Programs for Plato: Course Introduction

Models and Simulations in Philosophy
October 14th, 2013

Models and Simulations

This is an atypical philosophy class.

- Computer simulations? In Philosophy?
- You might say, "I've read Plato. He was a better-than-fair philosopher. He didn't need a computer."
- How can computer simulations help us in answering questions about justice, about the nature of mind, about free will, and so on? How can simulations answer any of the core questions in philosophy?

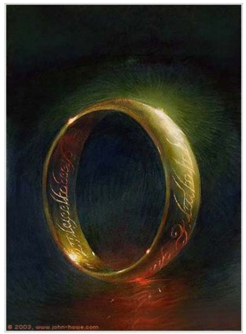
Outline

The Republic

In Plato's most famous work, Republic, Socrates is faced with a very difficult question:

Challenge: Why is it rational to behave justly?

The Ring of Gyges



Glaucon's Argument

Glaucon challenges Socrates to explain why it's rational to be just as follows:

> *This, they say, is the origins and essence of justice. It is intermediate between the best and the worst. The best is to do injustice without paying the penalty; the worst is to suffer it without being able to take revenge. Justice is a mean between the two extremes.*

Plato. Book II. Republic

Plato on The Origins of Language

- In his dialogue Cratylus, Plato studies meaning. In particular, he is interested in how noun phrases can acquire meaning.
- For instance, how did it come to be that the word "table" (or "Tisch") refers to a flat surface supported by legs?
- Roughly, Plato thinks there is a difficulty in explaining how we agree that "table" should refer to table **without already having a language**.
- His solution is rather ingenious . . .

Rosseau on The Origins of Language

> *[Cratylus] says that [names] are natural and not conventional; not a portion of the human voice which men agree to use; but that there is a truth or correctness in them, which is the same for Hellenes as for barbarians.*

Plato. Cratylus

Rosseau on The Origins of Language

> *[The] giving of names can be no such light matter as you fancy, or the work of light or chance persons; and Cratylus is right in saying that things have names by nature, and that not every man is an artificer of names, but he only who looks to the name which each thing by nature has, and is able to express the true forms of things in letters and syllables.*

Plato. Cratylus.

Rosseau on The Origins of Language

Rousseau discusses a similar issue in Discourse on the Origins of Inequality and Emile:

> *Whether there is a natural language, common to all mankind, has long been a matter of investigation. Without doubt there is such a language, and it is the one that children utter before they know how to talk.*

Rousseau. Emile.

Plato on The Origins of Language

How can we address Plato's puzzles?

Questions of justice and language deal with

- Multiple individuals who
- Interact with one another and
- Whose well-being depends upon the outcomes of everyone's actions, how well they coordinate their actions, and so on.

Game Theory

One of the best and most commonly employed tools for studying strategic interactions is game theory.

Idea: Perhaps we can employ game theory to start attacking Plato's puzzles.

Outline

Games

	Rock	Paper	Scissors
Rock	$\langle 0, 0\rangle$	$\langle -1, 1\rangle$	$\langle 1, -1\rangle$
Paper	$\langle 1, -1\rangle$	$\langle 0, 0\rangle$	$\langle -1, 1\rangle$
Scissors	$\langle -1, 1\rangle$	$\langle 1, -1\rangle$	$\langle 0, 0\rangle$

Game

A game is a triple $\langle I, \langle A_i\rangle_{i\in I}, \langle u_i\rangle_{i\in I}\rangle$ where I is a set representing the players, A_i is a set representing the actions available to each player, and $u_i : \Pi_{i\in I} A_i \to \mathbb{R}$ is a function representing the utilities ("payoffs") to each player for every possible sequence of player actions.

Games

	Rock	Paper	Scissors
Rock	$\langle 0, 0\rangle$	$\langle -1, 1\rangle$	$\langle 1, -1\rangle$
Paper	$\langle 1, -1\rangle$	$\langle 0, 0\rangle$	$\langle -1, 1\rangle$
Scissors	$\langle -1, 1\rangle$	$\langle 1, -1\rangle$	$\langle 0, 0\rangle$

Strategy

Roughly, a strategy for a player is an action in a game. So, for instance, "Rock" is a strategy in the game Rock, Paper, Scissors.

Mixed Strategies

In some games, like Rock, Paper, Scissors, it might seem reasonable for players to pick a strategy at random.

Mixed Strategies

Mixed Strategy

A mixed strategy for player $i \in I$ is a probability distribution over her actions A_i.

