoptosis
- animals: random \rightarrow scale-free [\rightarrow star]
J. Theor. Biol. 215, 481
- firm consortia random \rightarrow scale-free \rightarrow star
Santa Fe Working Papers No. 200112081
- scientific quotations random \rightarrow scale-free
J. Arch. Meth. Theor. 8, 35
- communistic equality \rightarrow social classes \rightarrow
dictatorships \rightarrow war, anarchy

Topological phase transitions – at identical resource levels



fungi and towns
may produce phase
transitions between identical
topologies experiencing
minimal congestions

arxiv.org/physics/0508228

Network dynamics

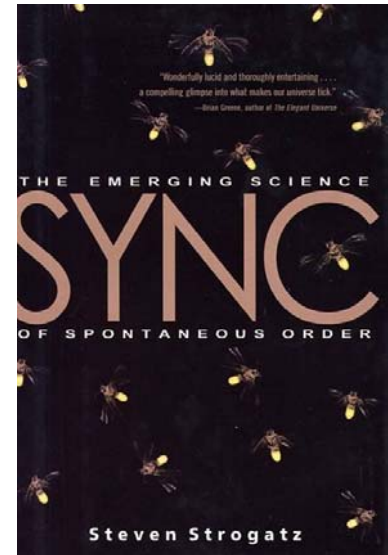
- perturbations, signal and noise
- relaxation, self-organized criticality
- cascading failures
- topological phase transitions
- **sync**
- synthesis: engineering vs. tinkering



Huygens, 1665

Sync

longitude determination
pendulum clock
synchrony



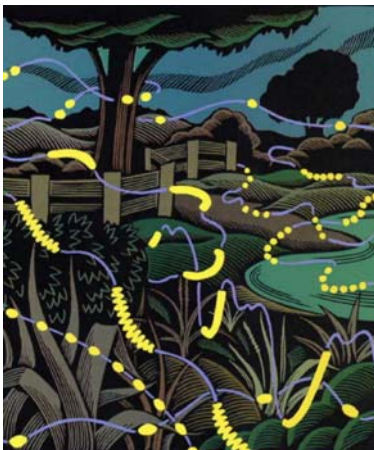
Sync: other examples

cricket



www.buzz.ifas.ufl.edu/a00samples.htm

firefly



bird-migration

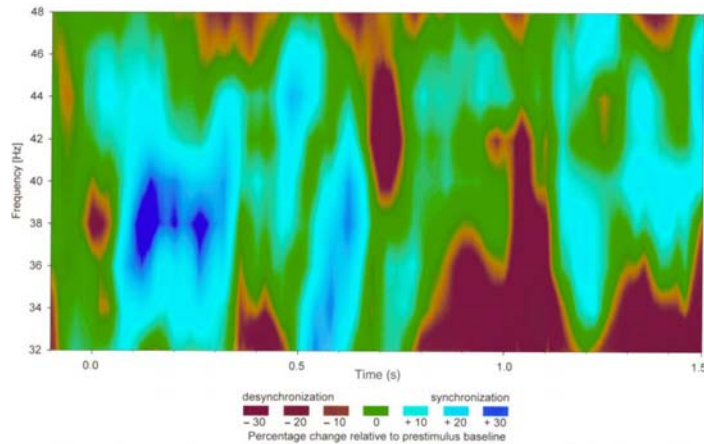


Nature 431, 646

Sync: other examples

neurons (circadian rhythm,
Pacemaker cells, etc.)

