Formal Theory & Causality

Lecture 5 – Part I

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Exp Class Lectures

Definition (Formal Model)

A set of precise abstract assumptions or axioms about the DGP presented in symbolic terms that are solved to derive predictions about the DGP.

Definition (Point Prediction of a Formal Model)

A precise prediction from a formal model about the values of the variables in the model when the model is in equilibrium.

Definition (Relationship Predictions of a Formal Model)

Predictions from a formal model about how to variables in the model will be related.

Definition (Causal Relationship Predictions of a Formal Model)

Relationship predictions in which the changes in one variable are argued to "cause" the changes in the other variable.

Definition (Nonformal Model)

A set of verbal statements or predictions about the DGP that involve idealization, identification, and approximation, but are given in terms of real observables or unobservables rather than symbols or abstracts. The predictions maybe presented in a diagram or graph or they may be presented even as mathematical equations with variables representing the real observables and unobservables. Although the researcher may have in mind some implicit assumptions underlying the predictions, the researcher has not proved that the predictions directly follow from those assumptions by stating them explicitly and solving for the predictions.

Using an RCM Approach with Predictions from Nonformal Models

The Theoretical Consistency Assumption

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The Theoretical Consistency Assumption

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- In RCM approach, need to make assumptions about data (which depend on method used, consult Tables in Chapters 4 & 5) plus SUTVA.
- **Theoretical Consistency Assumption:** Assumption made by researchers working with an RCM approach to causality that the assumptions underlying the causal predictions evaluated are consistent with the assumptions that underlie the methods used by the researcher to infer causal relationships.

- Principal way most political scientists deal with this.

Definition (Nonformal Structural Model)

When a researcher creates an empirical model that captures the structure he or she believes might underlie the predictions he or she is evaluating but does not solve the model as a theoretical formal model for predictions.

- Example – Empirical model used to estimate latent variables.

Addressing the Theoretical Consistency Assumption

Nonformal Structural Modeling

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- Example – Empirical model used to estimate latent variables.
- LISREL

Definition (Inspired-By Evaluations of Formal Theory Predictions)

When a researcher evaluates a formal theory prediction using an RCM based approach and assumes theoretical consistency, does not explicitly investigate whether it holds or not.

- Stress test similar, but different, talk about later.

Definition (Formal Theory Approach to Causality)

When a researcher evaluates causal predictions that are derived explicitly from the solution of a formal model by conducting an empirical study where either assumptions underlying the empirics are as equivalent as possible to those of the formal model underlying the predictions or the researcher has explicitly chosen which assumptions to relax. Instead of making the theoretical consistency assumption, the researcher controls the extent that the assumptions hold and do not hold so that the relationship between the empirical analysis and the formal model is explicit.

First Step of FTE – Identify Five Components of the Formal Model

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5. An equilibrium solution concept, such as: Nash equilibrium or subgame perfection in games of complete information, Bayesian-Nash in incomplete information, etc.

Definition (Theory Tests)

When a researcher investigates the predictions of a formal model while attempting to make all the assumptions underlying the empirical study as close as possible to the theoretical assumptions.

Definition (Stress Tests)

When a researcher investigates the predictions of a formal model while explicitly allowing for one or more assumptions underlying the empirical study to be at variance with the theoretical assumptions.

- In order to illustrate how an experimenter takes a formal model and creates an experimental design using FTA we use as an example the swing voter's curse model of Feddersen and Pesendorfer (1996).

- In order to illustrate how an experimenter takes a formal model and creates an experimental design using FTA we use as an example the swing voter's curse model of Feddersen and Pesendorfer (1996).
- We begin with a presentation of the model as it appears in its full blown theoretical glory so that we can explain how an experimenter moves from a more complicated model to a version of the model that is implementable in the laboratory but maintains those features of interest to the experimenter.

- The model is presented by the authors as follows on pages 411-4:

There are two states, state 0 and state 1, where $Z = \{0, 1\}$ *denotes the set of states. There are two candidates, candidate 0 and candidate 1. The set of candidates is* $X = \{0, 1\}$. *There are three types of agents, where* $T = \{0, 1, i]$ *is the set of types. Type-0 and type-1 agents are partisans: irrespective of the state type-0 agents strictly prefer candidate 0 and type-1 agents strictly prefer candidate 1. Type i-agents are independents: given a pair* $(x, z,)$, $x \in X$ *and* $z \in Z$, *the utility of a type i agent is*

$$U(x,z) = \begin{cases} -1 & \text{if } x \neq z \\ 0 & \text{if } x = z \end{cases}$$

