Social life is more like improvisational jazz than a symphony orchestra
- we compose our parts on the fly, but not just as we please
- how is this possible with millions of players?

Requires a new modeling approach

- An earlier generation: interactions among variables
- ABC modeling: interactions among agents
- A computational tool for exploring the dynamic implications of a set of assumptions
  - complexity of social systems need not be based on complex behavior
  - can we discover simple rules to explain some of the persistent puzzles of social life?

Modeling is as easy as ABC

- Begin with a puzzling population pattern
  - Why does segregation persist?
  - Why is trust lower in Japan?
- Look for the simplest set of conditions needed to generate the pattern.
- Test robustness of arbitrary assumptions ("sensitivity analysis").
- Manipulate key assumptions to identify causal mechanisms.

What is a "social agent"?

- Cognitive architecture
  - agents are heuristic
  - agents are adaptive
- Social architecture
  - agents are autonomous
  - agents are interdependent
  - agents are networked

heuristic adaptive autonomous interdependent networked

- "Human beings viewed as behaving systems, are quite simple" (Simon 1998)
- We follow rules
  - behavioral routines that provide standard solutions to recurrent problems
  - norms, conventions, rituals, routines, moral and social habits

heuristic adaptive autonomous interdependent networked

- Rules compete for propagation
  - individual learning: selection within
    - reinforcement
    - error-correction
    - bayesian updating
    - back-propagation
  - population learning: selection between
    - biological reproduction
    - role modeling, imitation of the fittest

heuristic adaptive **autonomous** interdependent networked

- Agents are not "representative"
- Not a model of the population but a population of models, each with its own
  - inputs
  - outputs
  - local environment
  - decision rules

heuristic adaptive autonomous **interdependent** networked

- Autonomy is constrained
- Behavioral interdependence
  - agents influence neighbors in response to the local influence that they receive
  - persuasion, sanctioning, exchange, imitation
- Strategic interdependence
  - consequences of each agent's decisions depend in part on the choices of others.
  - "Prisoner's Dilemma," "Chicken"

heuristic adaptive autonomous interdependent **networked**

- Interdependence is local
- Population dynamics depend on network properties
  - clustering
  - hubs ("scale free networks")
  - bridge ties ("small worlds")
  - elective ties (dynamic networks)
    - homophily
    - assortative matching
    - movement

What do agents do?

- Influence their neighbors in response to the local influence they receive.
  - exchange (gifts, blows)
  - sanction (approval, disapproval)
  - persuade (inform, lie)
  - innovate
  - imitate

Very similar to game theory

- An early agent-modeler: Schelling
- Game theory is also bottom up
  - Individuals are interdependent yet autonomous
  - Population outcomes need not reflect individual preferences
    - Prisoner's Dilemma
    - Coordination games

Differences

- Game theory
  - a fully connected population
  - perfect rationality, complete information, and unlimited calculating ability
  - representative agents
- ABC models
  - local interaction
  - simple rules (i/o)
  - onstrumental, emotional, or normative motivation
  - heterogeneous agents

Beyond game theory

- Game theory identifies Nash equilibrium
- ABC models also tell us
  - probability that this equilibrium will obtain
  - path into or out of the equilibrium
  - what happens when
    - interaction is local (complex networks)
    - agents are heterogeneous
    - agents do not have perfect information, rationality
    - system is far from equilibrium

From static to dynamic equilibrium

- Nash equilibrium
  - no incentive to unilaterally change strategy
  - Population is stable because no one moves
- Self-reinforcing equilibrium
  - The more agents who do X, the higher the probability that each agent will do X next time.
  - Cascades, fads, herd behavior
- Self-correcting (homeostatic) equilibrium
  - Balance between forces pulling in opposite directions
  - Individuals constantly change but population mean remains stationary.

Limitations of ABC models

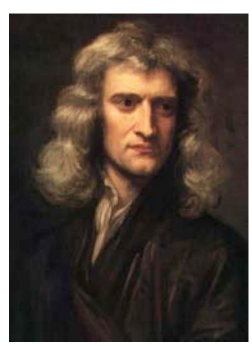
- Conclusions are less general than deductive proofs
  - results depend on numerical values
  - no way to test every possible number
- Causal processes are less transparent than in mathematical models
  - Observe how results change with parameters
  - But why is this happening?

The lure of realism

- Analytical models may sometimes be too simple to explain the dynamics of a complex system
- ABC models can easily become too complex to explain the dynamics of a simple system.
  - Correlation between inputs and outputs
  - But what is the explanatory mechanism?

