COMPUTATIONAL SOCIAL SCIENCE:

EXCITING POTENTIAL AND FUTURE CHALLENGES

Duncan Watts
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Social Science vs. Social Practice

- Over past 100 years social science has generated tremendous number of theories of individual and collective human behavior but has not produced a cohesive, cumulative, and empirically tested body of theoretical knowledge
  - Exceptions often artificial settings (e.g. mechanism design for auctions).
  - Macro-econ might have been exception pre-financial crisis
  - Nudging, J-PAL possible exceptions, but limited applicability
- Result is that social practice (business, government, policy) is largely uninformed by social science
  - Designing and conducting advertising and/or marketing campaigns
  - Optimizing organizational performance and/or strategy
  - Enhancing collective action and/or resolving conflict
  - Predicting market demand and/or public opinion
  - Managing systemic risk in financial systems
  - Designing communities and cities
  - Allocating development funds

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Why the Lack of Progress?

- Individual people are complicated enough, but **social** phenomena involve **many** individuals **interacting** to produce **collective** entities (firms, markets, cultures, political parties, social movements, audiences)
  - "Micro-Macro" problem (aka "Emergence")
  - Emergent phenomena arise in natural science, but in social science *every* problem of interest involves emergence
- Micro-macro problems are hard to study empirically
  - Difficult to collect observational data about individuals, networks, and populations at same time
  - Even more difficult to do "macro" scale experiments
- Hard to do science when you can't measure what you're theorizing about and can't do experiments

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Computational Social Science

- Revolution in digital communication technologies is beginning to life these historical barriers
  - Has dramatically increased the <u>scale</u>, <u>scope</u> *and* <u>granularity</u> of data available to social scientists
    - Email, e-commerce, search, social networking, social media, etc.
  - Web platforms are also lowering the cost, and increasing the speed and scale of experiments
    - Traditional lab-style experiments + Field experiments
- May revolutionize our ability to *study* society
  - Akin to the telescope + collider for social science
  - View as complement to modeling/simulation approach

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From Science to Policy?

- Past 15 years have led to remarkable progress in what is possible for social science
  - Also whole new conferences, research centers, journals, etc. on "computational social science," "network science," "big data"
- Nevertheless, little progress on matters of social policy
  - Systemic risk in financial systems, dynamics of emerging epidemics, factors affecting cultural change, organizational performance, or political polarization and conflict.
  - Even simpler questions like "when do people change their minds and why"? are still hard to answer except in trivial special cases
- How to close the gap between excitement and results?

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Improving Found Data

- Behavioral data ("digital breadcrumbs") currently collected on many disconnected platforms
  - Facebook for self-reported social networks, Google and Bing for search queries, Amazon and eBay for e-commerce, Nielsen for ratings, various email providers, etc.
- Many questions of interest to social science could be better addressed if these "modes" of behavior could be joined
  - E.g. "Who influences whom" requires (a) individual data, (b) interaction data, (c) behavioral data, (d) attribution data
  - Clear privacy, legal, and technical obstacles to doing this
- Another problem is that digital data is increasingly "algorithmically confounded"
  - Personalization + recommendations bias user behavior
  - Any feature change can impact apparently "social" phenomena
- May need to collect data with research questions in mind
  - Opt-in panels one possibility

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Scaling up the Lab

- History of experimental psychology / economics constrained by scale and speed
  - Unit of analysis was individuals or small groups
  - Experiments took ~ 1yr to design and run
- Potentially "Virtual labs" lift both constraints
  - State of the art ~ 5K workers, but in principle could construct subject panel ~ 100K – 1M
  - Could shrink hypothesis-testing cycle to days or hours
- Would open up fundamentally new research designs
  - Could study whole organizations, even "cultures" in the lab
  - Experiments could run for months not minutes
  - Tracking individuals would allow for novel sampling and insights

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Empirically Informed Modeling