Independent agents prefer candidate 0 *in state 0 and candidate 1 in state 1.*

At the beginning of the game nature chooses a state $z \in Z$*. State 0 is chosen with probability* α *and state 1 is chosen with probability* $1-\alpha$*. Without loss of generality we assume that* $\alpha \leq \frac{1}{2}$*. The parameter* α *is common knowledge and hence all agents believe that state 1 is at least as likely as state 0. Nature also chooses a set of agents by taking* $N+1$ *independent draws. We assume that there is uncertainty both about the total number of agents and the number of agents of each type. In each draw, nature selects an agent with probability* $\left(1-p_{\phi}\right)$*. If an agent is selected, then with probability* $p_i / \left(1-p_{\phi}\right)$ *she is of type* i*, with probability* $p_0 / \left(1-p_{\phi}\right)$ *she is type 0, and with probability* $p_i / \left(1-p_{\phi}\right)$ *she is type 1. The probabilities* $p = \left(p_i, p_0, p_1, p_{\phi}\right)$ *are common knowledge.*

After the state and the set of agents have been chosen, every agent learns her type and receives a message $m \in M$*, where* $M = \{0, \alpha, 1\}$. *Both her type and the message are private information. If an agent receives message m then the agent knows that the state is 0 with probability m. All agents who receive a message* $m \in \{0, 1\}$ *are informed, that is, they know the state with probability 1. Note that all informed agents receive the same message. The probability that an agent is informed is* q. *Agents who receive the message* α *learn nothing about the state beyond the common knowledge prior. We refer to these agents as uninformed. ...*

Every agent chooses an action $s \in \{\phi, 0, 1\}$ *where* ϕ *indicates abstention and 0 or 1 indicates her vote for candidate 0 or 1, respectively. The candidate that receives a majority of the votes cast will be elected. Whenever there is a tie, we assume that each candidate is chosen with equal probability.*

A pure strategy for an agent is a map $s : T \times M \rightarrow \{\phi, 0, 1\}$. *A mixed strategy is denoted by* $\tau : T \times M \rightarrow [0, 1]^3$, *where* τ_s *is the probabiity of taking action* s. *...*

We define a sequence of games with $N + 1$ *potential voters indexed by* N *a sequence of strategy profiles for each game as* $\{\tau^N\}_{N=0}^{\infty}$.

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FTA & the Design Stage of Experimental Research

The Formal Model: An Example

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- Certainly this & other assumptions may be criticized by some as unrealistic or inappropriate.
- Others may find assumptions reasonable & useful.
- Our purpose here is not to defend model but to use it as an illustration for how an experimenter moves from a formal model to a specific experimental design.

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  5. an equilibrium solution concept.

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  2. Actors (voters–partisans & independents, candidates, nature)
  3. Information (voters have varying degrees of information on state of world, know their own type & distribution of types)

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  2. Institutional Characteristics–election is decided by majority rule, ties are broken randomly

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5. the cost of voting.

The vote choices of the four types of voters:

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4. uninformed independents

- Bayesian-Nash symmetric equilibrium

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- This proediction follows because doing otherwise would be a strictly dominated strategy for these voters.
- Partisans clearly gain the highest expected utility from voting their partisan preferences and fully informed independents similarly gain the highest expected utility from voting according to their signals.

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- The second point prediction applies when the expected percentage of voters who will be uninformed is less than the expected partisan advantage for one of the candidates.
- In this case, Feddersen and Pesendorfer show that as the size of the electorate approaches infinity in the limit the optimal strategy for uninformed independents is to vote for the candidate who does not have the expected partisan advantage.

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  - If $p_0 - p_1 = 0$ then uninformed independent agents abstain; $\lim_{N\to\infty} \tau_\phi^N = 1$.

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Third Point Prediction Continued

- Case when expected percentage of voters who will be uninformed is greater than or equal to expected partisan advantages.
- Show as size of electorate approaches infinity, then in limit uninformed independents will use a mixed strategy.
- Vote for candidate with partisan disadvantage with just enough probability to offset disadvantage, so that informed independents' votes can decide outcome & abstain with one minus that probability.

- (Proposition 4) As the size of the electorate approaches infinity the probability that the election fully aggregates information (i.e. the outcome of the election is the right choice from the point of view of the independents) goes to one.

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- Feddersen and Pesendorfer's fourth point prediction follows from the strategies adopted by the uninformed independent voters. By offsetting the partisan voters, and facilitating the decisiveness of the votes of the informed independents, when the electorate is large the probability that the outcome is as independents most prefer is as high as possible.