Intuitively, a player employs a mixed strategy when she uses some randomizing to choose actions.

Zero Sum Games

	Rock	Paper	Scissors
Rock	$\langle 0, 0 \rangle$	$\langle -1, 1 \rangle$	$\langle 1, -1 \rangle$
Paper	$\langle 1, -1 \rangle$	$\langle 0, 0 \rangle$	$\langle -1, 1 \rangle$
Scissors	$\langle -1, 1 \rangle$	$\langle 1, -1 \rangle$	$\langle 0, 0 \rangle$

Example of Mixed Strategy: A player randomly chooses among rock, paper, and scissors - perhaps by rolling a standard die.

Pure Strategies

Let S_i be player i's set of mixed strategies.

Pure Strategy

If a strategy s_i assigns probability one to some action, it is called a pure strategy.

E.g., "Rock" is a pure strategy in Rock, Paper, Scissors.

Best Response

Best-Response

Let $i \in I$ be any player and $s_{-i} = \langle s_j \rangle_{j \in I \setminus \{i\}}$ be the strategies employed by all players except i. A best-response for player i is any strategy $s_i \in S_i$ maximizing $u_i(s_{-i} \frown s_i)$.

Best Response

	Rock	Paper	Scissors
Rock	$\langle 0, 0\rangle$	$\langle -1, 1\rangle$	$\langle 1, -1\rangle$
Paper	$\langle 1, -1\rangle$	$\langle 0, 0\rangle$	$\langle -1, 1\rangle$
Scissors	$\langle -1, 1\rangle$	$\langle 1, -1\rangle$	$\langle 0, 0\rangle$

Best Response to Rock/Paper/Scissors = Paper/Scissors/Rock

Best Response to $\langle \frac{1}{2}, \frac{1}{4}, \frac{1}{4}\rangle$ = Paper.

Nash Equilibria

Nash Equilibria

A sequence of strategies $s = \langle s_i \rangle_{i \in I}$ is called a Nash equilibrium if for all $i \in I$, the strategy s_i is a best response to $s_{-i} = \langle s_j \rangle_{j \in I \setminus \{i\}}$.

That is, if players are in a Nash equilibrium, then no one has any incentive to change his or her strategy: each player is doing the best given how other players are acting!

Nash Equilibria

	Rock	Paper	Scissors
Rock	$\langle 0, 0\rangle$	$\langle -1, 1\rangle$	$\langle 1, -1\rangle$
Paper	$\langle 1, -1\rangle$	$\langle 0, 0\rangle$	$\langle -1, 1\rangle$
Scissors	$\langle -1, 1\rangle$	$\langle 1, -1\rangle$	$\langle 0, 0\rangle$

(Unique) Nash equilibrium: Both players pick rock, paper, and scissors with equal probability.

Equilibria in Game Theory

> *The basic concept of traditional game theory is the idea of a Nash equilibrium . . . In traditional game theory, a Nash equilibrium is interpreted as . . . a situation from which no rational player will unilaterally deviate. Thus, we can predict that rational players in a game will end up at a Nash equilibrium. [my emphasis]*

Okasha and Binmore [2012], pp. 4.

Plato on The Origins of Language

Do real people (who are sometimes rather irrational) act in such a way that Nash equilibria are obtained?

- The research is mixed . . .
- It's generally recognized that individuals do **not** act in exactly the way that is predicted by Nash equilibria, but in many games, they approximate the behavior [Kline, 2012].

Fisher's Principle

- Equilibria explanations are also common in biology.
- E.g., The statistician R.A. Fisher asked, "Why are there equal numbers of males as females in the populations of many sexually reproductive animals?"
- Fisher's explanation, now called "Fisher's Principle", is one of the most celebrated pieces of reasoning in evolutionary biology.

Fisher's Principle

Here's how Hamilton [1967] explains it.

1. *Suppose male births are less common than female.*
2. *A newborn male then has better mating prospects than a newborn female, and therefore can expect to have more offspring.*
3. *Therefore parents genetically disposed to produce males tend to have more than average numbers of grandchildren born to them.*
4. *Therefore the genes for male-producing tendencies spread, and male births become more common.*
5. *As the 1:1 sex ratio is approached, the advantage associated with producing males dies away.*
6. *The same reasoning holds if females are substituted for males throughout. Therefore 1:1 is the equilibrium ratio.*

Platonic Equilibria?

