Modeling Social Emergence: Agent-Based Simulation

Prerequisites: <u>None</u>

(However, if you want to spend some extra time to ensure that you maximally benefit from this seminar, see the following pages.)

Theory:
It will help to be comfortable with the *basics* of Game Theory (e.g. payoff matrix, "prisoner's dilemma"). A few of the readings assume this knowledge.

Programming:

You should have intermediate skills in *Excel*. We will not teach Excel in this course. See the CSSCR web page for information on their Excel training session.

You do not need to have any experience in programming. We will not discuss computational syntax in the seminar meetings (but will discuss it in "labs").

It will help to acquaint yourself with *loops* (FOR, DO, etc.) and *conditional statements* (e.g. IF, WHILE, etc.) – even if you do not work with a programming language. This will also be useful in your data-analytical research.

Software:
I don't plan to require any programming in the seminar. If you want to develop a model but do not know a programming syntax, I encourage you to either collaborate with someone who does know a syntax or to use "pseudocode" – e.g. a flow chart with sequence of commands in plain English. We also may be able to find someone to help you translate these commands into working code. If you're ambitious, you should be able to teach yourself a simple programming syntax in one (long) afternoon.

Many of those who will use a syntax plan to work in *Matlab* (and/or *Octave* – which is an open-source freeware program that is "mostly compatible" with Matlab – or *R*, which is also open-source and free, but not compatible with Matlab). These are numerical computation languages with a lot of built-in functionality, allowing you to focus on modeling rather than programming. All will allow you to visualize and analyze your results, but Matlab has stronger user help, documentation, and source code exchange.

You're free to choose your own tools. The *Journal of Artificial Societies and Social Simulation* recently published an article called "Teaching Social Simulation With Matlab" – which advocates Matlab as the best tool for learning simulation and provides an introduction with exercises for agent-based modeling:
http://jasss.soc.surrey.ac.uk/3/1/forum/1.html
All the exercises in Thorngate's article should also work in Octave.
This web page will let you download today's version of Octave: http://www.octave.org/

You may often want to visualize a function using a graphing calculator or (much better) a symbolic math program like *Mathematica* or *Maple*. These programs are available in various computer labs for those who wish to use them. Use the CSSCR consultants for advice. We will not be studying this software in the seminar.

We will develop a toolkit of working code. This will include source code for the models we study as well as collections of routines that are generally useful for simulation. If you find helpful samples of source code or tutorials (e.g. on the web), please share them.

Math:
We won't be working on math problems in class, but most of the readings will present a model in formal notation as well as regular English, and reading the notation will help you understand the models precisely. All the math you need to know for this seminar you learned in 7th to 11th grade. If you took *Algebra I* a long time ago, it may help to practice a few topics. This notation is equally relevant for your work in statistics.

You should be comfortable with basic algebra notation,

such as for sums: $\sum_{i=1}^{N} x_i$ and products: $\prod_{j=1}^{N} p_j$

It will help to be comfortable with some basic rules of exponents and fractions, e.g.:

$x^a x^b = x^{a+b}$ $x^a y^b = x^a y^b$ $\frac{x^a}{x^b} = x^{a-b}$ $x^{-a} = \frac{1}{x^a}$ $x^{\frac{a}{b}} = \sqrt[b]{x^a}$

You will encounter basic Set Theory notation

$x \in \{-1,0,1\}$ $\{1,2\} \cup \{2,3\} = \{1,2,3\}$ $\{1,2\} \cap \{2,3\} = \{2\}$

You do *not* need to know any calculus for this seminar. However, it will help to be able to interpret a statement like "*x* is a _____ function of *y*" (where ____ is *linear*, *increasing*, *decreasing*, *accelerating*, *decelerating*, *exponential*, *logarithmic*, *non-monotonic*, etc.). You should get an intuition for functional forms, such that you can roughly sketch simple relationships. For example, how do the following functions behave as *x* approaches zero or infinity?

$f(x) = 2x$ $f(x) = x^2 - 4x$ $f(x) = \frac{1}{x}$ $f(x) = \ln x$

Especially if you have interests in social networks, you should familiarize yourself with the basic terminology of Graph Theory (*nodes*/*points*/*vertices* and *edges*/*lines*/*arcs*) and Matrix Algebra (*rows*, *columns*, *elements*). Most computational models in Sociology use the simplest scalar algebra (as above), but you will find it helpful to review notation and basic operations on matrices, especially matrix multiplication.

There are thousands of primers and tutorials on the web for the above topics (please share with your peers if you find a useful resource). I also purchased a high school mathematics tutorial set (on CD-ROM), which you can sign out if you want.

We won't be *using* algebra (e.g. finding and investigating equilibria analytically) in this seminar, but refreshing your understanding of mathematical notation should help you read articles containing formal theory.