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Predictions of the Model

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- These are predicted causal relations

- 3–From relationship predictions #1b and #2b, when the percentage of independents is held constant, there is a negative relationship between the margin of victory and abstention. That is, higher margins of victory are correlated with lower levels of abstention.

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Relationship Predictions 3 & 4

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- 4–From relationship predictions #1a and #2a, when the probability of being informed is held constant, there is a positive relationship between the margin of victory and abstention. That is, higher margins of victory are correlated with higher levels of abstention.

Predictions of the Model

Relationship Predictions 3 & 4

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- 4–From relationship predictions #1a and #2a, when the probability of being informed is held constant, there is a positive relationship between the margin of victory and abstention. That is, higher margins of victory are correlated with higher levels of abstention.
- These are not predicted causal relations, but correlations. Note that #3 is at odds with traditional view.

- 5–When the size of the electoric is large, then small changes in the *ex ante* probability that state 0 is the true state, α, has no effect on voting strategies or other equilibrium predictions. When the size of the electoric is small, and α is close to zero, then a small change in α can have significant effects on voting behavior.

Predictions of the Model

Relationship Prediction 5

- 5–When the size of the electoric is large, then small changes in the *ex ante* probability that state 0 is the true state, α, has no effect on voting strategies or other equilibrium predictions. When the size of the electoric is small, and α is close to zero, then a small change in α can have significant effects on voting behavior.
- predicted nonrelationship!

Definition (Comparative Static Predictions in a Formal Model)

Causal relationship predictions from a formal model in which researchers compare how one variable takes a different value given changes in another variable, holding time constant.

Designing an Experiment to Evaluate the Model's Predictions

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- Need to make a lot of design choices. Discuss each & use BMP as illustration.

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- Consider first the actors.
- What we are interested in is studying how human would behave as actors within the political environment and assumptions of the model.
- So the actors are the roles to which our human subjects will be assigned.

Recreating the Political Environment

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- However, it is less clear that we want to assign humans subjects to the other roles as actors.
- For instance, nature is clearly not a human role but represents exogenous factors outside the model that determine which candidate is optimal for independent voters.
- Thus, we would not assign a human subject as nature, but have nature choices as part of the design of the experiment.

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- Also, the choices made by informed independents are as well boring.
- However, by filling these roles with artificial actors the experimenter may find that the subjects who are uninformed independent voters may choose differently than they would if these roles were filled with other human subjects.
- Moreover, if we are interested in the comparison of how voter behavior changes when a voter is informed versus uninformed, then if we did not assign subjects to the roles of informed independents we would not be comparing human behavior when uninformed with human behavior when informed in the experiment.

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- Here we focus on the answer to this question for the Feddersen and Pesendorfer theory.

Recreating the Political Environment
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- Here we focus on the answer to this question for the Feddersen and Pesendorfer theory.
- Two potential answers.
  - First, the theory is a theory of how individuals vote in an election. Thus, the population that is the subject of the theory is essentially all citizens with the right to vote in an election.
  - Second, the mathematical constructs of the theory are quite general and could be applied to other collective choice situations that are similar in which any human might conceivably participate.

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- But would have to keep secret the number drawn from chosen as theory assumes voters do not know the total number.

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- But obviously in the laboratory the number of potential voters must necessarily be finite.
- Because Feddersen and Pesendorfer's theory had been solved for the case where the number of voters was randomly drawn and the predictions were for limit cases as the number of potential voters approached infinity, must prove that the same predictions held for the finite case in which the total number of voters is fixed.

Recreating the Political Environment

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- The experiments with small sized electorates provide us with a test of the general theory and its predictions that is valuable.
- One might argue that the experiments are a strong test of the theory; that a failure of the theory's predictions in such a context would mean more than a failure of the theory in a large sized electorate.

Dealing with the Primitives of the Model & Motivating Subjects

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- The winner is the candidate receiving the majority of votes and ties are broken randomly.
- Motivating subjects to have same preferences as in theory more complicated – most use financial incentives, but should we give them advice? Discuss in more detail shortly.

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- Dal Bo has one subject randomly chosen to be monitor toss a fair die to determine whether game ends or not after each round.
- Induce common subjective probabilities about whether game will continue & control & manipulate

But Subjects May Still Believe as Game Continues, Likelihood of End Increases

Dal Bo's Justification

The subjects' real discount factor may have two components: one component determined by the roll of the die, and another subjective component which incorporates subjects' belief regarding the experimenter ending the experiment. (Given that subjects were paid at the end of the experiment and that there is a very short span of time between rounds, I disregard the temporal preference component of the discount factor.)