Can equilibria explanations help us to solve Plato's puzzles?

Let's take a closer look at the game described by Glaucon.

The Prisoner's Dilemma

The best is to do injustice without paying the penalty; the worst is to suffer it without being able to take revenge. Justice is a mean between the two extremes.

	Justice	Injustice
Justice	$\langle -1, -1 \rangle$	$\langle -3, 0 \rangle$
Injustice	$\langle 0, -3 \rangle$	$\langle -2, -2 \rangle$

The Prisoner's Dilemma

Games with the following payoff structure are called prisoners' dilemmas.

Here's the standard story:

	Silent	Confess
Silent	$\langle -1, -1 \rangle$	$\langle -3, 0 \rangle$
Confess	$\langle 0, -3 \rangle$	$\langle -2, -2 \rangle$

The Prisoner's Dilemma

What's the Nash equilibria of a Prisoner's dilemma?

	Silent	Confess
Silent	$\langle -1, -1 \rangle$	$\langle -3, 0 \rangle$
Silent	$\langle 0, -3 \rangle$	$\langle -2, -2 \rangle$

Predictions in Prisoner's Dilemmas

- So, if Nash equilibria were used to make predictions when prisoner's dilemmas arise, we would expect little cooperation.
- But experiments show that people do cooperate in many prisoner's dilemma scenarios.
- We need a different solution to Plato's first puzzle.

Platonic Equilibria?

What about Plato's second puzzle?

Predictions in Prisoner's Dilemmas

- In the last 45 years or so, philosophers, biologists, and economists have developed a number of games aimed at representing communication among individuals. See Skyrms [2010].
- Some equilibria in the game represent the case in which "signals" (think words for now) acquire meaning, e.g., where we reach agreement that "table" refers to tables.
- **Problem:** These games often have **several** equilibria, not just one.
- So it's hard to use them for predictions ...

The Stag Hunt

The most common example of a game with multiple equilibria is called the stag hunt.

	Stag	Hare
Stag	$\langle 2, 2\rangle$	$\langle 0, 1\rangle$
Hare	$\langle 1, 0\rangle$	$\langle 1, 1\rangle$

Game Theory and Plato's Puzzles

So we've seen two problems for giving standard equilibria explanations to Plato's puzzles:

- **Justice**: Some times individuals don't play the Nash equilibria (e.g., Prisoner's dilemmas)
- **Meaning**: Some times the equilibria are not unique.

But there are other criticisms of equilibria explanations as well ...

Problems for Equilibria Explanation

Equilibria explanations, like Fisher's, typically also do not discussion:

- How long it takes to get to equilibria
- The path to equilibria
- Homogeneous vs. heterogeneous agents
- Global vs. Local Interactions
- In economics: Agents are presumed to be rational

See Epstein and Axtell [1996], Alexander [2007], and Grimm and Railsback [2005].

Outline

1. Two Platonic Puzzles
   - Justice
   - Meaning
2. Equilibria Explanations in Economics and Biology
   - Basic Game Theory
   - Game Theory and Plato's Puzzles
3. Agent-Based Models
4. NetLogo
5. References

Example abm

Wilensky [1999]

Components of abms

Agent based models (ABMs) have the following components:

- Agents with properties (e.g., location, preferences, beliefs)
- Environment (e.g. a terrain)
- Initial Conditions for agents and environment
- Rules specifying how agents interact with one another and the environment

ABMs vs. Classical Economic Models

Classic Models	ABMs
Rational, EU Maximizers	Boundedly Rational
Homogeneous agents	Heterogenous Agents
Global Interaction	Local interactions in a network
Equilibria	Dynamics

And many more ...

Computer Simulations and ABMs

- In the last two decades, philosophers have begun employing ABMs to answer a number of different questions in addition to Plato's puzzles.
- ABMs are harder to analyze mathematically, but that's why we use computer simulations!
- So let's start learning how to build an ABM!

Structure of the Course

Structure of the course

- Three Units: Cooperation, Language, and Social Norms
- Each unit has two parts:
  1. One "classic" game-theoretic/equilibrium explanation of a social phenomenon (e.g., the existence of political cooperation, language, and/or social norms)
  2. Several ABMs used to explain how such behavior might arise.
- Last two classes: What can we learn from models and ABMs in particular? What are the advantages and limitations?

NetLogo

Click on the links below (current as of October 14th, 2013):

- Download NetLogo
- Tutorials
- NetLogo Dictionary

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