Computational Social Science

Course #04199, module 04IN2042

How can we simulate social dynamics?

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Naming games, extensions and applications

Slides based on slides by
Sergey Dedukh, S. Sreenivasan, J. Xie
W. Zhang, C. Lim, G. Korniss, B.K. Szymanski, Arnim Bleier

Current topics & discussion

Facebook's Secret Mood Manipulation Experiment

It was probably legal. But was it ethical?

ROBINSON MEYER | JUN 28 2014, 2:51 PM ET

ETHICS, MEDIA, SCIENCE JOURNALISM

IN DEFENSE OF FACEBOOK

JUNE 28, 2014 TAL YARKONI 90 COMMENTS

Facebook's Emotional Manipulation Study: When Ethical Worlds Collide

JUNE 30, 2014 BY ED FELTEN 12 COMMENTS

The research community is buzzing about the ethics of Facebook's now-famous experiment in which it manipulated the emotional content of users' news feeds to see how that would affect users' activity on the site. (The paper, by Adam Kramer of Facebook, Jamie Guillory of UCSF, and Jeffrey Hancock of Cornell, appeared ... of the National Academy of Sciences.)

TECH

Learning To Love Big Data

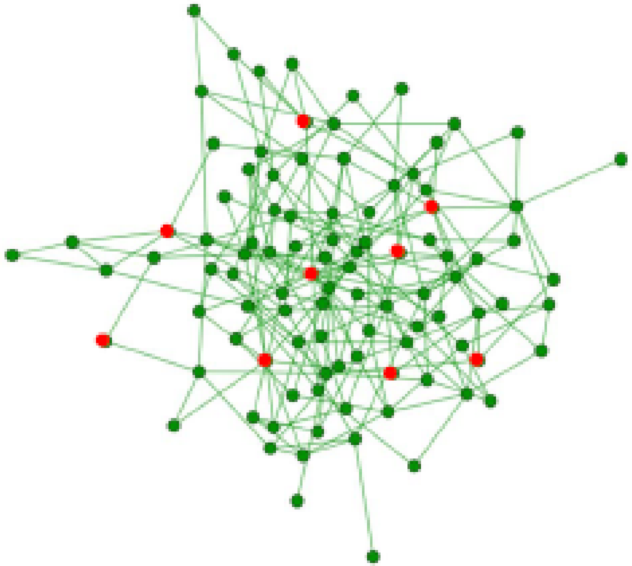
Tue, Jun 18, 2013 | by Nicholas A. Christakis | 4

"Never doubt that a small group of thoughtful, committed, citizens can change the world. Indeed, it is the only thing that ever has."

\- Margaret Mead

"The role of inflexible minorities in the breaking of democratic opinion dynamics", Galam and Jacobs , *Physica* A **381**, 366 (2007). (homogeneous mixing/mean-field)

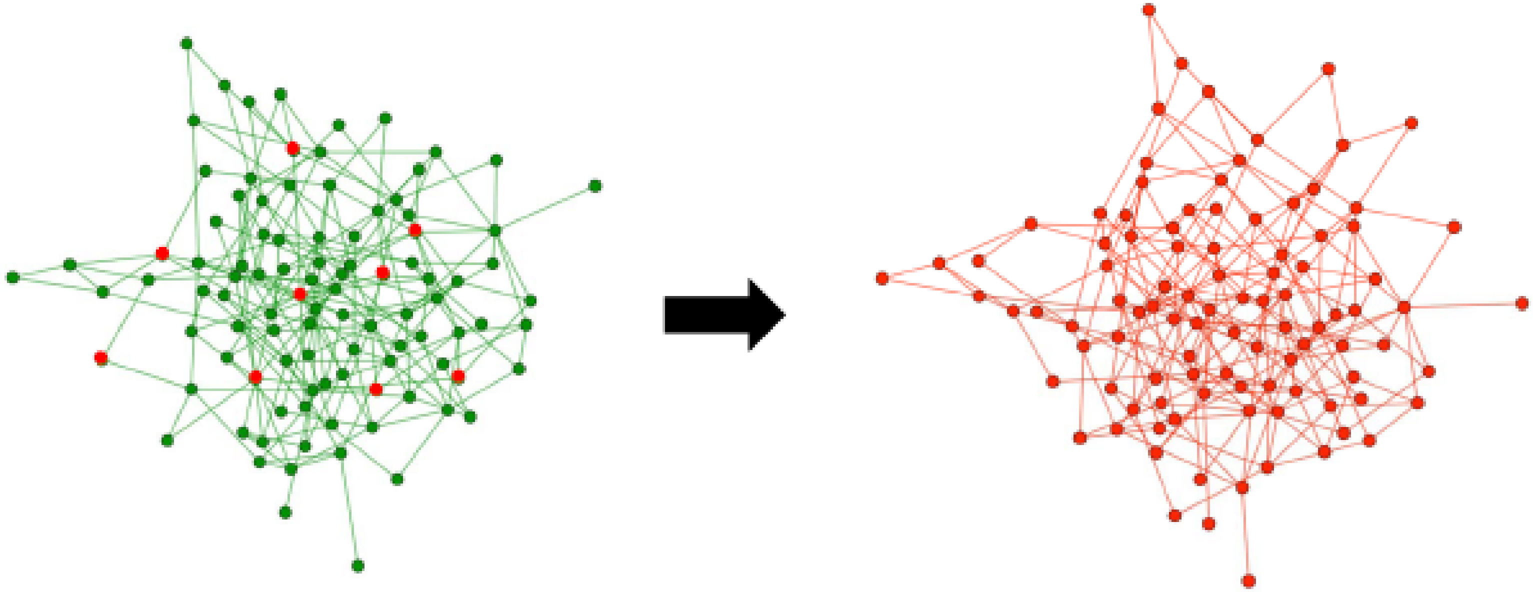
Q. Can a committed set of minority opinion holders on a network, reverse the majority opinion?



A (vaccinations do not cause autism)

B (vaccinations cause autism)

Q. Can a committed set of minority opinion holders on a network, reverse the majority opinion?



Applications: Influencing public opinion on preventative healthcare, Eradicating hostile opinions in terrorist states.

6

Model of social influence: *Binary agreement model* (*2-word Naming Game*)

Baronchelli et al., *PRE* (2007).
Castelló et al., *EPJB* (2009).
Baronchelli, *PRE* (2011).
Xie et al., *PRE* (2011).

