SOC 795E-01 – Modeling Emergence: Social Simulation

Tue, 2:30-4:-00pm – Machmer Hall, Room W-13 (Seminar) **James A. Kitts**
Thus, 2:30-4:00pm – DuBois Library Tower Room 1667 (Lab) **Machmer W34B**
Office Hours- Tue 9:00am-11:00am **jkitts@soc.umass.edu**

Much quantitative social science and behavioral research has focused on identifying statistical relationships in cross-sectional data. While rigorous and tractable, this research typically assumes the objects of study are independent of one another, and thus assumes away the complex social processes that we hope to understand. Qualitative (ethnographic and comparative-historical) lenses have allowed us to view the social world as a web of interdependent and contingent processes, with macro-level cultures, communities and organizations emerging from and constraining the micro-level interactions of individuals, relationships, and families. An explosion of recent work in Sociology has used computer simulation to think systematically and rigorously about these complex social dynamics. Simulation research can offer rich, nuanced process models similar to qualitative work, but employs a rigorous, transparent, and replicable framework that can be extended to other research contexts, similar to statistical approaches.

Theorists use computer models to elucidate, extend, integrate, and validate social theory. Policy analysts use computer models to predict outcomes of policy scenarios in complex and interactive domains. Managers use computer models to design efficient and robust organizational operations and implement effective interventions. This proliferation of simulation work has generated great interest in computer modeling methods. This seminar will give participants a deep critical exposure to the most prominent sociological literatures using simulation, and use these models as a springboard to learn and practice the methods of social simulation.

We will focus primarily on agent-based simulation, with a brief introduction to some more traditional modeling approaches (including closed-form analytic solutions and system-level simulation). Students must share an interest in abstract theory, but do not need any specialized training in mathematics or computer science for this course.

BOOKS

- Schelling, Thomas C. 1978. *Micromotives and Macrobehavior.* (required)
- Wilenski, Uri and William Rand. 2016. *An Introduction to Agent-Based Modeling* (optional)

GRADES: 75% Participation (including discussions & reflections); *25%* Final Project. This class is a collaborative project, so most of the evaluation depends on your engagement in our peer learning exercises. There is no exam and you will not be evaluated on memorizing concepts, but your participation in class discussion and sharing your work through the weekly reflections and discussant opportunities are crucial.

SEMINAR REQUIREMENTS

- **Intensive Pre-Seminar Workshop:**
  Before the course begins, you experience a 2-day skill-building workshop, offered through ISSR. This workshop exposes you to core concepts, classes of models, methodological lessons, and relevant software packages. Following from this workshop, we will apply these skills to deeply investigate models, simulation projects, and intellectual debates.

- **Seminar project:**
  Each student will work on a modest and flexible seminar project. This might be a conventional term paper, such as a review essay, but <u>I encourage you to instead design a project that will advance your career (some modeling work toward a publishable paper, a grant proposal, a future job, etc.)</u>. For most, this will be a replication or extension of an existing model (perhaps a model on this syllabus). In any case, <u>collaboration (with other students) or double-dipping (combining a seminar project with some other seminar) will be fine, if this contributes to a publishable product that is useful for you</u>. The final project is a capstone aiming to make the class useful for you, but it is not a centerpiece of the course.

- **Lab meeting:**
  Our Thursday labs include 60-90 minutes of required structured activities along with 30-60 more minutes of optional open exploration. (The official lab time is 2:30-4:00 but we have the room until 4:30 in case students want to continue working.)

- **For one class session you will serve as "lead discussant" and for one session you will serve as "secondary discussant." Work out your session preferences with me.**
  The lead discussant gives a brief orientation for the class, including discussion questions relevant to our learning goals. The secondary discussant offers supplementary comments and questions. Either may choose to address points from colleagues' "reflections" below.

- **Each week, all students who are not discussants write "reflections" on the reading:**
  Write an informal one-page single-spaced response, grappling with some <u>model</u>(s) in the reading. Submit to Moodle by *Noon* on *Monday*. You may also submit a replication or implementation (e.g. a computer program, an awfully good diagram) as your "reflections."