- Traditional mathematical or computational modeling
  - Tends to rely on many, often questionable, assumptions
  - Not generally tested in detail against data
- Result is proliferation of models that exist in parallel and are often incompatible with each other
  - Diffusion, cooperation, systemic risk, organizational performance
- New sources of data allow both to test models and also calibrate them
  - Diffusion models tested against observational data
  - Lab experiments used to calibrated agent-based models
- Models complete hypothesis-testing cycle
  - Observations → Models → Lab → Field → Observations

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Institutional Innovations

- New platforms and protocols for data management
  - Better coordination of data collection, storage, sharing
  - Recruitment and management of subject pools, field panels
- Collaborative interdisciplinary teams
  - For a given data set, often unclear what the most interesting question is
  - For a given question, often unclear how to collect the right data
- Integrated research designs
  - Coordination across theoretical, experimental and observational studies
- Potentially new research institutions
  - UrbanCCD, CUSP interesting models
  - Public-private partnerships (especially around data sharing)?
  - Janelia Farm for Social Science?
  - J-PAL for the first world?

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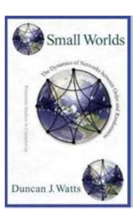
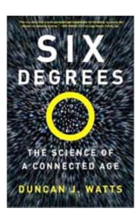
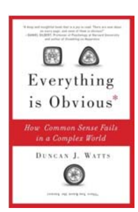
THANK YOU

http://research.microsoft.com/en-us/people/duncan/

http://everythingisobvious.com







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BACKUP SLIDES:
ILLUSTRATIVE EXAMPLES OF CSS

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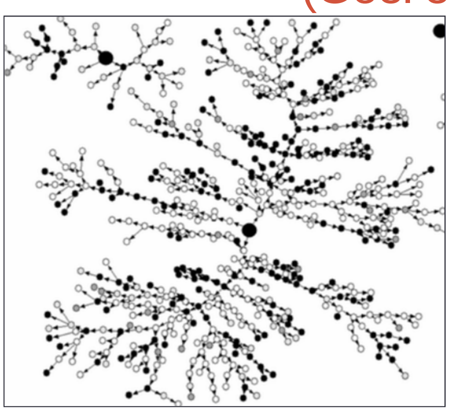
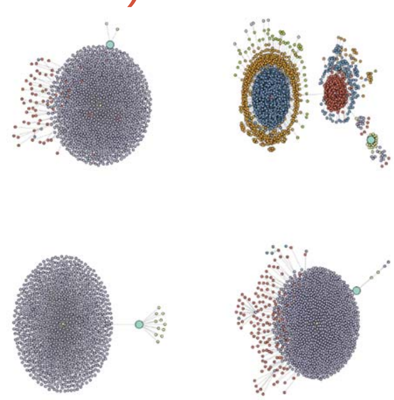
How Does Popular Content Get Popular? (Goel et al 2014)





Viral vs. Broadcast?

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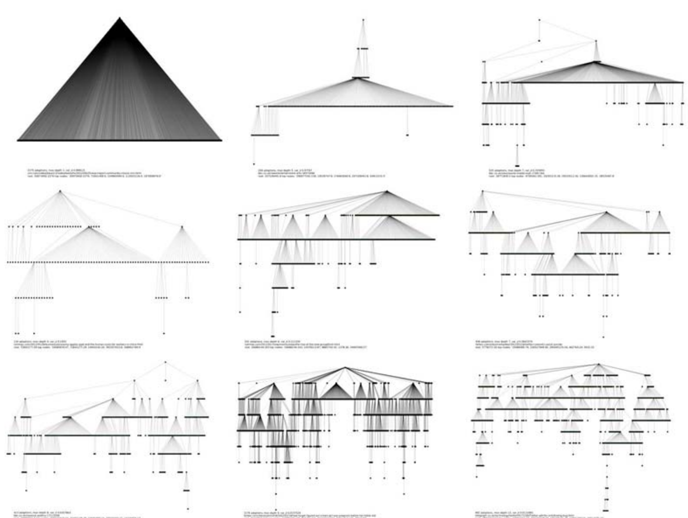
Online Diffusion (Goel et al 2014)