- Difference from *epidemic* like models:
  - A "converted" individual can revert back.
    (in contrast to Threshold Model, Bass Model)
  - Influencing is symmetric in both opinions.
    (for ex: in contrast to SIS model)

- Difference from *voter* model:
  - Presence of intermediate state – coarsening & domain formation.

Plausible for studying situations where ***an individual does not require high personal investment to change opinion***:
Spread of buzz (Uzzi et al, forthcoming)

Model of social influence: *Binary agreement model*

Agents possess one of the following opinions at any given time:

A (vaccinations do not cause autism)

B (vaccinations cause autism)

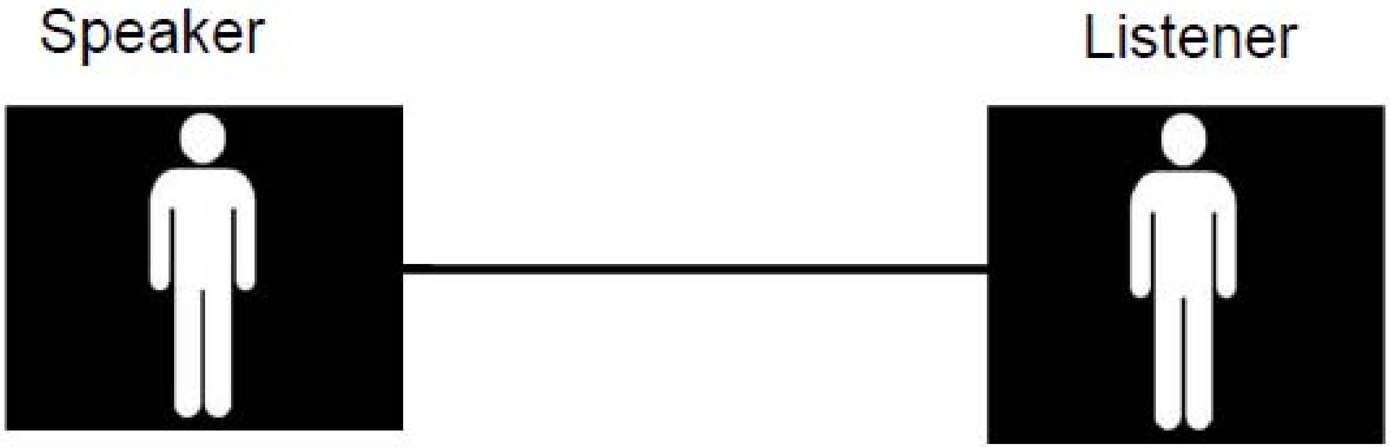
A B (mixed / not sure)

Model of social influence: *Binary agreement model*

At each microscopic time step:

A *speaker* is chosen at random.

A random neighbor of the speaker is chosen as *listener*.



Model of social influence: *Binary agreement model*

Opinion change:

Speaker voices an opinion from his list

Case 1: If spoken opinion not on listener's list - he adds it

Model of social influence: *Binary agreement model*

Opinion change:

Speaker voices an opinion from his list

Case 2: If spoken opinion *is* on listener's list - both retain only spoken opinion

Self-organization phenomena

Based on information exchange among individuals

Emerges without external control

No one have a complete picture of the overall structure, individuals react according to partial information

Information spread and how individuals react to it is crucial for crowd formation

[M. Moussaid, S. Garnier, G. Theraulaz, D. Helbing, Collective Information Processing and Pattern Formation in Swarms, Flocks, and Crowds, Topics in Cognitive Science vol. 1(3), 2009.]

Problem

Questions:

How online crowds form?

How consensus emerges?

Modeling the problem

One of the most used approaches to model the problem – perform an agent-based **simulation** of human behavior.

The Naming Game

Agents perform pairwise games in order to reach agreement on the name to assign to a single object

The Naming Game - Setup

Set of social networks (high-school friendship networks).

~1000 users in each network.

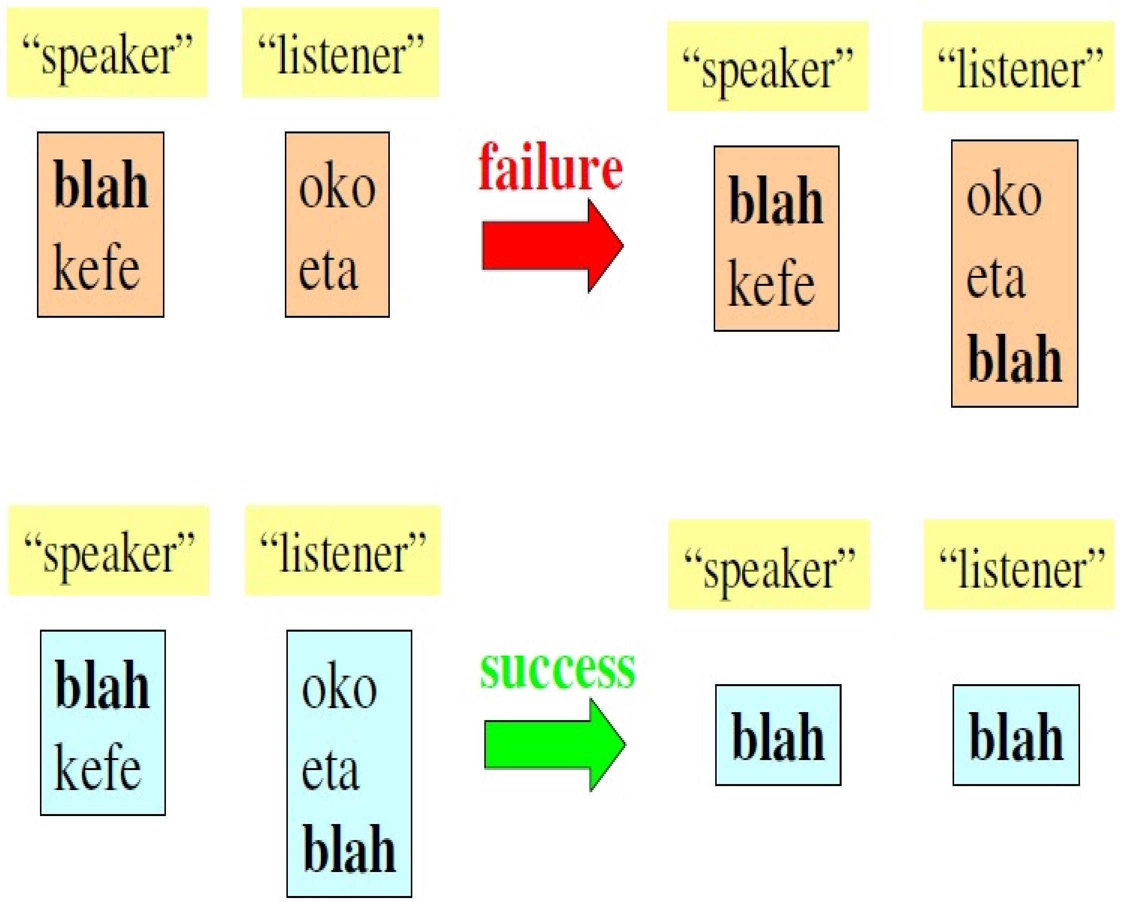
Nodes represent students, edges – mutual relations or friendship.