- ***How* to read the articles and chapters –**
  There isn't much reading for this class. However, we share high expectations for <u>*deeply*</u> engaging the models that we do study. See the syllabus for particular pages that I ask everyone to read. Strive to understand *how the models work*. We are here to understand the *methods* of building and exploring models. For this purpose, we won't distract ourselves with thoughts about what might be missing from a model, how it could be extended, why the model is or isn't important, how its assumptions may be unrealistic, or how misleading the framing of the article may be. If you can deeply study a model, dissect it, reconstruct it, and replicate it (in a diagram, spreadsheet, computer code, or pseudocode), this experience will teach you deep methodological lessons that you can carry into your own area of study.

COURSE SCHEDULE

INTENSIVE 2-DAY SKILL-BUILDING 'BOOT CAMP' WORKSHOP

Aug 29, Mon, 9am-3pm DuBois 1667
Aug 30, Tue, 9am-3pm DuBois 1667

<u>If you have already taken my 2-day or 3-day ISSR workshop you need not attend it again.</u>

WEEK 1 (Sept 6) MEET IN MACHMER W-13: Introduction

We begin by discussing a variety of motivations for simulation in the social sciences. Prognostic simulation uses data-driven ("realistic") models to forecast future trends and events. Methodologists use simulation to generate surrogate datasets with known properties for the purpose of validating or calibrating their analytical tools. Planners use simulation to aid in decision-making. Increasingly, social scientists are using simulation as a virtual laboratory for conducting "computational experiments" to investigate basic theoretical questions. We will focus mostly on the latter use of simulation as a flexible tool for inventing and refining theory. We begin with classic readings by Schelling and Axelrod, who motivate the use of "bottom-up" (agent-based) formal models to understand the emergence of nonobvious macro-level patterns from micro-level behavioral regularities. Gilbert gives a more general orientation to modeling.

READING (required for this first class):

Schelling, Thomas C. 1978. Chapters 1 (pp. 11-**19**, **36**-43), 2 (pp 47-80), and 3 (pp. **83-102**). *Micromotives and Macrobehavior*. New York: Norton. *84 pgs*

Gilbert, G. Nigel and Klaus G. Troitzsch. 2002. Chapter 2, pp 15-27. *Simulation for the Social Scientist*. Philadelphia, PA: Open University Press.*

LAB 1 (Sept 8) DuBois Library Tower Room 1667

* = reading to be found on Moodle

WEEK 2 (Sept 13): System-Level Simulation as a Theory-Building Tool
[Lead Discussant: Amanda; Secondary Discussant: Devika]

Hanneman et al and Leik & Meeker demonstrate "top-down" (system-level) simulation as a method for developing and refining theory in Sociology. They differentiate the goals of computational experiments from the goals of empirical research and from alternative methods of formalization (logic and mathematics). They also demonstrate that simulation can be used for macrosociological research on political and cultural changes over long time spans, as well as microsociological research on groups and local interaction.

Hanneman, Robert A., Randall Collins, and Gabriele Mordt. 1995. "Discovering Theory Dynamics by Computer Simulation: Experiments on State Legitimacy and Imperialist Capitalism" *Sociological Methodology* 25. (pgs **1-7**, **11-24**, **39-40**)* *33 pgs*
[Implementation available in *Stella*]

Leik, Robert K. and Barbara F. Meeker. 1995. "Computer Simulation for Exploring Theories: Models of Interpersonal Cooperation and Competition." *Sociological Perspectives* 38. (pgs **463-470**)*
[Implementations available in *Excel*, *Stella*, *Matlab*, *R*]

FURTHER READING

[Discrete system dynamics]

Mooney, Douglas and Randall Swift. 1999. "Discrete Dynamical Systems." Chapter 1, pp 9-37, in *A Course in Mathematical Modeling*. Mathematical Association of America.

Huckfeldt, R. Robert, Kohfeld, C. W., and Thomas W. Likens. 1982. *Dynamic Modeling: An Introduction.* Newbury Park, CA: Sage Publications.

