



# Dynamic Approach to Game and Economic Theory

Celebrating SERGIU HART'S 65th Birthday

**June 21-24, 2015**

## Organizers:

**Ilan Kremer** (Chair), The Hebrew University & University of Warwick

**Robert J. Aumann**, The Hebrew University

**Eddie Dekel**, Tel Aviv University & Northwestern University

**Ehud Kalai**, Northwestern University

**Andreu Mas-Colell**, University of Pompeu Fabra

**Igal Milchtaich**, Bar-Ilan University

**Eilon Solan**, Tel Aviv University

**Eyal Winter**, The Hebrew University & University of Leicester

All lectures will take place at the Edmond J. Safra Campus  
The Hebrew University, Feldman Building, Lecture Hall 130  
Givat Ram, Jerusalem, Israel

**We thank the following for their support**

- The Hebrew University of Jerusalem:
  - The Federmann Center for the Study of Rationality
  - Einstein Institute of Mathematics
  - Department of Economics
  - The Authority of Research and Development
- Israel Institute for Advanced Studies
- ERC – European Research Council

## PROGRAM

### SUNDAY June 21, 2015 ■

09:30 - 10:00     **Welcome**

■ **SESSION 1A**     Chair: **Roger Myerson** (University of Chicago)

10:00 - 10:20     **Yannai Gonczarowski** (The Hebrew University of Jerusalem)  
*Cascading to Equilibrium: Hydraulic Computation of Equilibria in Resource Selection Games* (with Moshe Tennenholtz)

10:20 - 10:40     **Leeat Yariv** (California Institute of Technology)  
*On the Efficiency of Stable Matchings in Large Markets*

10:40 - 11:00     **Shmuel Zamir** (The Hebrew University of Jerusalem)  
*Representations of Constitutions under Incomplete Information*  
(with Bezalel Peleg)

11:00 - 11:20     **Olivier Gossner** (CNRS - Université Paris Saclay and LSE)  
*Demand for Information and the Appeal of Information Transactions* (with Antonio Cabrales and Roberto Serrano)

11:20 - 11:40     **Break**

■ **SESSION 1B**     Chair: **Eric van Damme** (Tilburg University)

11:40 - 12:00     **Rann Smorodinsky** (Technion)  
*Subjective Perception Games and Privacy* (with Ronen Gradwohl)

12:00 - 12:20     **Ziv Hellman** (Bar-Ilan University)  
*Sex and Portfolio Investment* (with Omer Edhan and Dana Sherill-Rofe)

12:20 - 12:40     **Françoise Forges** (Université Paris-Dauphine)  
*Cheap Talk and Commitment in Bayesian Games*  
(with Ulrich Horst and Antoine Salomon)

12:40 - 14:15     **Lunch**

## **SESSION 1C**

Chair: **Asher Wolinsky** (Northwestern University)

14:15 - 14:35

**Elchanan Ben-Porath** (The Hebrew University of Jerusalem)  
*Disclosure and Choice*

14:35 - 14:55

**Dieter Balkenborg** (University of Exeter)  
*Rationalizability and Logical Inference*

14:55 - 15:15

**Eric van Damme** (Tilburg University)  
*Rationality and the Golden Rule*

15:15 - 15:35

**Einav Hart** (The Hebrew University of Jerusalem)  
*Single and Multi-field Asymmetric Competitions*  
(with Judith Avrahami and Yaakov Kareev)

15:35 - 16:00

**Break**

16:00 - 16:45

**Robert J. Aumann** (The Hebrew University of Jerusalem)  
*My Sergiu*

## **MONDAY June 22, 2015**

### **SESSION 2A**

Chair: **Eddie Dekel** (Northwestern University)

10:00 - 10:20

**Ron Siegel** (Northwestern University)  
*Effort-Maximizing Contests* (with Wojciech Olszewski)

10:20 - 10:40

**Ella Segev** (Ben-Gurion University)  
*Sequential Bidding in Asymmetric First-Price Auctions*

10:40 - 11:00

**Moshe Babaioff** (Microsoft Research)  
*A Simple and Approximately Optimal Mechanism for an Additive Buyer*  
(with Nicole Immorlica, Brendan Lucier, and S. Matthew Weinberg)

11:00 - 11:20 **Vijay Krishna** (Penn State University)  
*Communication and Cooperation in Repeated Games*  
(with Yu Awaya)

11:20 - 11:40 **Break**

**SESSION 2B**

Chair: **Ehud Kalai** (Northwestern University)

11:40 - 12:00 **Ariel Rubinstein** (Tel Aviv University)  
*Players' Competition for the Attention of a "Problem Solver"*  
(with Kobi Glazer)

12:00 - 12:20 **Yakov Babichenko** (Technion)  
*One-Shot Bargaining Mechanisms*

12:20 - 12:40 **Roberto Serrano** (Brown University)  
*Slutsky Matrix Norms and the Size of Bounded Rationality*  
(with V. Aguiary)

12:40 - 14:15 **Lunch**

**SESSION 2C**

Chair: **Vijay Krishna** (Penn State University)