Relationships considered reciprocal – links are undirected.

The Naming Game - Rules

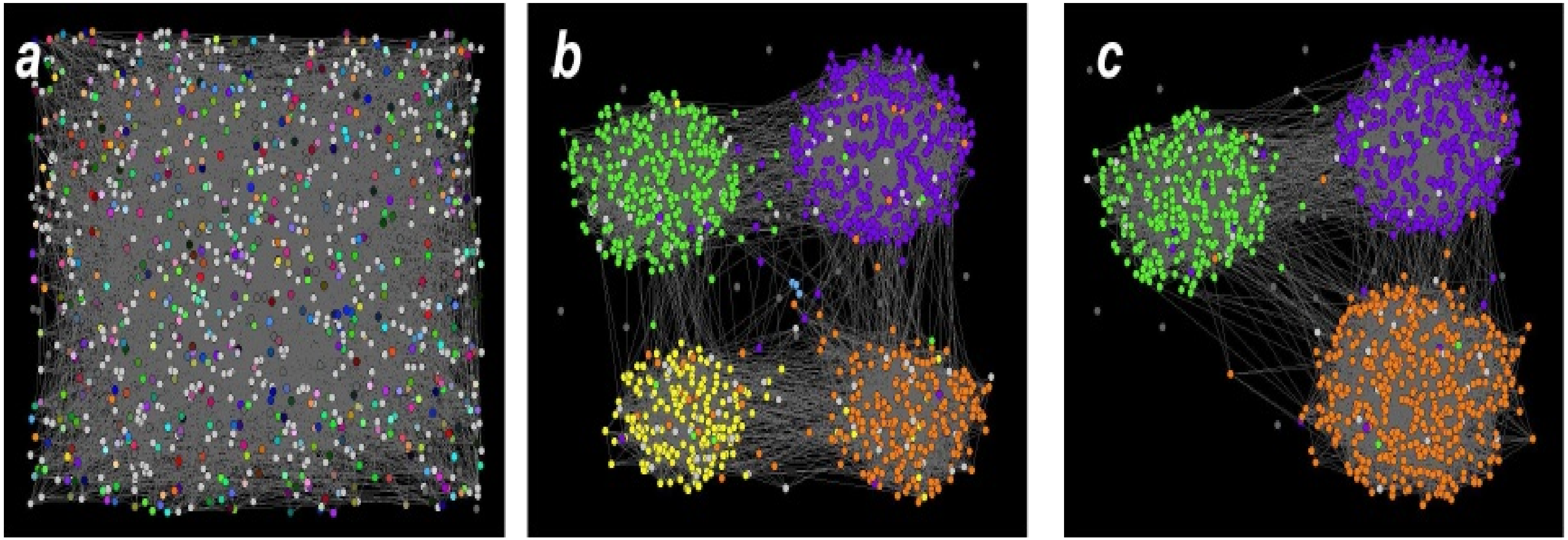
- A pair of neighboring nodes, a “speaker” and a “listener”, are chosen at random to update their vocabularies.
- The speaker transmit a word from her list of synonyms to the listener.
- If the listener has this word, the communication is termed “successful”, and both players delete all other words i.e., collapse their list of synonyms to this one word.
- If the listener does not have the word transmitted by the speaker (termed “unsuccessful” communication), she adds it to her list of synonyms without any deletion.

The Naming Game - example



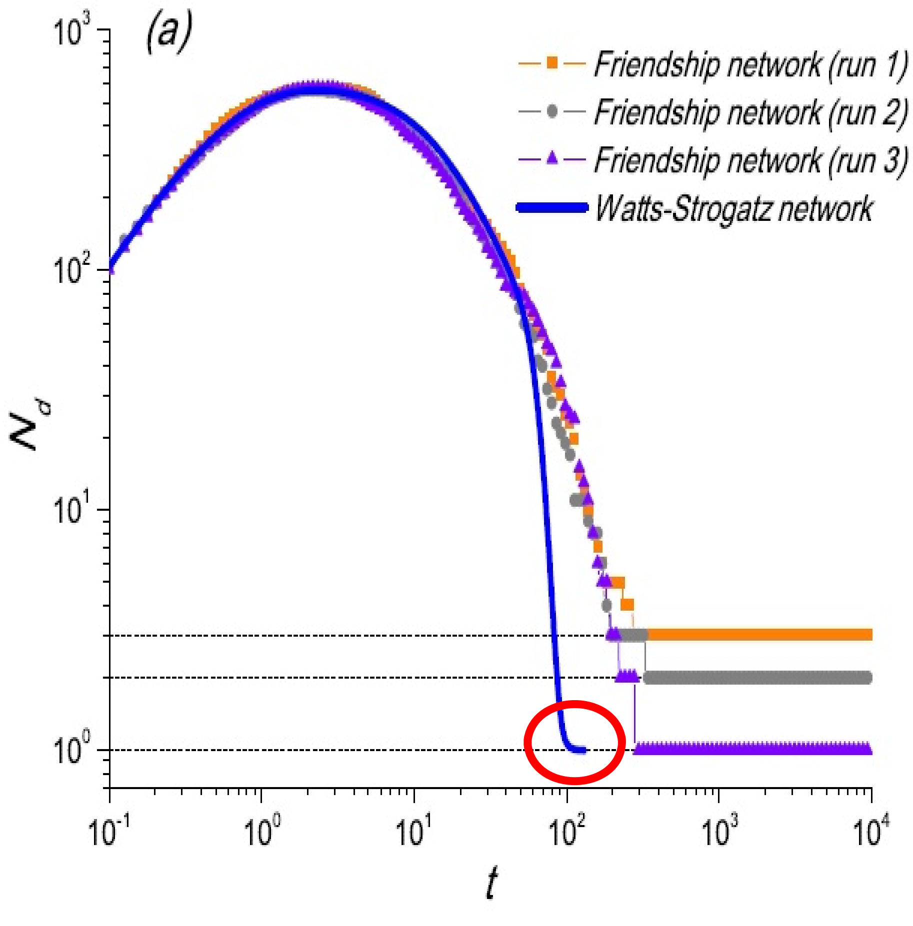
[Q. Lu, G. Korniss, B.K. Szymanski, The Naming Game on Social Networks: Community Formation and Consensus Engineering, Journal of Economic Interaction and Coordination, vol. 4(2), 2009.]