[Continuous system dynamics; requires familiarity with Differential Calculus]

Mooney, Douglas and Randall Swift. 1999. "Continuous Models." Chapter 5, pp 239-305 in *A Course in Mathematical Modeling*. New York: Mathematical Association of America.

Gintis, Herbert. 2000. "Dynamical Systems and Differential Equations." Chapter 8, pp 164-187 in *Game Theory Evolving*. Princeton, NJ: Princeton.

Turchin, Peter. 2003. "Geopolitics." Chapter 2, pp 9-28. *Historical Dynamics: Why States Rise and Fail*.

Simon, Herbert A. 1952. "A Formal Theory of Interaction in Social Groups." *American Sociological Review* 17:202-211.
[Implementations available in *Excel*, *Stella*, *Matlab*]

LAB 2 (Sept 15) DuBois Library Tower Room 1667

WEEK 3 (Sept 20): Agent-Based Simulation as a Theory-Building Tool
[Lead Discussant: Fei; Secondary Discussant: Rick]

Axelrod's *Evolution of Cooperation* remains one of the most influential implementations of agent-based modeling, having earned tens of thousands of citations across the natural sciences and social sciences. That book examined the robustness of strategies in an iterated prisoner's dilemma tournament, examining conditions for the emergence of individually-costly cooperation. This week's readings – looking at extensions of Axelrod's study to 'noisy' environments – illustrate two perennial debates in social simulation. Kollock's criticism of Axelrod (as well as Reeves & Pitts' criticism of Kollock) raises the question of model sensitivity and the robustness of conclusions from simulation. Bendor, Kramer, and Swistak's criticism of Kollock (as well as Binmore's criticism of Axelrod) raises questions about the strengths and limitations of simulation as an alternative to mathematical analysis.

Kollock, Peter. 1993. "'An Eye for an Eye Leaves Everyone Blind': Cooperation and Accounting Systems." *American Sociological Review* 58:**770-785**.*
[Implementation available in *Excel*]

39 pgs

Bendor, Jonathan, Roderick Kramer, and Piotr Swistak. 1996. "Cooperation Under Uncertainty: What is New, What is True, and What is Important." *American Sociological Review* 61:333-337.*

Reeves, Edward B. and Timothy C. Pitts. 1996. "Cooperative Strategies in Low-Noise Environments." *American Sociological Review* 61:338-340.*

Kollock, Peter. 1996. "The Logic and Practice of Generosity." *American Sociological Review* 61:341-346.*

Wu, Jianzhong, and Robert Axelrod. 1995. "How to Cope With Noise in the Iterated Prisoner's Dilemma." *Journal of Conflict Resolution* 39(1): 183-189.*

FURTHER READING

Heckathorn, Douglas. 1990. "Collective Sanctions and Compliance Norms: A Formal Theory of Group-Mediated Social Control." *American Sociological Review* 55:366-384.

Macy, Michael, and Milena Tsvetkova. 2013. "The Signal Importance of Noise." *Sociological Methods & Research* : 0049124113508093.

Lomborg, Bjørn. 1996. "Nucleus and Shield: The Evolution of Social Structure in the Iterated Prisoner's Dilemma." *American Sociological Review*. 61(2) : 278-307.

Binmore, Ken. 1998. Review of Axelrod's *The Complexity of Cooperation* in the *Journal of Artificial Societies and Social Simulation* 1(1).

LAB 3 (Sept 22) DuBois Library Tower Room 1667

WEEK 4 (Sept 27): System-Level and Agent-Based Models of Evolutionary Dynamics
[Lead Discussant: Mariam; Secondary Discussant: Amanda]

This week we maintain our interest in the emergence of cooperation in the prisoner's dilemma. However, we look at work that recasts this problem with ecological and evolutionary lenses, examining the "fitness" of strategies leading to propagation in a population of other strategies. In ecological models, the fitness of strategies depends on the distribution of other strategies in the population, and their proliferation depends on their fitness. Hirshleifer et al. demonstrate the use of deterministic system-level models to understand these dynamics. Like Kollock, Axelrod and Takahashi use agent based stochastic models, but their models are explicitly *evolutionary,* allowing for mutation (or innovation) along with selection (or social learning), and thus the emergence of strategies not present in the initial population.