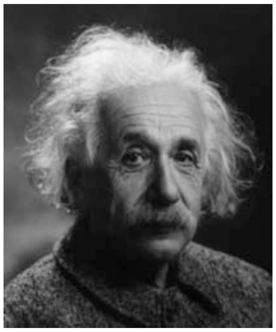
"All models are wrong but some models are useful."

-- George E.P. Box, statistician



"Truth is ever to be found in the simplicity, and not in the multiplicity and confusion of things."

-- Sir Isaac Newton



"Everything should be made as simple as possible, but not simpler."

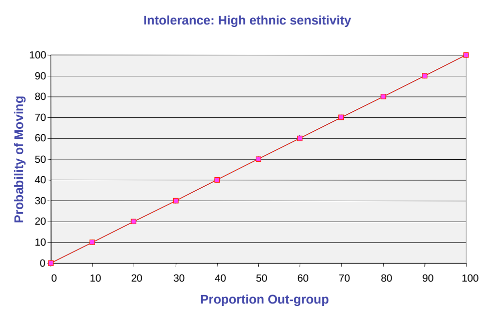
-- Albert Einstein

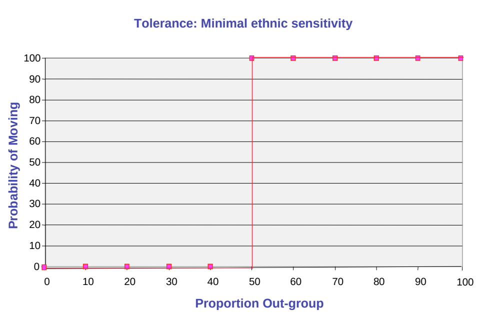
Don't results depend on the assumptions?

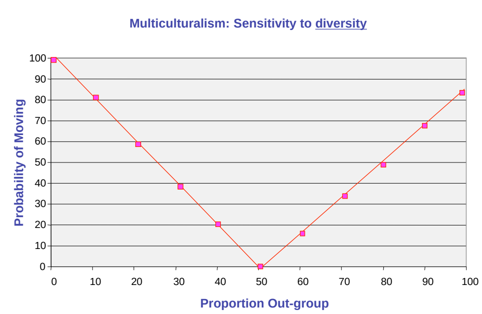
- Yes (unless there's a bug)
- Don't trust your intuition!
  - "common sense" can be dangerous
  - implications of assumptions are not self-evident and are often surprising.
    - complex systems are highly non-linear
    - the whole is more than the sum of its parts.
    - population behavior need not reflect individual preferences or intentions.

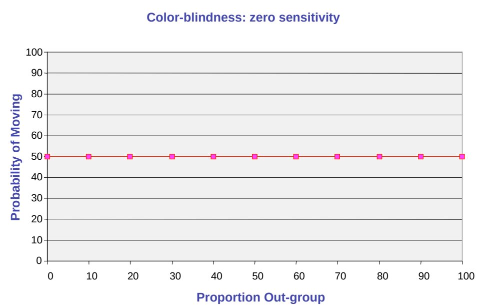
Puzzle #1: Persistence of segregation

- Fair Housing Act (1964) outlawed housing discrimination based on race or ethnicity.
- Surveys show steady increase in racial and ethnic tolerance since 1964.
- Yet residential segregation persists.
- Is racial and ethnic intolerance the problem?









Predictions

- Intolerance promotes segregation.
- Tolerance, multi-culturalism, and color-blindness inhibit segregation.

Schelling model

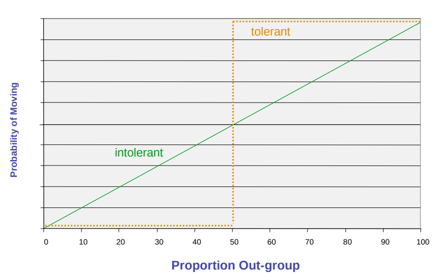
- A regular lattice, *N*=[100-250*K*].
- Each agent has [4,8,24,48] contiguous neighbors.
- Two equal-sized ethnic groups, red & blue.
- If dissatisfied, agents pick the closest empty slot that is satisfactory.
- Random or segregated start.