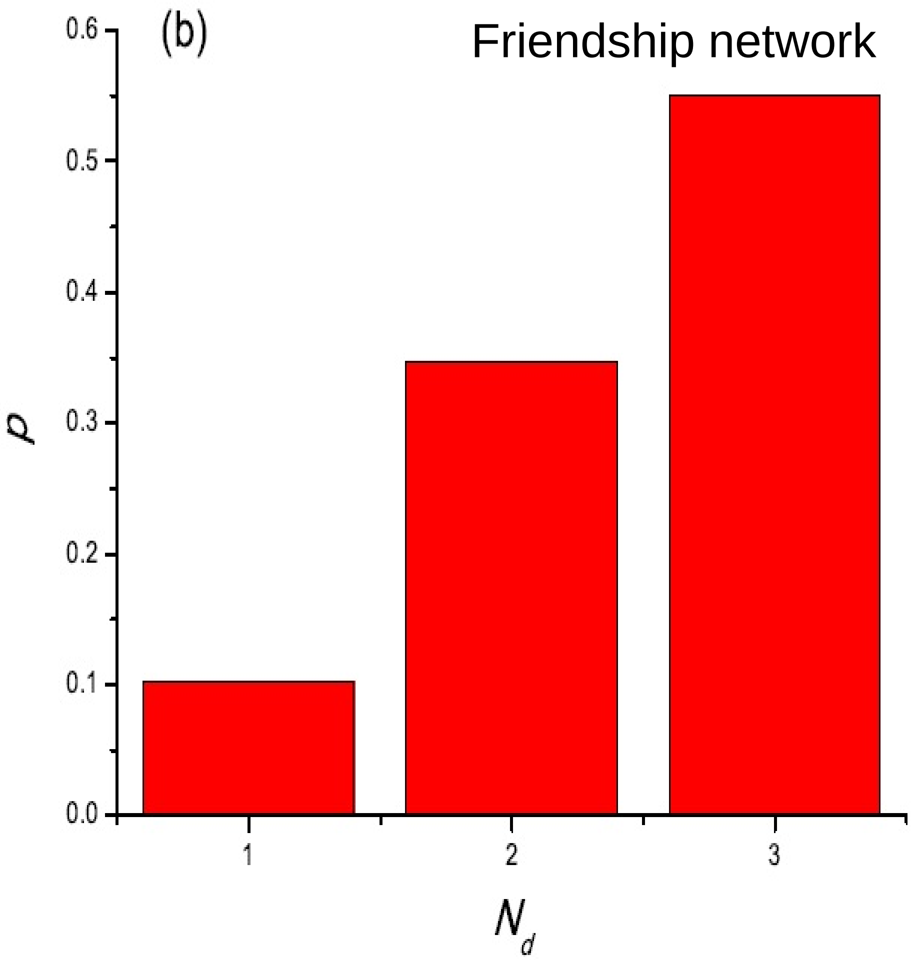
Time-evolution of the Naming Game



[Q. Lu, G. Korniss, B.K. Szymanski, The Naming Game on Social Networks: Community Formation and Consensus Engineering, Journal of Economic Interaction and Coordination, vol. 4(2), 2009.]

The Naming Game - Results





[Q. Lu, G. Korniss, B.K. Szymanski, The Naming Game on Social Networks: Community Formation and Consensus Engineering, Journal of Economic Interaction and Coordination, vol. 4(2), 2009.]