Hirshleifer, Jack and Juan Carlos Martinez Coll. 1988. "What Strategies Can Support the Evolutionary Emergence of Cooperation?" *Journal of Conflict Resolution* 32:**367-378**, **382-390**.* [Implementation available in *Excel, Stella, Matlab*] *38 pgs*

Takahashi, Nobuyuki. 2000. "The Emergence of Generalized Exchange." *American Journal of Sociology* 105:1105-1034. (**1109-1126**).*
[Implementation available in *Matlab, C, Netlogo*]

Axelrod, Robert. 1997. "An Evolutionary Approach to Norms." *American Political Science Review* 80(4):1095-11**02**. [Implementation available in *Pascal*]

FURTHER READING

Allison, Paul. 1992. "The Cultural Evolution of Beneficent Norms." *Social Forces*. 71(2): 279-301.

Macy, Michael W. and John Skvoretz. 1998. "Trust and Cooperation between Strangers." *American Sociological Review*. 63: 638-660.
[Implementation available in *Pascal*]

Heckathorn, Douglas D. 1996. "The Dynamics and Dilemmas of Collective Action." *American Sociological Review* 61:250-277. [Implementation available in *Matlab*]

Gilbert, G. Nigel and Klaus G. Troitzsch. 2002. "System Dynamics and World Models." Chapter 3, pp 27-43. *Simulation for the Social Scientist.* [Implementation available in *Excel, Matlab, Stella*]

Bendor, Jonathan and Piotr Swistak. 2001. "The Evolution of Norms." *American Journal of Sociology* 106:1493-1545.

LAB 4 (Sept 29) DuBois Library Tower Room 1667

WEEK 5 (Oct 4): System-Level Threshold Models of Collective Behavior
[Lead Discussant: Devika; Secondary Discussant: Chen-Shuo]

Critical mass theory incorporates another form of interdependence in individuals' choices: Agents' propensity to engage in a behavior may depend on the frequency of other agents who are engaging in that behavior. That is, each agent may choose to join a strike only if a sufficient share of peers (that actor's 'threshold') also join the strike. Agents in a population may have different thresholds because they are more or less interested in the strike goals or concerned about negative repercussions. A prominent class of models describes heterogeneous propensities to join in collective behavior as a *distribution* of thresholds in the population, and then derives a macro-level function for the dynamic behavior of the population resulting from that distribution: The overall level of collective action (such as participation in a riot or seminar) at a given time is a function of the previous level of participation. In these models, both the interdependence of actors' choices and heterogeneity among actors can be characterized and analyzed as a function for the behavior of the aggregate.

Granovetter, Mark S. 1978. "Threshold Models of Collective Behavior." *American Journal of Sociology* 83:1420-**1433**.* [Implementation available in *Excel, R, Matlab, Netlogo*] *46 pgs*

Schelling, Thomas C. 1978. "Thermostats, Lemons, and Other Families of Models." Chapter 3, pp. **102-110**. *Micromotives and Macrobehavior*.

Oliver, Pamela E., Gerald Marwell, and Ruy Teixeira. 1985. "A Theory of Critical Mass I. Interdependence, Group Heterogeneity, and the Production of Collective Action." *American Journal of Sociology* 91:522-**546**, **553-555**.*

FURTHER READING

Heckathorn, Douglas D. 1993. "Collective Action and Group Heterogeneity: Voluntary Provision versus Selective Incentives." *American Sociological Review* 58:329-350.

Hedstrom, Peter; Sandell, Rickard; Stern, Charlotta. 2000. "Mesolevel Networks and the Diffusion of Social Movements: The Case of the Swedish Social Democratic Party." *American Journal of Sociology* 106: 145-172.