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It is important to note that if the subjective component is not very sensitive to changes in the random continuation rule, increases in the probability of continuation must result in increases in subjects' expectation of future interaction. Thus, by changing [the continuation rate], I affect the subjects' belief on the possibility of future interactions. In their experiments, Murnighan and Roth (1983) elicited their subjects' beliefs about continuation probabilities. They found that subjects' estimates that there would be at least two more rounds increased strongly with the probability of continuation.

Manipulating the Exogenous Variables, Random-Assignment, and Within-and-Between Subject Comparisons

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- Ideally the experimenter wishes to manipulate the probability of being informed, partisan advantages of candidates, and ex ante priors of uninformed voters.
- Ideally, the researcher also would like to create an experimental design in which these manipulations allow for within-subjects' comparisons or between-subjects' coupled with random assignment to manipulations.

Choosing the Parameters of the Experiment

- Why choose $\alpha = 1/2$ & $4/9$?

The Decision Variables

- Decision variables – voting.

Framing the Experiment

- Should it be framed as political or not?

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- Recognition of the Game Form – Chou et al Guessing Game Experiment

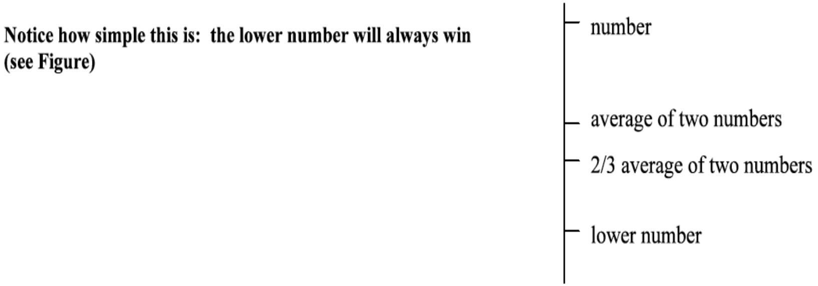

Figure: Hint shown to subjects in Chou et al experiment

Framing the Experiment: Battle Version of Guessing Game

CALIFORNIA INSTITUTE OF TECHNOLOGY

CALTECH

You have been chosen to play a simple strategic game. This game is a small part of a larger project, so your performance will not be scrutinized or manipulated. Please think strategically about the scenario below.

Setting of the Game:

- Imagine yourself at war facing an opponent in a battle on a hill
- Both you are your opponent (a random person from this room) must locate yourselves on the hill
- The hill is 100 feet high

Instruction to the Game:

- Your job is to choose how high to locate your troop on the hill, from 0 feet high to 100 feet high (both heights included).
- You win the battle if your chosen location is higher than your opponent's.

Winning Rule:

- If your location is higher than your opponent's, you will win $8 cash at the end of class today. If you choose the same location as your opponent, you will receive $4.

You have five minutes to think about your answer. Write your location in the space below.

LOCATION CHOSEN ________________(please enter one number here)
Group ID ____________________________
My Name & ID Number____________________________

Please write down your motives for choosing your number on the back of the instructions.

Figure: The Battle Version of the Guessing Game

Framing the Experiment: Results Chou et al

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- Found hint significantly increased probability subjects from Caltech chose as predicted by game theory, but had no effect on choices of subjects from community college.
- Other changes, however, in presentation & framing, in response to results from a post experiment survey, increased probability subjects from community college chose game theoretic prediction.

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- Found that a simplified presentation of the game using bullet points and bold coupled with the hint significantly increased likelihood subjects at community college chose game theoretic prediction.
- Wen game was presented as a battle community college students chose as game theory predicted significantly more.
- Found that when subjects from the community college first played Battle game & then simplified version of guessing game, subjects significantly more likely to choose according to game theoretic predictions in guessing game.

Framing the Experiment: Interpretation Chou et al

- Chou et al argue suggests rejection of game theory reported previously resulted from a loss of experimental control.

If the purpose of the experiment is to test predictions of game theory, then the initial abstract instructions contain a 'bug.' Participants do not understand the game form and therefore a crucial assumption for solution concepts is violated. Recognition of the game form is a necessary condition for the testing of game theory. If subjects do not understand the game form, then it is unclear what behavior game theory predicts. From the point of view of game theory, one does not know what experiment is conducted. Since game form recognition is a necessary condition for the theory, its absence in an experiment reflects a lack of experimental control.