The Naming Game - Results

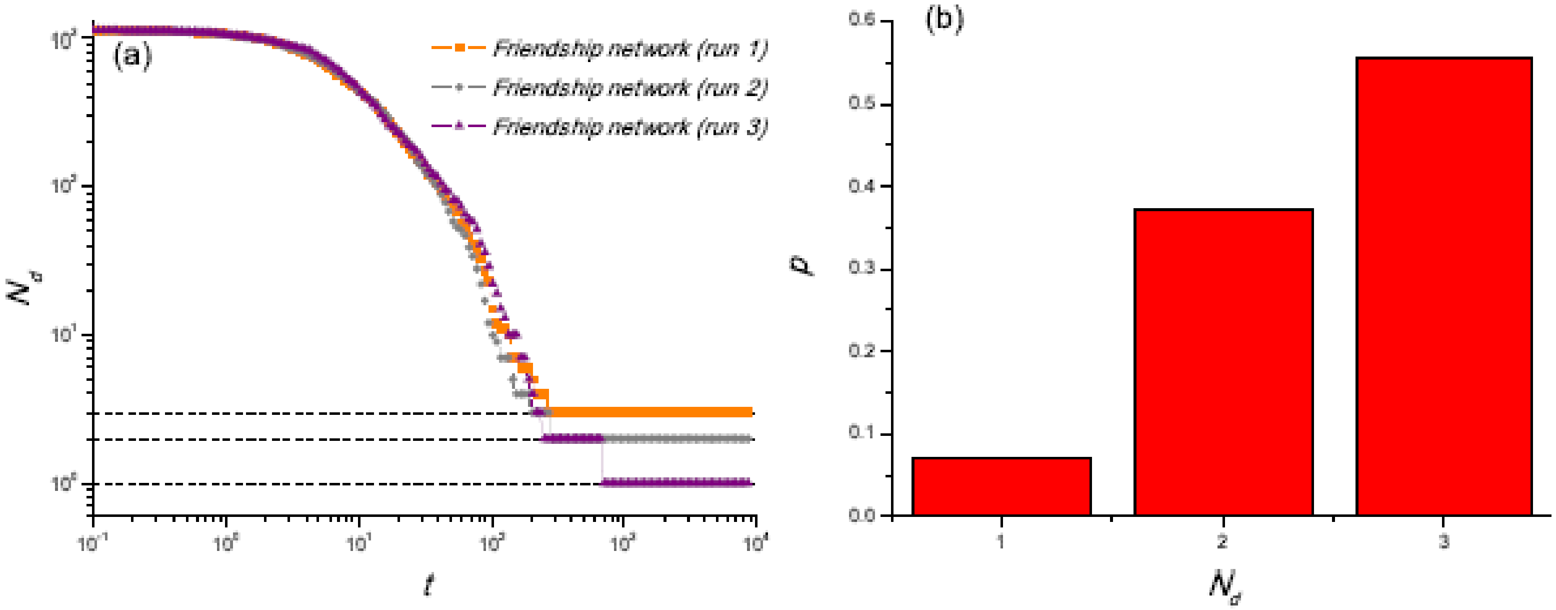


Fig. S1 The Naming Game on a friendship network where the simulations are initialized from configurations with a single word per agent (different for each agent). (a) Number of different words N_d vs time for a friendship network with $N = 1,127$, $\overline{k} = 8.8$, and $\overline{C} = 0.067$ (same friendship network as in Fig. 2 of the main article). Results are shown for three individual realizations, reaching different final states with $N_d = 1$, $N_d = 2$, and $N_d = 3$ (indicated with horizontal dashed lines). (b) The probability (relative frequency) of final configurations with N_d different words (opinions) for the same friendship network as in (a) based on 10,000 independent runs.

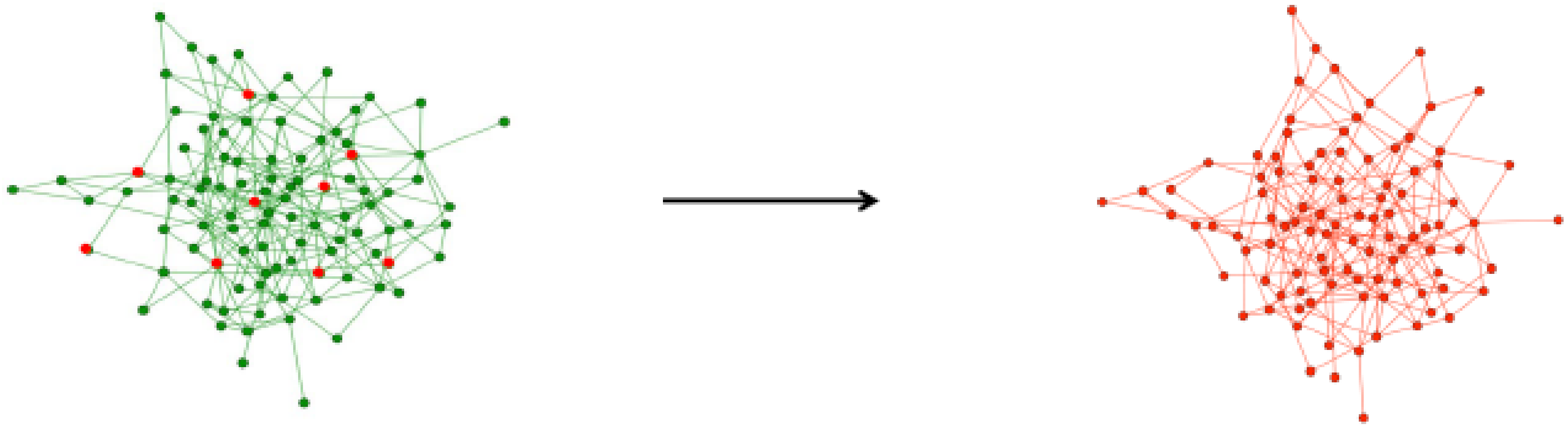
[Q. Lu, G. Korniss, B.K. Szymanski, The Naming Game on Social Networks: Community Formation and Consensus Engineering, Journal of Economic Interaction and Coordination, vol. 4(2), 2009.]

Initial condition we care about:

- Small fraction $p < 0.5$ of nodes *randomly chosen* are *committed* to opinion A

  Committed nodes are un-influencable i.e. never change opinion

- Remaining fraction (1-*p*) of nodes have opinion B



Only absorbing state is the all A consensus state

Q. How long does it take to reach the all A consensus state as a function of the committed minority fraction p ?

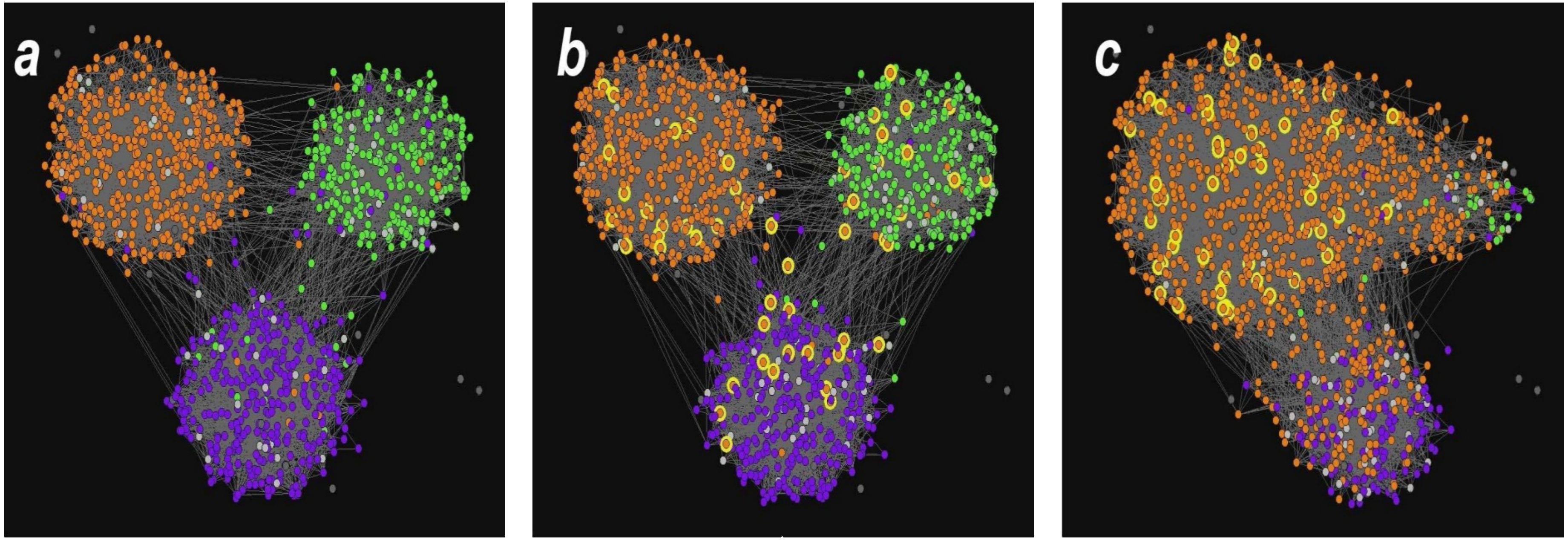
How to influence the outcome?