From tolerance to multiculturalism

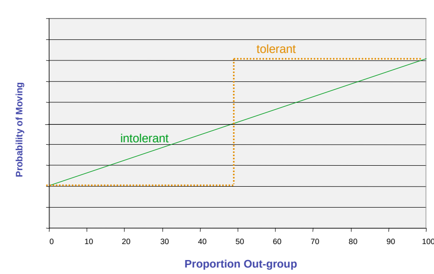
- Complete segregation is an equilibrium for agents who tolerate minority out-group neighbors.
- But suppose agents strictly prefer diversity?
- Segregation should now decrease…

[Click here for demonstration]

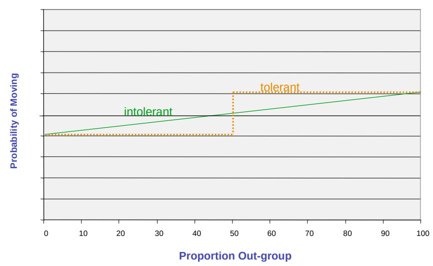
Strong ethic preference



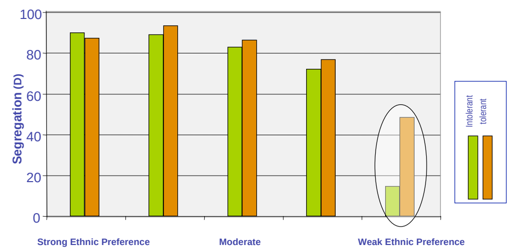
Moderate ethnic preference



Weak ethnic preference



Effect of tolerance and color-blindness*



*See also Bruch and Mare, "Neighborhood Choice & Neighborhood Change," *AJS*, 2006.

What did we learn?

- Don't trust intuition…
  - When ethnic preferences are strong, we get segregation in a population that seeks diversity
  - When ethnic preferences are weak, we get integration in a population that seeks segregation but not one that tolerates diversity.

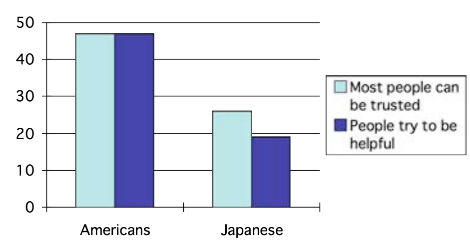
But is the model realistic?

- Schelling's neighborhood
  - a very small 10x10 checkerboard.
  - no housing prices, no crime, no train tracks, no lousy schools.
- Agent-based models are used for thought experiments
  - similar to game theory, only non-mathematical.
  - resist the temptation to make the models "realistic."
    - requires numerous complications.
    - undermines the power to reveal micro-macro links.

Puzzle #2: Trust and Mobility in US & Japan

- JP: Monitoring, sanctioning within tightly clustered social networks
- US: Higher mobility, lower social control
- So where would we expect to find higher levels of social trust?

A Surprising Result



Yamagishi & Yamagishi, 1994, "Trust and Commitment in the United States and Japan," *Motivation and Emotion*, 18: 129-66.

Mobility and Trust

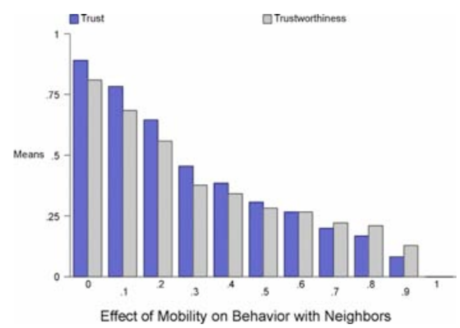
- Lowers opportunity costs (more choice of partners, seek out opportunities)
- Raises transaction costs (“hit and run”)
  - No incentive to build a reputation.
  - Hard to learn about reputations

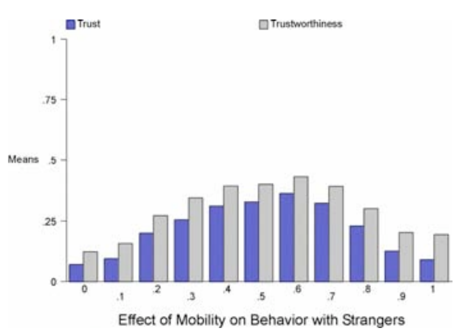
Hypothesis: U-Shaped Effect of Mobility

- Too little mobility:
  - Parochialism, not trust
  - Agents prefer safety of the neighborhood
- Too much mobility: cheating, not trust

Theoretical Model

- Agents make three decisions:
  - Whether to look for a partner outside the neighborhood
  - Whether to cheat the partner
  - Whether to trust the partner
    - Based on familiarity
    - Based on signaling





Implications

- Warning to Japan: Parochialism imposes high opportunity costs in an increasingly global market.
- Warning to the US: Rapid advances in telecommunications could undermine on-going relations needed to sustain effective signaling conventions.

Puzzle #3: Influence & Diversity

- Axelrod:
  - If people influence neighbors, and
  - If people prefer neighbors similar to themselves ….
  - How is diversity possible?

[CLICK HERE FOR DEMONSTRATION]