Framing the Experiment: Interpretation Chou et al

- Chou et al suggest subjects use a "recognition heuristic" following Goldstein & Gigerenzer (2002).

"Subjects formulate their understanding of an environment through recognition of similarities between environments. Thus, when the game is presented in the context of a battle, subjects immediately recognize the elements of the game form due to the prominence of those elements in games (sports, contests, competitions, etc.) with which they have had either experience or some sort of education (books, advisors, etc.)."

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- Job researcher when purpose is to evaluate game theory in a theory test is to present experiment in such a way to increase probability subjects recognize game form.

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- Post experiment questionnaires can be useful tools in helping the experimenter understand the subjects' problems.
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- Subjects' ability to recognize the game form can differ from subject pool to subject pool. ... This means that each subject pool might require slightly different instructions or procedures.
- Making the game less abstract helps with game form recognition, but it may introduce other sources of loss of control. When contextually rich instructions are used, it might be important to inform the subject that the less abstract features are included to help with the understanding and should not be taken literally.

Presentations, Stress Tests, & Frames (Stahl & Haruvy, ultimatum game as game tree)

- Goal of experiment might be to investigate how much subjects "recognize" a game & effects of different presentations.

> *Our results do not imply that the game-tree presentation is the only proper experimental design for the ultimatum game. ... if one is asking how people behave in a socially rich context of dividing a pie that activates social norms and social judgments, then obviously a context-sparse game-tree presentation would be inappropriate.*

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- Stahl & Haruvy state (p. 293-4):

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Presentations, Stress Tests, & Frames Chou et al:

if the purpose of the experiment is something other than a test of game theory then the lack of recognition could be a desirable "feature." The "empirical approach" or "data first" approach in which the experimenter creates phenomena and examines a "contest" between models to determine which is more accurate (and why) has been one of the most powerful tools available for use in experimental economics since its beginning. Frequently, models work where they have no "right" to work. The models work when many of the assumptions of the theory are not satisfied, e.g. the competitive model works in the double auction with disequilibrium trades and with small numbers of agents operating under imperfect information.

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- Experience does matter.
- But this reduces arguably the number of observations (are the subjects' choices observations or should we worry about the interdependence)?

Definition (Strangers Matching)

Game theoretic experiments in which subjects play a game repeatedly but the other players in the game are new random draws from a larger set of subjects in the experiment.

Definition (Perfect Strangers Matching)

Strangers matching where researchers make sure that subjects always face a new set of other players and that contamination from previous play is not possible.

Definition (Partners Matching)

Game theoretic experiments in which subjects play a game repeatedly with the same players.

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Repetition of One-Shot Games withRandomization

Problem of Independence of Observations with Repetition

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- One solution – divide into subgroups and randomize within those groups only.
- Another solution is to conduct multiple sessions with smaller numbers of subjects

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- Or if goal is to evaluate extent subjects "solve" games & make choices as if they were game theorists or use some alternative non-rational choice mental process.
- In which case may also choose not to allow for repetition or, in some cases, have subjects play a game repeatedly or more than one game in the experiment, but simply not give subjects feedback during the experiment–only after all games have been completed.

Repetition of One-Shot Games withRandomization

Costa-Gomes & Crawford – 16 one shot guessing games with variation strangers matching, but no feedback

To test theories of strategic behavior, an experimental design must identify clearly the games to which subjects are responding. This is usually done by having a "large" subject population repeatedly play a given stage game, with new partners each period to suppress repeated-game effects, viewing the results as responses to the stage game. Such designs allow subjects to learn the structure from experience, which reduces noise; but they make it difficult to disentangle learning from cognition, because even unsophisticated learning may converge to equilibrium in the stage game. Our design, by contrast, seeks to study cognition in its purest form by eliciting subjects' initial responses to 16 different games, with new partners each period and no feedback to suppress repeated-game effects, experience-based learning, and experimentation.

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- But subjects typically aren't symmetric
- How should we deal with this? Usually ignore ...
- Can introduce a parameter in the model to capture what we theoretically might think is causing asymmetry?

- What does it mean for an actor to use a mixed strategy?

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- How can we observe mixed strategy use?

- Consider following game:

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	Winning Candidate	
Payoffs to Orange Voters	Orange	Blue
If Vote for Orange	1	0
If Vote for Blue	0	.75
Payoffs to Blue Voters	Orange	Blue
If Vote for Orange	.75	0
If Vote for Blue	0	1

- Sometimes empirical question is what factors lead to some equilibria being selected over others.

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- But other times better to consider how model might be changed to eliminate multiple equilibrium problem to get clearer predictions.