Choose a small number of well-positioned “committed” agents who stick to a preferred opinion without deviation.

- nodes with the highest degrees (nodes with the highest number of neighbors),
- with the highest betweenness (likely to bridge different communities),
- with hop-distance proximity to the core cluster (nodes outside, but no farther than two hops from the core cluster of “preferred” opinion),
- selecting committed agents at random.

Introduce “external” global signal (analogous to mass media effects)

The Naming Game with committed agents



50 committed agents selected according to their degree ranking.

[Q. Lu, G. Korniss, B.K. Szymanski, The Naming Game on Social Networks: Community Formation and Consensus Engineering, Journal of Economic Interaction and Coordination, vol. 4(2), 2009.]

Committed agents performance

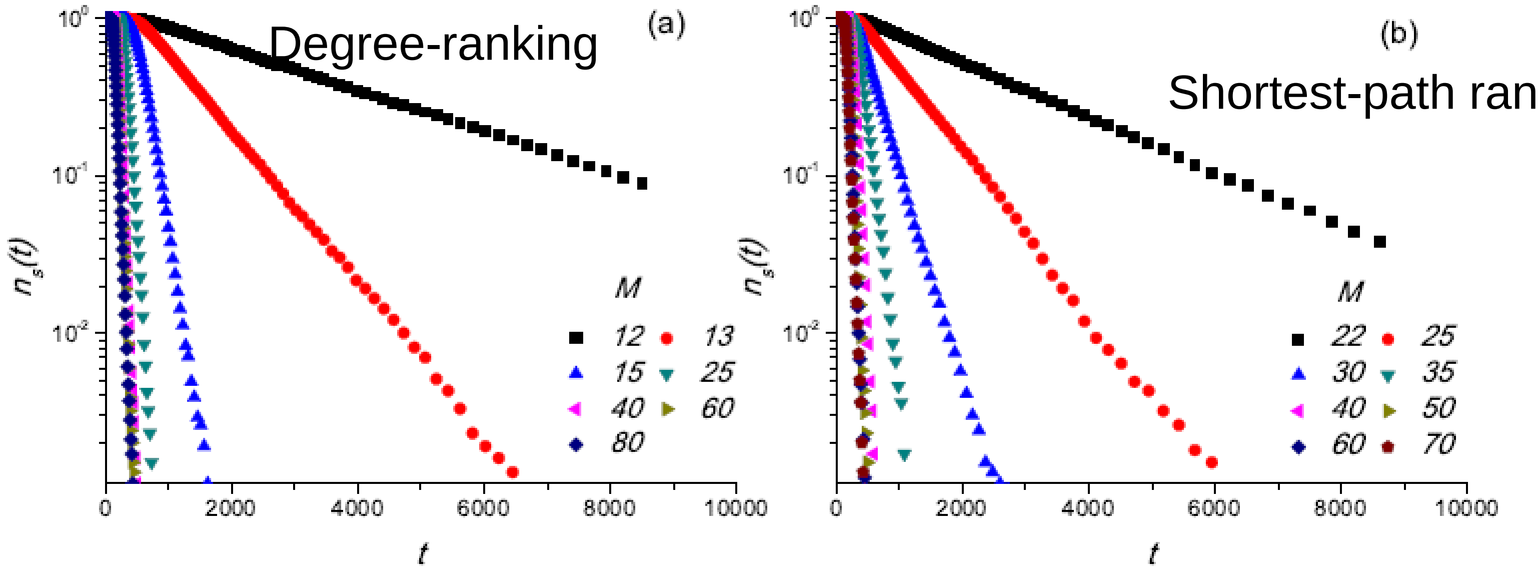


Fig. 5 Fraction of surviving runs as a function of time for varying number of committed agents M when agents are selected according to their (a) degree ranking and (b) (shortest-path) betweenness ranking. The total number of agents is $N = 1,127$. For the degree-based ranking selection method different symbols represent the fraction of surviving runs for 12, 13, 15, 25, 40, 60, and 80 committed agents, from top to bottom. In betweenness selection method the number of committed agents M ranges from 22, 25, 30, 35, 40, 50, 60, to 70, from top to bottom.

Fraction of surviving runs, ns(t), defined as the fraction of runs that have not reached global consensus by time t, i.e., runs that have more than one opinion at time t.

[Q. Lu, G. Korniss, B.K. Szymanski, The Naming Game on Social Networks: Community Formation and Consensus Engineering, Journal of Economic Interaction and Coordination, vol. 4(2), 2009.]

