Unit 7: Coda

READINGS AND RESOURCES

- Epstein JM (2008) Why model? *Journal of Artificial Societies and Social Simulation* 11(4): 12.
- Gunawardena J (2014) Models in biology: 'Accurate descriptions of our pathetic thinking.' *BMC Biology* 12: 29.
- Smaldino P (2019) Better methods can't make up for mediocre theory. *Nature* 575: 9.

What have we learned?

There are a number of key principles that form the basis for understanding human social organization and cultural evolution. These tend to revolve around the 3 C's: Cooperation, Communication, and Coordination. Important properties can be considered in terms of simple models. Here is a brief recap of some of the things I hope you've learned from each of the modeling units.

- Building models. Most formal models of social behavior require at least 3 kinds of assumptions.
    1. How are internal states represented?
    2. How are individuals influenced by their environment and each other?
    3. How are behaviors and interactions structured?

  Building a formal helps clarify your thinking on your system and the parts of that system that are relevant whatever dynamics you're interested in.
- Contagion. The time course of adoption for a disease, technology, or behavior depends on the extent to which it is socially transmitted. Adoption by individual exploration will yield an r-shaped curve, whereas adoption by social influence will yield an s-shaped curve.
- Opinions. The more people only are influenced by people already similar to themselves, the more distinct communities will form. If we also seek to distance ourselves from those with whom we disagree, the result can be polarization and extremism.
- Cooperation. Because it can be easily exploited, a strategy of naïvely cooperating with everyone can only persist if group boundaries are very rigid, so cooperators can primarily interact with other cooperators. If this condition does not hold, a savvy reciprocating strategy can maintain cooperation as long as there are sufficient opportunities for repeat interaction.
- Coordination. When there are benefits to coordination, almost anything can become a norm, and better, more prosocial norms may have a hard time spreading in a tight-knit community. However, even a little interaction with other communities and a willingness to occasionally

adopt norms that originated elsewhere *can* aid the spread of group-beneficial norms.
- Cycles. Something that spreads rapidly when rare but becomes weakened by its own growth provides the foundation for cyclical dynamics. And counterintuitively, factors that limit growth may benefit an organism or society in the long run.

What is there still to learn?

I mean, holy hell. There's so much more to learn. Social and cultural systems are complex. And models are essential for understanding them.

- Models provide concrete, shared analogies for understanding complex systems, which avoid problems of ambiguity, miscommunication, and underspecification inherent in merely verbal or statistical explanations.
- Models provide us with a tractable system we can thoroughly explore and analyze in ways impossible with natural systems.
- Models can illustrate patterns in data that suggest which mechanisms may or may not be possible explanations for patterns in a natural system.

We've only looked at a handful or relatively simple models. Modelers have been hard at work to understand complex systems. Join them. But we don't only need more modelers. We also need more model-literate empirical researchers, who understand that the questions they ask and the measurements they take can be better informed by models, and can also improve models by helping to calibrate them.

Advanced Topics

This course a meant to be a fairly gentle introduction to working with models of social behavior and cultural evolution. As such, I didn't go into very much detail about things like model analysis, mathematical proof, or fitting models to data. These are all important topics, and warrant a richer treatment than I can provide here, but let me just briefly touch on them.

Analyzing agent-based models

For the most part, our treatment of the models in this course was cursory and exploratory. Sometimes, simply demonstrating that some behavior is possible under certain assumptions is sufficient. And certainly, playing around with the model and observing some individual cases in details is extremely important to get intuitions about its behavior and a sense of the types of outcomes it produces. That said, to do research with agent-based models requires quite a bit more rigor. In general, you must run enough simulations to accurately characterize the long-term behavior of the model system, and you must explore sufficient parameter values to identity the robustness and sensitivity of the model. This can be costly in terms of both time and computational requirements. The good news is that computers are quite fast now, and many universities and research institutes have access to high performance computing clusters that can cut time on even the most complicated models. You may get discouraged if all the simulations you need to analyze your model take days or weeks to run. But consider that you are running computational experiments, and that many of your colleagues may take months or years to collect data sets a fraction of the size of the ones you are simulating. If your model is interesting and revealing, it will be worth doing it right.

Mathematical proof

With only a couple of exceptions, we have tended to use qualitative descriptions to describe how our models respond to changes in parameter values. *When X goes up, Y goes down.* For some simple models, it is possible to derive mathematical proofs that tell us things like "When conditions *A* are met, outcome *B* always occurs," or "The threshold between these two behavioral outcomes is exactly this relationship between parameters." This sort of thing is very useful, and can provide quite concise insights into the behavior of complex systems, as well as insights that are more readily generalizable to any system where particular conditions hold. For the mathematically inclined, learning how to prove the things you suspect is a valuable skill to learn. That said, we should always be cautious because the map is not the territory. For example, in our coordination model example, we saw that the mathematically derived threshold for when a group-beneficial norm should or shouldn't spread didn't allow us an exact prediction of whether the norm would spread, but only a probabilistic one due to the stochasticity inherent in the model. The real world tends to have considerably more sources of noise than our models (which is part of the point of models), and so we should exercise caution in our interpretations.

Models and data

The data question is the elephant in the room when it comes to modeling social phenomena. How do the fairly abstract models we've discussed relate to data from the real world? There are several possible relationships between formal models and data, including (but not limited to) the cases where…

1. Empirical data may exist, but an explanation of patterns found in that data may be lacking. Formal models can allow us to test out possible mechanisms and see which ones both fit the data and are consistent with other things known or suspected about the world. For example, the contagion models indicate that product adoption trajectories that

approximate a sigmoid curve are likely driven by social influence rather than by independent actions.

2. A model may suggest possibilities, but the empirical data to calibrate its assumptions may be lacking. For example, a model may allow us to say something like “If X is the case, we should expect A, but if Y is the case, we should expect B.” The model can therefore be used to help guide empirical research toward filling in those important gaps. Identifying either assumptions (X vs. Y) or conclusions (A vs. B) can be useful. A warning however: one should be careful not to be too hasty to attempt to fit models to data if the model relies on key behavioral or structural assumptions that are useful computational simplifications but not valid assumptions about the real world.
3. A model may not directly relate to any particular data set, but be useful in understanding broad principles of complex social systems. This describes most of the models we have discussed in this course. Keep in mind that any of these models can be further refined to better represent specific systems, at which point comparisons to particular data sets may become appropriate.

In general, models and empirical data should work together in a virtuous cycle. Models allow us to study assumptions about the world and discover their consequences. The results can show what measurements are needed to test the assumptions, and those measurements can provide empirical patterns that invite explanations, which models can provide. And on and on.

I hope you’ve enjoyed this course. Feel free to reach out to me with any questions or comments.