Oliver, Pamela E. and Gerald Marwell. 1988. "The Paradox of Group Size in Collective Action: A Theory of Critical Mass II." *American Sociological Review* 53:1-8.

LAB 5 (Oct 6) DuBois Library Tower Room 1667

LAB 6 (Oct 13) DuBois Library Tower Room 1667

WEEK 6 (Oct 18): Agent-Based Threshold Models for Spatial Mixing
[Lead Discussant: <u>Alex;</u> Secondary Discussant: Joel]

In this week we consider structural models, which allow for direct interdependence in agents' choices that is not reducible (for practical purposes) to a function for macro-level behavior. Agents make autonomous choices, but are influenced by the behaviors of other agents in their neighborhood. Thomas Schelling introduced a now-classic argument about how individual preferences can aggregate to counterintuitive macro-level outcomes (such as pervasive racial segregation in neighborhoods of agents who would be happy in integrated neighborhoods). Bruch and Mare challenge Schelling's argument as a specific empirical claim about racial segregation in neighborhoods. Again, an exchange of comment and reply illuminates for us some issues at stake in computational modeling experiments.

Schelling, Thomas C. 1978. "Sorting and Mixing: Race and Sex." Chapter 4, pp. 137-66. *Micromotives and Macrobehavior*. (**137-161**) *58 pgs*

Bruch, Elizabeth E. and Robert D. Mare. 2006. Neighborhood Choice and Neighborhood Change. *American Journal of Sociology*. 112 (3): **667-682**, **690-697**, **703-706.*** [Implementation available in *Netlogo*]

Van de Rijt, Arnout, Siegel, Savid, and Michael Macy. 2009. Neighborhood Chance and Neighborhood Change: A Comment on Bruch and Mare. *American Journal of Sociology*. 114(4): 1166-**72**, **1176-8**.* [Implementation available in *Matlab*]

Bruch, Elizabeth E. and Robert D. Mare. 2006. Preferences and Pathways to Segregation: Reply to Van de Rijt, Siegel, and Macy. *American Journal of Sociology*. 114(4): 1182-**1183**, **1189–1192**.*

FURTHER READING

Steinnes, Donald N. 1977. "Alternative Models of Neighborhood Change." *Social Forces*, 55(4): 1043-1057.

LAB 7 (Oct 20) DuBois Library Tower Room 1667

WEEK 7 (Oct 25): Applications: Network Critical Mass Models of Collective Action
[Lead Discussant: Rick; Secondary Discussant: Fei]

This week we look at extensions to the previous models, where agents' choices depend on the choices of their neighbors. But the structure of social contacts is not modeled as 'spatial' (i.e. a regular lattice of contacts, as on a grid). Instead, agents observe or influence once another through 'social networks' that may allow irregular sets of contacts: Some agents may be more connected than others, some may be more central in the overall structure, some overall structures can be more centralized than others, and these variations in structure and position allow researchers to investigate abstract relationships between social networks and collective behavior. Our readings for this week are important early contributions in the sociological literature on critical mass models and the network dynamics of collective action.

Marwell, Gerald, Pamela E. Oliver, and Ralph Prahl. 1988. "Social Networks and Collective Action: A Theory of the Critical Mass, III." *American Journal of Sociology* 94:502-**32**.***** [Implementation available in *FORTRAN*] *49 pgs*

Macy, Michael W. 1991.***** "Chains of Cooperation: Threshold Effects in Collective Action." *American Sociological Review* 55:730-747.
[Implementation available in *Matlab, Netlogo*]

FURTHER READING

Kim, Hyojoung and Peter S. Bearman. 1997. "The Structure and Dynamics of Movement Participation." *American Sociological Review* 62:70-93. [Implementation available in *Pascal*]

Gould, Roger V. 1993. "Collective Action and Network Structure." *American Sociological Review* 58:182-196.

Chwe, Michael Suk-Young. 1999. "Structure and Strategy in Collective Action." *American Journal of Sociology* 105:128-156.)

Centola, Damon. "A simple model of stability in critical mass dynamics." *Journal of Statistical Physics* 151, no. 1-2 (2013): 238-253.

