# AGENT-BASED MODELS
# PSY 992 – FALL 2017
# THURSDAYS 12:40P – 3:30P, C204 SNYDER HALL


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| **INSTRUCTOR:** | Dr. Zachary Neal | **EMAIL:** | zpneal@msu.edu |
| **OFFICE:** | 134B Psychology | **OFFICE HOURS:** | By appointment |


**COURSE DESCRIPTION**

Agent-based models are a highly flexible type of simulation model that can be used to explore complex systems where behaviors (e.g. forming social networks) and environmental characteristics (e.g. residential segregation) interact to produce macro-level patterns (e.g social cohesion). They are particularly useful for building theory and testing causal mechanisms when doing so in the field would be impossible or impractical. The course will provide a conceptual and methodological introduction to agent-based models. Over the course of the semester, each student will develop a simulation model designed to explore a phenomenon in their own area of research.

*NOTE: This course may be applied toward the requirements of the Quantitative Methods and Evaluation Science (QMES) concentration in Psychology. If your final project is related to cities or has an explicit spatial component, it may also be applied toward the requirements of the Global Urban Studies Program (GUSP) specialization.*

**GOALS, EXPECTATIONS, AND FORMAT**

This course has three main goals:

1. Familiarize students with agent-based simulation methods and the NetLogo software.
2. Explore the use of simulation to understand phenomena in diverse areas of study.
3. Strengthen skills in research, writing, and oral presentation.

Some parts of the course will follow a "seminar" format where we will discuss, debate, explore, and challenge the readings each week. It is essential that you actively participate in the course. I expect you to complete the reading assignments prior to class, and come prepared to talk about them. This will require more than simply reading; plan to spend at least as much time outside of class *thinking* about the materials as actually reading them.

Other parts of the course will follow a "workshop" format where we will practice and experiment with building simulation models using the NetLogo software. Again, it is essential that you actively participate. I expect you to be prepared to use the software, to have reviewed the example models, to ask questions, and to help one another with model building.

**PRE-REQUISITES**

1. A graduate level course in inferential statistics, and a basic working knowledge of concepts like means, standard deviations, correlation.

2. A graduate level course in research methods, and a basic working knowledge of the scientific method, hypothesis testing, and experimental design.

3. No prior experience with computer programming is necessary. However, you should be ready to build your programming skills in the NetLogo language. [Don't worry – it's pretty intuitive once you get started.]

**REQUIRED MATERIALS**

A computer to use in class (preferably a laptop).

Wilensky, U. 1999. NetLogo. http://ccl.northwestern.edu/netlogo/. Center for Connected Learning and Computer-Based Modeling, Northwestern University. Evanston, IL. [NetLogo is a free software and will run on almost any type of computer]

Additional readings posted on D2L.

*Recommended –*
Railsback, S. F. and Grimm, V. 2011. Agent-based and individual-based modeling: A practical introduction. Princeton University Press, Princeton, NJ. [I will post some chapters from this book online, but you may find it useful to have a printed copy. It is an excellent resource, and is available on Amazon for around $42.]

**COURSE POLICIES**

*Academic Integrity:* The General Student Regulations state that: "[1.00] The principles of truth and honesty are fundamental to the educational process and the academic integrity of the University; therefore, no student shall: [1.01] claim or submit the academic work of another as one's own, [1.02] procure, provide, accept or use any materials containing questions or answers to any examination or assignment without proper authorization, [1.03] complete or attempt to complete any assignment or examination for another individual without proper authorization, [1.04] allow any examination or assignment to be completed for oneself, in part or in total, by another without proper authorization, [1.05] alter, tamper with, appropriate, destroy or otherwise interfere with the research, resources, or other academic work of another person, [1.06] fabricate or falsify data or results." In accordance with the All-University Policy on the Integrity of Scholarship and Grades, any student found in violation of this regulation will receive a final grade of 0.0 for the course. This includes all instances of plagiarism; if you do not know what plagiarism is, please see me immediately.

*Limits to confidentiality*. Essays, journals, and other materials submitted for this class are generally considered confidential pursuant to the University's student record policies. However, students should be aware that University employees, including instructors, may not be able to maintain confidentiality when it conflicts with their responsibility to report certain issues to protect the health and safety of MSU community members and others. As the instructor, I must report the following information to other University offices (including the Department of Police and Public Safety) if you share it with me:

- Suspected child abuse/neglect, even if this maltreatment happened when you were a child,
- Allegations of sexual assault or sexual harassment when they involve MSU students, faculty, or staff, and
- Credible threats of harm to oneself or to others.