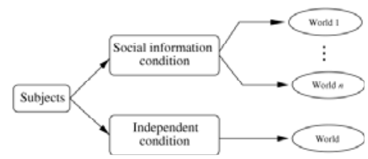
- Study every tweet containing a link to a video, news story, image, or petition over 12 month period
    - About 1.4B tweets total
    - "Popular" subset ~ 350,000 events
  - Also crawled entire "active" follower graph
    - ~65M users, > 10B edges
- To focus now on "popular" content, consider only URLs that receive > 100 tweets, roughly 1 in 3,000 events
  - > 1,000 tweets roughly 1 in 1,000,000 events
  - If want thousands of large events, need ~ 1B observations!
- Measure "structural virality" of cascades:
  - Construct tree of all retweets, retweets of retweets etc.
  - Compute average all-pairs path length on these trees

Diversity of Structural Virality (Goel et al 2014)



Music Lab
Salganik, Dodds, Watts (Science, 2006)

- Why are ‘hits’ in cultural markets
  - Much more successful than average
  - Yet so hard to predict?
- Conducted experiment on social influence and market dynamics
  - 14,000 participants chose between 48 songs by unknown bands
  - Randomly assigned to ‘social influence’ and ‘independent’ conditions
- Social influence simultaneously increased inequality and unpredictability
  - Markets “construct” preferences as well as reveal them



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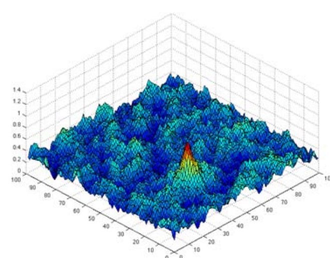
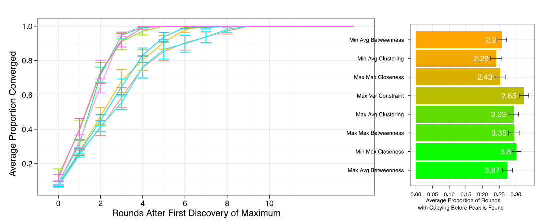
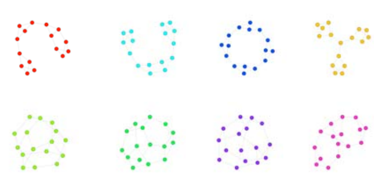
Collaborative Learning in Networks
Mason and Watts (2012)

- Networks of N=16 individuals collaboratively searching a fitness landscape
  - Efficient (short path length) networks distributed information faster
  - Also resulted in less copying, more exploration







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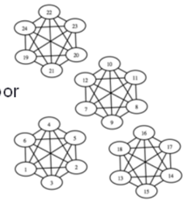
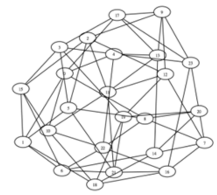
Cooperation on Dynamic Networks
Wang, Suri, Watts (2012)

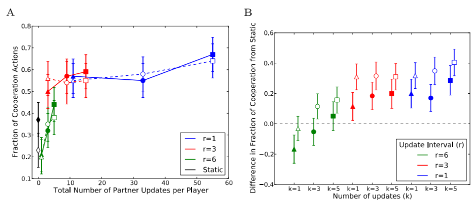




- Studied repeated prisoner's dilemma on a network (n=24)
- Every r rounds, players allowed to make up to k updates
  - Delete an edge from an existing neighbor **or** propose an edge to a new neighbor
  - Proposed ties had to be accepted, but deletions were unilateral
- Example: for = 3, k = 5, have:

|1|2|3| rewire 5 links |4|5|6| rewire 5 links |7|8|9| rewire 5 links |10|11|12|

- Studied r =1,3,6; k = 1,3,5
  - Studied two initial substrates (random and cliques)
  - Also studied static networks as controls
  - ~4 trials per treatment, so 80 experiments in total
- Found that rewiring matters (a lot!) but substrate doesn't
  - Consistent with earlier exps on static networks (Suri and Watts 2011)



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