Oliver, Pamela E. and Gerald Marwell. 2001. "Whatever Happened to Critical Mass Theory? A Retrospective and Assessment." *Sociological Theory* 19:292-311.

LAB 8 (Oct 27) DuBois Library Tower Room 1667

WEEK 8 (Nov 1): Applications: Network Models of Social Inequality
[Lead Discussant: Yeongsu; Secondary Discussant: Mariam]

This week we delve into more advanced contemporary models in social science literatures on inequality. DiMaggio and Garip use a computational experiment to investigate inequality deriving from network externalities in a process for adoption of new technology. Kogut, Colomer, and Belinky investigate the implications for the population of corporate directors (and the network resulting from interlocking boards) of a policy that mandates a modest quota of female directors on corporate boards.

DiMaggio, Paul and Filiz Garip. 2011. "How Network Externalities Can Exacerbate Intergroup Inequality." *American Journal of Sociology*. 116(6): 1887-1893, **1894-1913**, 1914-1930.* [Implementation available in *Netlogo*, *Matlab*, *R*] *33 pgs*

DiMaggio, Paul and Filiz Garip. 2011. "How Network Externalities Can Exacerbate Intergroup Inequality." Appendix pages **1-3**.*

Kogut, Bruce, Colomer, Jordi, and Mariano Belinky. 2014. "Structural equality at the top of the corporation: Mandated quotas for women directors." *Strategic Management Journal*, 35: 891–902.* [Implementation available in *Python*]

Kogut, Bruce, Colomer, Jordi, and Mariano Belinky. 2014. "Structural equality at the top of the corporation: Mandated quotas for women directors." Appendix pages **1-6**.*

FURTHER READING

Biggs, Michael. "Strikes as forest fires: Chicago and Paris in the late nineteenth century." *American Journal of Sociology* 110, no. 6 (2005): 1684-1714.

Fountain, Christine and Stovel, Katherine. 2014. "Turbulent Careers: Social Capital, Employer Hiring Preferences, and Job Instability." In G. Manzo (ed.). *Analytical Sociology - Norms, Actions and Networks*. John Wiley & Sons.

Manzo, Gianluca. 2013. "Educational Choices and Social Interactions: A Formal Model and a Computational Test." *Comparative Social Research*. 30: 47-100. [Implementation available in *Netlogo*]

LAB 9 (Nov 3) DuBois Library Tower Room 1667

WEEK 9 (Nov 8): Applications: Models of Convergence and Differentiation
[Lead Discussant: Joel; Secondary Discussant: Alex]

In this week, we consider basic models of the proliferation of ideas, practices, or behaviors across populations. All of these models can be taken to represent dynamic networks driven by homophily, where individuals preferentially interact with others who share "culture" with them. Latané and Axelrod include an explicit representation of space (2-D cellular automata), while Mark allows the network to emerge purely as a function of cultural familiarity.

Axelrod, Robert. 1997. "The Dissemination of Culture: A Model With Local Convergence and Global Polarization." Chapter 7, pp. 148-174. *The Complexity of Cooperation*. Princeton, NJ: Princeton University Press. *42 pgs*
[Implementation available in *Pascal, Visual Basic, Netlogo*]

Mark, Noah. 1998. "Beyond Individual Differences: Social Differentiation from First Principles." *American Sociological Review* 63:312-330.*
[Implementation available in *GAUSS, Netlogo*]

FURTHER READING

Carley, Kathleen. 1991. "A Theory of Group Stability." *American Sociological Review* 56:331-54. [Implementation available in *Matlab*]

Latané, Bibb. 2000. "Pressures to Uniformity and the Evolution of Cultural Norms." pp. 189-215 in *Computational Modeling of Behavior in Organizations: The Third Scientific Discipline*, edited by D. R. Ilgen and C. L. Hulin.
[Implementation available in *Excel*]

Epstein, Joshua M. and Robert Axtell. 1996. *Growing Artificial Societies: Social Science from the Bottom Up*. Cambridge, MA: MIT Press.