These reports may trigger contact from a campus official who will want to talk with you about the incident that you have shared. In almost all cases, it will be your decision whether you wish to speak with that individual. If you would like to talk about these events in a more confidential setting you are encouraged to make an appointment with the MSU Counseling Center.

*Students with disabilities*: Michigan State University is committed to providing equal opportunity for participation in all programs, services and activities. Accommodations for persons with disabilities, with documentation from the MSU Resource Center for Persons with Disabilities, may be requested by contacting me at the start of the term and/or two weeks prior to the accommodation date (test, project, etc). Requests received after this date will be honored whenever possible.

*Attendance & Late Assignments:* If you are unable to attend class, please let me know as early as possible. You may only make up coursework if you make arrangements with me in advance. All assignments are due at the beginning of class; late assignments will not be accepted unless you have a documented emergency.

*Questions or concerns:* I want to see each of you succeed in this course. If you have any questions or concerns, please contact me and we can set up a time to talk. Please let me know as soon as possible if you experience any problems in the course. By letting me know early, we can work out a plan to make sure you do not fall behind.

*Extra Credit*: Each of the model building assignments (Birds of a Feather Model, AIDS Intervention Model, Zombie Apocalypse Model, and Frienemies Mobility Model) include two opportunities for extra credit:

- All members of the group submitting the working model with the fewest lines of code (excluding comments) will receive 1 points extra credit.
- All members of the group submitting the working model voted "most interesting" at the end of class will receive 1 points extra credit.

**ASSIGNMENTS**

*Readings*: The weekly assigned readings include three different types of material:

- Traditional journal articles and book chapters – I will expect that you have read these materials in advance and taken time to think through what they say.
- Sections from the NetLogo programming guide (noted **PG** on the schedule) – I will expect that you have read these sections carefully and have experimented with using the commands presented. If the guide includes an example, do it.
- Example models (noted **ML** on the schedule) – I will expect that you have read the model's "info" tab to understand what the model is supposed to do, reviewed the model's code and comments to try and understand how it works, and experimented with running the model.

*Sample Model Presentation* (10 points; completed in groups): You will select one of the models listed below from the NetLogo model library to study and present to the class. The models in the Model Library are accompanied by detailed documentation (on the "info" tab) and code comments (on the "code" tab). In your presentation, you should (a) explain the purpose of the model, (b) explain what each parameter does, (c) explain what happens when you run the model, and (d) demonstrate the model to illustrate an interesting finding. Your presentation should last about 10 minutes. Providing a brief handout may be helpful. You may choose any of the following models, which are roughly ordered from simple to complex.

- Life – one of the first ABMs (cellular automata) ever
- Party – composition of cliques, depending on tolerance of mixed-gender groups
- Traffic Basic – traffic flow, depending on driver behaviors
- Simple Birth Rates – demographic change, depending on fertility rates
- Sprawl Effect – urban sprawl, depending on residents' moving behaviors
- Diffusion on a Directed Network – distribution of resources, depending on network ties
- Piaget-Vygotsky Game – different outcomes of Piagetian and Vygotskiian learning

*Birds of a Feather Model* (10 points; completed in groups): As the saying goes, "birds of a feather, flock together." The problem with the Flocking model in the Model Library is that all the birds are the same color (i.e. different shades of yellow). This is not very realistic. Modify the Flocking model so that:

- There is a slider that allows the user to adjust the number of bird colors (up to 5)
    - *Hint:* This will require changing how the bird population is created in the "setup" submodel. The Segregation model, which creates a population with two different colors, is a good example.
- Birds only flock with other birds of the same color
    - *Hint:* In the new model, who should be considered a bird's "flockmates"?
    - *Hint:* The code "with [color = [color] of myself]" restricts a command's scope to only include turtles that are the same color as the acting turtle. The Segregation model uses this code in the "update-turtles" submodel to count how many nearby turtles are the same/different.

Otherwise, you may design your model as you see fit, drawing on your ornithological expertise, but keep it simple. You will present and demonstrate your model to the class, following the same format

as the Sample Model Presentation assignment. [**TO RECEIVE CREDIT FOR YOUR MODEL, IT MUST BE ABLE TO RUN WITHOUT ERRORS**.]

*AIDS Intervention Experiment* (10 points; completed in groups): The National Institutes of Health has asked you to develop and implement an intervention designed to reduce the spread of HIV. However, they want you to consider a range of possible interventions, and want to see estimates of the expected infection rates under each scenario, before they will release the funding. Use the BehaviorSpace tool to conduct an experiment testing different types of interventions. Here are some basic guidelines:

- Your outcome of interest is the percent of the population infected with HIV after 5 years (260) weeks.
- You have the capacity to intervene on only two of the four parameters. You should focus on the two parameters you think will be the most effective points of intervention.
- Your experiment should consider at least three different levels (e.g. high, medium, low) of each or the two parameters involved in your intervention.
- You should test each intervention scenario at least 50 times.
- Summarize your results and conclusions in a 2-page executive report, which you will briefly present to the class.