Committed agents performance

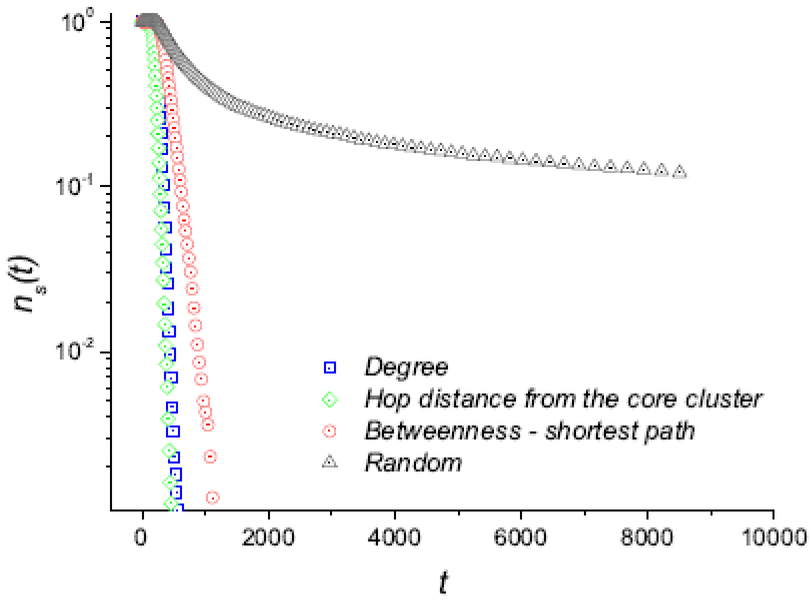


Fig. 6 Fraction of surviving runs as a function of time for different strategies with the same number of committed agents on the same network ($M = 35$, $N = 1,127$, $f \simeq 0.031$.). The three strategies (selection of committed agents) shown here are based on degree ranking (squares), hop-distance proximity to the core cluster (diamonds), and shortest-path betweenness (circles). For comparison, the result of selecting committed agents randomly is also shown (triangles).

Fraction of surviving runs, ns(t), defined as the fraction of runs that have not reached global consensus by time t, i.e., runs that have more than one opinion at time t.

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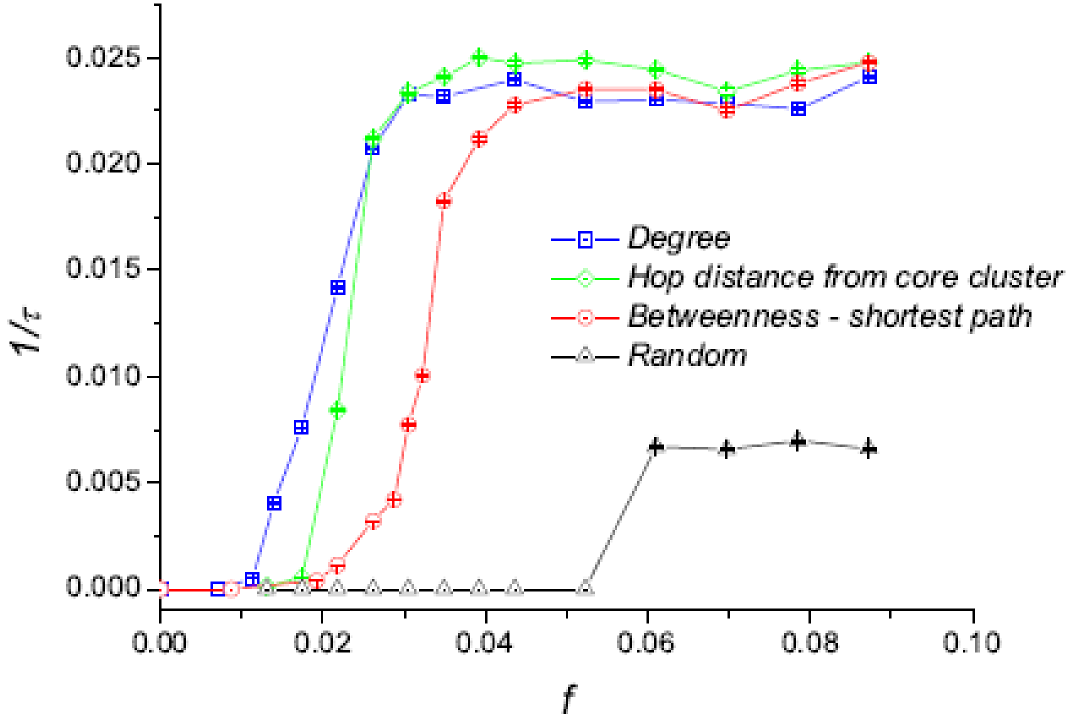
Committed agents performance



$$n_s(t) \propto e^{-t/\tau}$$

Fig. 7 Convergence rate as a function of the fraction of committed agents $f = M/N$, for different selection methods of committed agents, including the degree ranking (squares), hop-distance proximity to core cluster (diamonds), and shortest-path betweenness (circles). For comparison, the result of selecting committed agents randomly is also shown (triangles).

[Q. Lu, G. Korniss, B.K. Szymanski, The Naming Game on Social Networks: Community Formation and Consensus Engineering, Journal of Economic Interaction and Coordination, vol. 4(2), 2009.]