Harrison, J. Richard and Glenn R. Carroll. 1991. "Keeping the Faith: A Model of Cultural Transmission in Formal Organizations." *Administrative Science Quarterly* 36:552-582.

Kitts, James A. and Paul T. Trowbridge. 2007. "Shape Up Or Ship Out: Social Networks, Turnover, and Organizational Culture." *Computational and Mathematical Organization Theory,* 13(4): 333-353. [Implementation available in *Matlab, Netlogo*]

Chang, Myong-Hun; Harrington, Joseph E , Jr. 2005. "Discovery and Diffusion of Knowledge in an Endogenous Social Network." *American Journal of Sociology*, 110, 4, Jan, 937-976. [Implementation available in *C*]

Centola, Damon, Juan Carlos Gonzalez-Avella, Victor M. Eguiluz, and Maxi San Miguel. 2007. "Homophily, cultural drift, and the co-evolution of cultural groups." *Journal of Conflict Resolution* 51, no. 6: 905-929.

LAB 10 (Nov 10) DuBois Library Tower Room 1667

WEEK 10 (Nov 15): Applications: Models of Polarization and Alliance in Conflict
[Lead Discussant: Chen-Shuo; Secondary Discussant: Jenn]

This week we consider models of aggregation or bifurcation, depicting the processes by which agents align with one another (and against others) to generate coherent macrolevel patterns – such as military alliances between nations or polarization of political beliefs in populations.

DellaPosta, Daniel J., Yongren Shi, and Michael W. Macy. "Why Do Liberals Drink Lattes?" *American Journal of Sociology* 120(5)*:* **1473-6**, **1486-97**, **1502-3.*** *30 pgs*
[Implementation available in *Java, Netlogo*]

Baldassarri, Delia, and Peter Bearman. (2007). "Dynamics of Political Polarization," *American Sociological Review*, 72: **784-6, 788-807.***
[Implementation available in *R*]

FURTHER READING

Bhavnani, Ravi, Donnay, Karsten, Miodownik, Dan, Mor, Maayan and Helbing, Dirk. 2014. Group Segregation and Urban Violence. *American Journal of Political Science*. 58: 226–245.

Gilbert, G. Nigel and Klaus G. Troitzsch. 1999. "Neural Networks." Chapter 9, pp 195-218. *Simulation for the Social Scientist*.

Macy, Michael W., James A. Kitts, Andreas Flache, and Steve Benard. 2003. "Polarization in Dynamic Networks: A Hopfield Model of Emergent Structure." Pp. 162-173 in *Dynamic Social Network Modeling and Analysis*. Washington, DC: National Academies Press. [Implementation available in *Matlab*]

Kitts, James A. 2006. "Social Influence and the Emergence of Norms Amid Ties of Amity and Enmity." *Simulation Modelling Practice and Theory*. 14: 407-22. [Implementation available in *Netlogo*]

LAB 11 (Nov 17) DuBois Library Tower Room 1667

WEEK 11 (Nov 29): Applications: Models of Norm Emergence and Maintenance
[Lead Discussant: Jenn; Secondary Discussant: Yeongsu]

Here we examine the evolution of norms as an outcome of interaction among heterogeneous agents. Strang and Macy model firms adopting strategies in uncertain environments, where their beliefs about the efficacy of strategies depend on the performance of other firms in their environment. This demonstrates the possibility that even maladaptive strategies may emerge and be promoted as 'fads' in the population. Centola and Macy model development and enforcement of norms, showing conditions under which populations will publicly enforce norms that they do not privately support.

Strang, David and Michael W. Macy. 2001. "In Search of Excellence: Fads, Success Stories, and Adaptive Emulation." *American Journal of Sociology* 107: 147-**9**, **157-72**.* *48 pgs*

Centola, Damon, Robb Willer, and Michael W. Macy. 2005. "The Emperor's Dilemma: A Computational Model of Self-Enforcing Norms." *American Journal of Sociology* 110:1009–**37**.* [Implementation available in *Netlogo*]

FURTHER READING

Orbell, John, Langche Zeng, and Matthew Mulford. 1996. "Individual Experience and the Fragmentation of Societies." *American Sociological Review* 61:1018-1032.