14:15 - 14:35 **Francis Bloch** (Paris School of Economics)  
*Dynamic Allocation of Objects to Queueing Agents*  
(with David Cantala)

14:35 - 14:55 **Tomás Rodríguez Barraquer** (MOVE Barcelona)  
*Revisiting Games with Strategic Complements in Networks*

14:55 - 15:15 **Federico Valenciano** (Universidad del País Vasco)  
*Strategic Network Formation* (with Norma Olaizola)

15:15 - 15:45 **Break**

15:45 - 16:30     **Andreu Mas-Colell** (Universitat Pompeu Fabra)  
*Trying Hard but No Regrets*

17:00 - 20:00     **Israel Museum Tour and Gala Dinner** (by invitation)

## TUESDAY June 23, 2015 ■

■ **SESSION 3A**     Chair: **Noa Nitzan** (The Hebrew University of Jerusalem)

10:00 - 10:20     **Igal Milchtaich** (Bar-Ilan University)  
*Polyequilibrium*

10:20 - 10:40     **Yuval Salant** (Northwestern University)  
*Generalized Sampling Equilibrium* (with Josh Cherry)

10:40 - 11:00     **Ron Holzman** (Technion)  
*Strong Equilibrium in Network Congestion Games :  
Increasing versus Decreasing Costs* (with Dov Monderer)

11:00 - 11:20     **Yossi Rinott** (The Hebrew University of Jerusalem)  
*On Measuring and Comparing Usefulness of Statistical Models*  
(with David Azriel)

11:20 - 11:40     **Break**

■ **SESSION 3B**     Chair: **Igal Milchtaich** (Bar-Ilan University)

11:40 - 12:00     **Noam Nisan** (The Hebrew University of Jerusalem)  
*On the Borders of Border's Theorem*  
(with Parikshit Gopalan and Tim Roughgarden)

12:00 - 12:20     **Ran Spiegler** (Tel Aviv University)  
*Search Design and Broad Matching* (with Kfir Eliaz)

- 12:20 - 12:40     **Aloisio Araujo** (FGV, Rio de Janeiro)  
*Refining Dynamic Equilibria*  
(with M. Choubdar, W. L. Maldonado, D. Pinheiro, and A. A. Pinto)
- 12:40 - 14:00     **Lunch**
- 14:00 - 15:20     **POSTER SESSION** ■
- **Avishay Aiche** (Haifa University)  
*The Mas-Colell Bargaining Set for Mixed Production Games with Two Types of Players*
  - **Nadav Amir** (The Hebrew University of Jerusalem)  
*Uniqueness of Optimal Strategies in Captain Lotto Games*
  - **Mathias Barra** (Akershus University Hospital)  
*Representations of Preferences over Quantified Spaces*
  - **Emiliano Catonini** (International College of Economics and Finance)  
*Non-Binding Agreements and Forward Induction Reasoning*
  - **Endre Csóka** (University of Warwick)  
*Efficient Teamwork*
  - **David Lagziel** (Tel Aviv University)  
*Bankruptcy in Second-Price Auctions and the Bid Caps Solution*
  - **Artyom Jelnov** (University of Ariel)  
*Attacking the Unknown Weapons of a Possible Provocateur: How Intelligence Affects Strategic Interaction* (with Yair Tauman and Richard Zeckhauser)
  - **Eiichiro Kazumori** (University at Buffalo)  
*Bayesian Games with Baire Class 1 Payoff Functions*
  - **Marius Ochea** (Université Cergy-Pontoise)  
*Heterogeneous Heuristics in 3x3 Bimatrix Population Games*
  - **Brian Powers** (University of Illinois)  
*An Analysis of Multi-Issue Final-Offer Arbitration*
  - **Andres Salamanca** (Toulouse School of Economics)  
*An Egalitarian Value for Cooperative Games with Incomplete Information*
  - **Valeriu Ungureanu** (State University of Moldova)  
*Linear Discrete PNS Control Processes with Echoes and Retroactive Future*
  - **Peio Zuazo Garin** (Universitat Rovira i Virgili)  
*Uncertain Information Structures and Backward Induction*

### ■ SESSION 3C

Chair: **Leeat Yariv** (California Institute of Technology)

15:20 - 15:40

**Martin Shubik** (Yale University)  
From General Equilibrium to Schumpeter

15:40 - 16:00

**Yishay Mansour** (Tel Aviv University)  
*Bayesian Incentive-Compatible Bandit Exploration*  
(with Alex Slivkins and Vasilis Syrgkanis)

16:00 - 16:20

**T.E.S Raghavan** (University of Illinois at Chicago)  
*Some Remarks on a Proof of the Existence of Correlated Equilibria*  
by Hart and Schmeidler

16:20 - 16:40

**Werner Hildenbrand** (University of Bonn)  
*Demand Functions*

16:40 - 17:00

**Break**

17:00 - 17:45

**Sergiu Hart** (The Hebrew University of Jerusalem)  
*Game-Theoretical Snapshots*

17:45 - 18:00

**Break**

18:00 - 18:15

**Avi Shmida** (The Hebrew University of Jerusalem)  
*Bombus Colony: All Social Conflicts in One Box*  
(Note: This lecture will be held in Elath Hall, Feldman Building.)