[**TO RECEIVE CREDIT FOR YOUR MODEL, IT MUST BE ABLE TO RUN WITHOUT ERRORS**.]

*Zombie Apocalypse Model* (10 points; completed in groups): As we all know, the risk of a zombie apocalypse is ever present. To help the authorities develop a disaster readiness plan, you have been asked to build a simulation model of a zombie apocalypse. Your model should include the following features:

- A starting population of people, and a starting population of zombies
  - *Hint:* Use breeds to distinguish people from zombies
- When a zombie and a person meet, either (a) the person kills the zombie or (b) the zombie turns the person into a zombie
  - *Hint:* Use a slider to set the probability that a person is successful at killing the zombie
- People move faster than zombies
- A line graph that shows the population of people and zombies over time

Otherwise, you may design your model as you see fit, drawing on your past experiences interacting with zombies, but keep it simple. You will present and demonstrate your model to the class, following the same format as the Sample Model Presentation assignment. [**TO RECEIVE CREDIT FOR YOUR MODEL, IT MUST BE ABLE TO RUN WITHOUT ERRORS**.]

*Frienemy Mobility Model* (10 points; completed in groups): We all have some friends and some enemies. Despite the adage to "keep your friends close, and your enemies closer," we usually want to be near our friends and avoid our enemies. You will build a model to simulate this phenomenon. Here are some basic guidelines:

- Start with a population of two types of people; like a real neighborhood, each person occupies one patch and the world does not wrap
  - *Hint:* Look at the Segregation model
- Each person is friends with X others of the same type and is enemies with Y others of the opposite type
  - *Hint:* Use sliders to set X and Y
  - Hint: *U*se link breeds to distinguish friendship relations from enemy relations
- Each person <u>may</u> also be friends with one person of the opposite type
  - *Hint:* Use a switch to turn this option on or off
- Each person moves to an unoccupied patch if his/her enemies are closer than his/her friends, on average
  - *Hint:* Look at the Segregation model
  - *Hint:* the code "mean [ distance myself ] of friend-neighbors" will give the average distance between a given turtle and each of the turtles with which it has a "friend" breed link.

- Your model should include display (a) the average distance to friends and (b) the average distance to enemies

Otherwise, you may design your model as you see fit, drawing on your past experiences interacting with frienemies, but keep it simple. You will present and demonstrate your model to the class, following the same format as the Sample Model Presentation assignment. [**TO RECEIVE CREDIT FOR YOUR MODEL, IT MUST BE ABLE TO RUN WITHOUT ERRORS**.]

*Your own model* (50 points; completed individually): Over the course of the semester, you will develop an agent-based model designed to simulate a social phenomenon you select. The assignment has four components:

- Three-page proposal (October 5; 5 points) – You should briefly describe the phenomenon you are interested in modeling, explain what you expect to learn from your model, and sketch some of the features you would like your model to incorporate.
- Progress presentation (October 26; 15 points) – You will demonstrate your in-progress model to the class, describing what parts are completed/working and what parts are incomplete/not working. You should be prepared to answer questions about your model, and to seek feedback from others about specific features of your model.
- Final presentation & writeup (November 30/December 7; 30 points) – You will present your final model to the class, highlighting some findings or conclusions you are able to draw from observing the model's behavior. Your writeup should be approximately 20 double-spaced pages, and include (a) a brief literature review and conceptual motivation that contextualizes your model, (b) a description of how your model works, (c) a presentation of results obtained from running your model using different parameters, (d) a discussion of the significance and meaning of the results, and (e) a conclusion that considers your model's limitations and offers suggestions for ways the model may be refined or expanded in the future. [**TO RECEIVE CREDIT FOR YOUR FINAL PRESENTATION/WRITEUP, YOUR MODEL MUST BE ABLE TO RUN WITHOUT ERRORS**.]

Here are some suggestions to bear in mind as you work on this assignment:

- **Keep your model simple:** Start with a single quantitative outcome of interest, and at most two continuous independent parameters.
- Select a phenomenon that you already know a bit about.
- Select a phenomenon that is related to your other program goals (e.g.dissertation).
- Work together on these models, seeking feedback and assistance from one another.
- Consider adapting an existing model or combining pieces of existing models.
- Develop your model in parts, making sure that each part is working before moving on.