Fowler, James H.; Smirnov, Oleg. 2005. "Dynamic Parties and Social Turnout: An Agent-Based Model." *American Journal of Sociology* 110 (4): 1070–1094. [Implementation available in *R*]

LAB 12 (Dec 1) DuBois Library Tower Room 1667

WEEK 12 (Dec 6): Review Session: Methodological Judgment Calls in Simulation

This week we will review many methodological judgment calls that a simulation researcher must face: system-level vs. agent based, continuous vs. discrete time, synchronous vs. asynchronous updates (and order of activation), deterministic vs. stochastic (and various roles of stochasticity), continuous vs. discrete state space, local vs. global influence, network topology, choice functions and functional forms, specification of parameter values and initial conditions, experimental design (which parameters to fix or manipulate), range and granularity of manipulations, numerical exploration and illustration vs. mathematical proof, statistical analysis, number of replications, number of iterations, stability analysis and convergence, sensitivity analysis, interpretation and presentation of results, replication and alignment of simulations, verification and validation, calibration with empirical data, software tools, and many more…

There is no one 'right' answer for these judgment calls, but different right answers for different purposes and different audiences. In the past 12 weeks you have studied and discussed these concepts in applying them to research articles in our seminar, and practiced the concepts in our hands-on lab sessions. This week we will look at a single model I developed, then follow its revision through several rounds of journal review, as it encountered and responded to challenges on many of the above issues raised by different reviewers and editors.

Kitts, James A. 2006. "Collective Action, Rival Incentives, and the Emergence of Antisocial Norms." *American Sociological Review*, 71(2): 235-259.*
[Implementation available in *Matlab*]

Kitts, James A. 2008. "Dynamics and Stability of Collective Action Norms." *Journal of Mathematical Sociology*, 32(2): 1-22.*

LAB 13 (Dec 8) DuBois Library Tower Room 1667

WEEK 13 (Dec 13): TBA / Final Presentations / Wrap-Up

The last week is flexible until I determine how to best advance the research programs of the seminar participants. We will likely spend our last week on seminar projects, including presentations and peer review.

This course does not require a background in college mathematics. However, a foundation in math would be helpful for theoretical work on social dynamics (as well as statistics). See a few recommendations below.

Calculus for Biology and Medicine (Neuhauser 2009) – This is a condensed textbook, mostly applied to population dynamics. It surveys differential and integral calculus, providing an accessible introduction to differential equations, linear algebra, and dynamical systems.

A Course in Mathematical Modeling (Mooney & Swift 1999) – This is an accessible undergraduate textbook in math modeling, using mostly applications to population dynamics. It surveys differential and difference equations, including deterministic and stochastic versions. It works through examples in *Mathematica*, and also discusses fitting models to data.

Introduction to Mathematical Sociology (Bonacich & Lu, 2012) –This is an introduction to various mathematical foundations most commonly applied in the social sciences: set theory, probability theory, graph theory, matrix algebra, and complexity theory, with applications in network analysis, social network theory, population demography, evolutionary game theory, and network exchange theory.

The following books offer more specialized extensions to some of the basic lessons introduced in this course:

Agent Based Computational Demography (Billari & Prskawetz, 2003) – This is an accessible collection of ABM applications to demographic processes (e.g. migration, mating, mortality).

Agent Based and Individual Based Modeling (Railsback & Grimm 2012) – Basic introduction to modeling highly integrated with learning the Netlogo environment.

Game Theory Evolving (Gintis 2009) – This is an accelerated introduction to evolutionary game theory, including a brief review of differential equations and dynamical systems theory.

Historical Dynamics: Why States Rise and Fall (Turchin 2003) – This is an application of system dynamics to historical sociology.

Matrix Population Models (Caswell 2001) – General text in matrix models of population dynamics (of particular interest to demographers and ecologists), in both continuous and discrete time. It works through examples in *Matlab* and includes a review of matrix algebra.