Committed agents performance

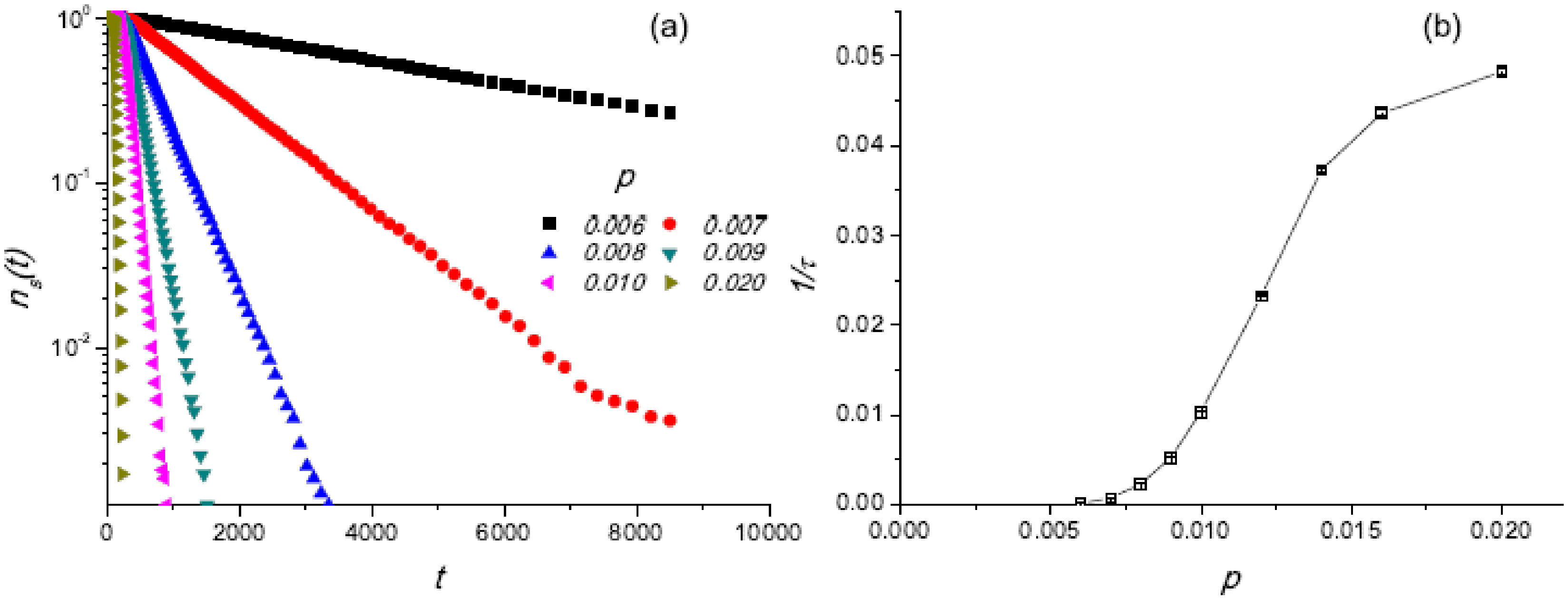


Fig. 8 (a) The fraction of surviving runs as a function of time for several values of the strength of external influence p (p is the probability that in a time step an agent will adopt the fixed externally and globally promoted opinion). (b) Convergence rate to global consensus as a function of the strength of external field p.

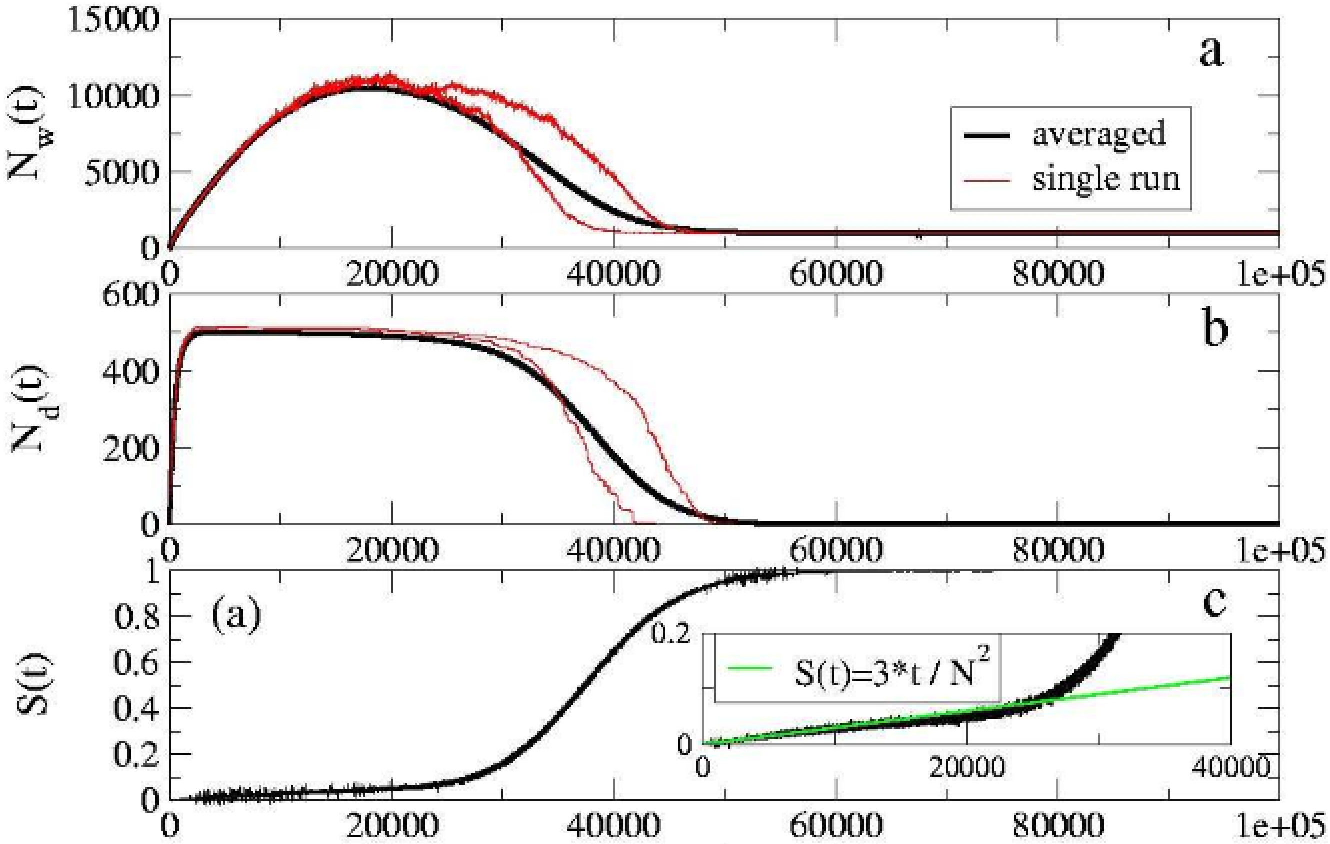


Figure 2. Temporal evolution: we report here time evolution curves of a Naming Game played by $N = 1000$ agents. Without loss of generality (see text) we consider $M = 1$ objects. Bold curves are obtained averaging 3000 runs, while the light ones are obtained by a single run. **(a)** Total number of words in the system $N_w(t)$ vs. t (t here denotes the number of games played) ; **(b)** Number of different words in the system $N_d(t)$, whose average maximum is $N/2$; **(c)** Success rate $S(t)$, calculated by assigning 1 to a successful interaction and 0 to a failure and averaging over many realizations. In the inset it is shown that, up to the disorder/order transition, the success rate is well described by the relation $S(t) = 3t/N^2$.

Summary

Self-organizational behavior leads to crowd formation.

Simulations (e.g. The Naming Game) are often used to model the problem.

Community structure have strong influence on consensus emergence and crowd formation.

Consensus emergence can be influenced by making some agents “committed” to a certain opinion or by adding “external” global signal .

Thank you.

SEE YOU NEXT WEEK!