A final note about your project: You should move at your own pace, and develop a model with a scope that makes sense for you. A simple model that works and that you understand is better than a non-working complicated model that you don't understand. If you have prior experience with programming and your model comes together quickly, I encourage you to continue expanding/refining your model, conducting additional analyses, and writing it up as a standard journal article.

**COURSE SCHEDULE**

| DATE | READINGS<br>(**ML:** Models in the Model Library; **PG:** Entries in the NetLogo Programming Guide) | ASSIGNMENTS |
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| August 31 | Introduction | In-class: Install NetLogo |
| September 7 | What is agent-based modeling?<br>**ML:** Flocking | |

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| | Macy MW, Willer R. 2002. From factors to actors: Computational sociology and agent-based modeling. *Annual Review of Sociology* 28, 143 – 166.<br><br>Epstein JM. 1999. Agent-based computational models and generative social science. *Complexity* 4, 41 – 60.<br><br>Epstein JM. 2008. Why model? *Journal of Artificial Societies and Social Simulation* 11, 12. | |
| September 14 | <u>Introduction to NetLogo</u><br>**PG:** Agents, Ask<br>Netlogo Tutorial 1 – 3<br>Netlogo Interface Guide<br>Netlogo Dictionary (browse, to get familiar with its organization) | Sample model presentation |
| September 21 | <u>The Modeling Process (wsg/ Jenny Lawlor)</u><br>Lawlor JA, Neal ZP. 2016. Networked community change: Understanding community systems change through the lens of social network analysis. *American Journal of Community Psychology, 57*, 426-436.<br><br>Railsback SF, Grimm V. 2012. Agent-based and Individual-based Modeling. Princeton University Press: Princeton, NJ. [Chapters 1 & 3]<br><br>Recommended: Schlüter M, et al. 2017. A framework for mapping and comparing behavioural theories in models of social-ecological systems. *Ecological Economics, 131*, 21-35. | |
| September 28 | <u>The Anatomy of an Agent-Based Model</u><br>**ML:** Segregation<br>**PG**: Tick counter, View updates<br><br>Schelling TC. 1971. Dynamic models of segregation. *Journal of Mathematical Sociology* 1, 143 – 186. [You can stop at page 166] | |
| October 5 | <u>Experiments</u><br>**ML:** AIDS, Histogram Example, Plotting Example<br>**PG:** Plotting, BehaviorSpace (listed under "Features")<br><br>Browse around https://wiki.hpcc.msu.edu/display/hpccdocs/HPCC+Basics and watch the video located under the first link on this page. I will demo the HPCC system in class. | Birds of a Feather Model; Proposal |
| October 12 | <u>Turtles</u><br>**ML:** Hatch Example, Breeds and Shapes Example, Random Walk Example, Communication-T-T Example<br>**PG:** Agentsets, Breeds, Turtle Shapes, Variables | |
| October 19 | <u>Stochasticity</u><br>**ML:** Nhoodnet (posted on D2L)<br>**PG:** Random Numbers<br><br>Railsback SF, Grimm V. 2012. *Agent-based and Individual-based Modeling*. Princeton University Press: Princeton, NJ. [Chapter 15]<br><br>Neal ZP, Neal JW. 2014. The (In)compatibility of diversity and sense of community. *American Journal of Community Psychology* 53, 1 – 12. | AIDS Intervention Experiment |
| October 26 | No readings | Progress Presentation 1 |
| November 2 | <u>Patches</u> | Zombie |

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| | **ML:** Neighborhoods Example, Communication-T-P Example, Move Towards Target Example, Hill Climbing Example<br>**PG:** Topology | Apocalypse Model |
| November 9 | Networks<br>**ML:** Network Example, Link Breeds Example, Team Assembly<br>**PG:** Links<br><br>Guimera R, Uzzi B, Spiro J, Amaral LAN. 2005. Team assembly mechanisms determine collaboration network structure and team performance. *Science* 308, 697 – 702. | |
| November 16 | Conflict<br>**ML:** Rebellion<br><br>Epstein JM. 2002. Modeling civil violence: An agent-based computational approach. *Proceedings of the National Academy of Sciences* 99, 7243 – 7250. | Frienemy Mobility Model |
| November 23 | **Thanksgiving – No class** | |
| November 30 | Analysis<br>Railsback SF, Grimm V. 2012. *Agent-based and Individual-based Modeling*. Princeton University Press: Princeton, NJ. [Chapters 22 – 24]<br><br>Review the Neal & Neal (2014), Guimera et al. (2005), and Epstein (2002) examples. What "currency" did they use? How did they analyze their models? | Early final presentations |
| December 7 | No readings | Final presentation & Writeup |