memory
region

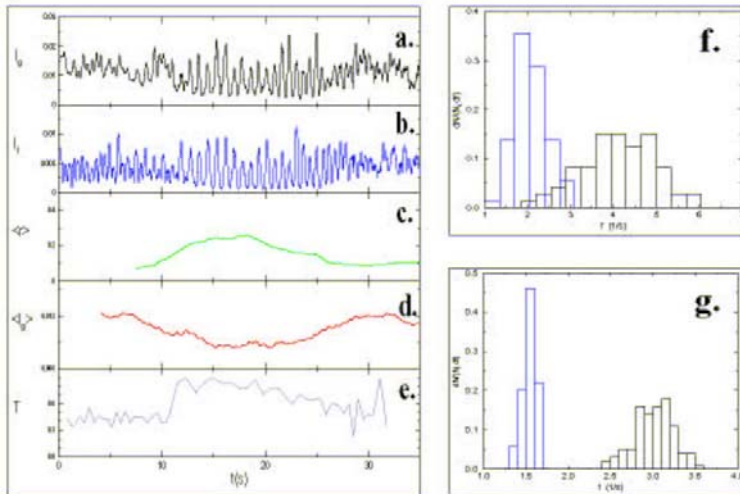


successful word recognition

Nature Neurosci. 4, 1259

Sync: other examples

clapping



Nature 403, 849

yawning, laugh

menstruation

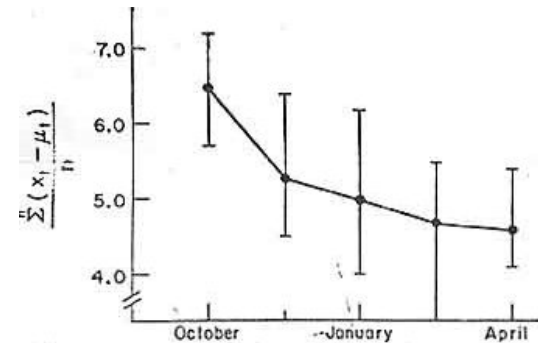
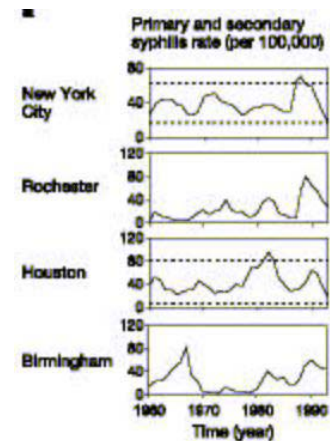


Fig. 1 The median individual mean difference from the group

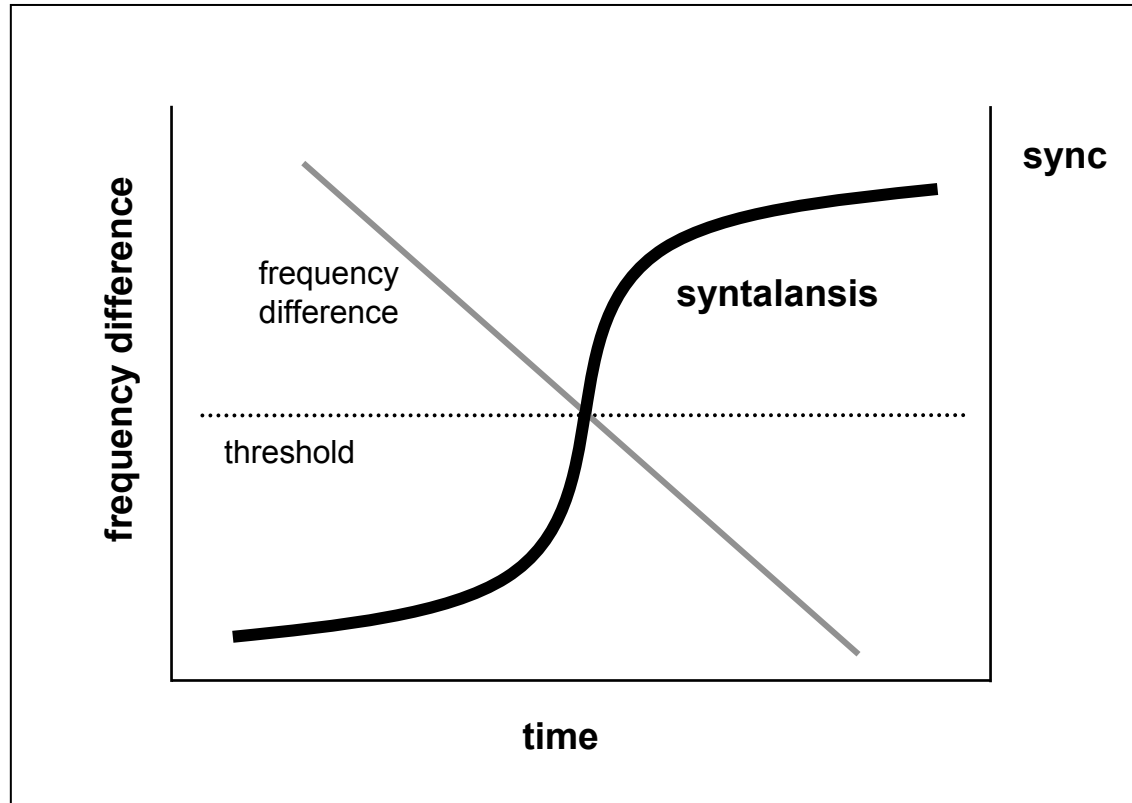
Nature 229, 244; 392, 177

syphilis



Nature 433, 417

The phase transition of sync



Sync conditions

- small-world ↑
- modules ↓
- scale-free ↓
- weights ↑
- weak links ↑

Network dynamics

- perturbations, signal and noise
- relaxation, self-organized criticality
- cascading failures
- topological phase transitions
- sync
- **synthesis: engineering vs. tinkering**

Differences between engineering and evolution

Property	Engineering	Evolution
development	needs designer input	self-organization, grows
parts & whole	additive (complicated)	non-additive (complex)
optimization	one-time, parts piece by piece	continuous the whole only
optimized parameters	few	many
intermediates	many times virtual	need to be stable
designability	low	high (many configurations)
elements	isolated (?), have low complexity	not isolated, but many times independent, complex
degeneracy	low, „thrifty”	high, „overspending”
unexpected changes	low survival	high survival