### WEDNESDAY June 24, 2015 ■

### ■ SESSION 4A

Chair: **Larry Samuelson** (Yale University)

10:00 - 10:20

**Zibo Xu** (Singapore University of Technology and Design)  
*Best-Response Dynamics in Zero-Sum Stochastic Games*  
(with David Leslie and Steven Perkins)



- 10:20 - 10:40 **Peter J. Hammond** (University of Warwick)  
*Designing a Strategy-Proof Spot Market Mechanism:  
Twenty-Four Steps to Walrasian Equilibrium*
- 10:40 - 11:00 **Andriy Zapechelnyuk** (University of Glasgow)  
*Persuading a Heterogeneous Audience* (with Anton Kolotilin,  
Ming Li, and Tymofiy Mylovanov)
- 11:00 - 11:20 **George Mailath** (University of Pennsylvania)  
*The Curse of Long Horizons* (with V. Bhaskar)

11:20 - 11:40 **Break**

**SESSION 4B**

Chair: **Johannes Hörner** (Yale University)

- 11:40 - 12:00 **José Manuel Zarzuelo** (Universidad del País Vasco)  
*Characterization of Solutions of Highway Cost-Sharing Problems*  
(with Peter Sudhölter)
- 12:00 - 12:20 **Peter Sudhölter** (University of Southern Denmark)  
*On Bargaining Sets of Convex NTU Games* (with Bezalel Peleg)
- 12:20 - 12:40 **Oscar Volij** (Ben-Gurion University)  
*Consensus* (with M. Mahajne and S. Nitzan)
- 12:40 - 14:00 **Lunch**



## **ABSTRACTS**



**Yannai Gonczarowski** (The Hebrew University of Jerusalem)  
*Cascading to Equilibrium: Hydraulic Computation of Equilibria  
in Resource Selection Games*  
(with Moshe Tennenholtz)

21/6 - Session 1A

Drawing intuition from a (physical) hydraulic system, we present a novel framework, constructively showing the existence of a strong Nash equilibrium in resource selection games (i.e., asymmetric singleton congestion games) with nonatomic players, the coincidence of strong equilibria and Nash equilibria in such games, and the invariance of the cost of each given resource across all Nash equilibria. Our proofs allow for explicit calculation of Nash equilibrium and for explicit and direct calculation of the resulting (invariant) costs of resources, and do not hinge on any fixed-point theorem, on the Minimax theorem or any equivalent result, on linear programming, or on the existence of a potential (though our analysis does provide powerful insights into the potential, via a natural concrete physical interpretation). A generalization of resource selection games, called resource selection games with I.D.-dependent weighting, is defined, and the results are extended to this family, showing that while resource costs are no longer invariant across Nash equilibria in games of this family, they are nonetheless invariant across all strong Nash equilibria, drawing a novel fundamental connection between group deviation and I.D.-congestion. A natural application of the resulting machinery to a large class of constraint-satisfaction problems is also described.

**Leeat Yariv** (California Institute of Technology)  
*On the Efficiency of Stable Matchings in Large Markets*

21/6 - Session 1A

Stability is often the goal for clearinghouses in matching markets, such as those matching residents to hospitals, students to schools, etc. Stable outcomes absent transfers need not be utilitarian efficient, suggesting the potential value of transfers. We study the wedge between stability and efficiency in large one-to-one matching markets. We show that stable matchings are asymptotically efficient for a large class of preferences. In these environments, stability remains an appealing objective even on efficiency grounds, and monetary transfers are not necessary for efficiency purposes. Nonetheless, for severely imbalanced markets, when preferences entail sufficient idiosyncrasies, stable outcomes may be inefficient even asymptotically.

**Shmuel Zamir** (The Hebrew University of Jerusalem)  
*Representations of Constitutions under Incomplete Information*  
(with Bezalel Peleg)

21/6 - Session 1A

We model constitutions by effectivity functions. We assume that the constitution is common knowledge among the members of the society. However, the preferences of the citizen are private information. We investigate whether there exist decision schemes (i.e., functions that map profiles of strategies to lotteries on the set of social states), with the following properties: i) the distribution of power induced by the decision scheme is identical to the effectivity function under consideration; and ii) the (incomplete information) game associated with the decision scheme has a Bayesian Nash equilibrium in pure strategies. If the effectivity function is monotonic and superadditive, then we find a class of decision schemes with the foregoing properties.

**Olivier Gossner** (CNRS - Université Paris Saclay and LSE)  
*Demand for Information and the Appeal of Information Transactions*  
(with Antonio Cabrales and Roberto Serrano)

21/6 - Session 1A

Consider agents that are heterogeneous in their preferences and wealth levels. These agents may acquire information prior to making investment decisions, and each piece of information bears a corresponding cost. We associate a quantity to each information transaction (information-cost pair). This index describes the appeal or attractiveness of the transaction in the market with the following property. No agent more risk averse than the index finds it profitable to acquire the information, whereas all agents less risk averse than the index do. Given an empirically measured range of degrees of risk aversion in an economy, our model therefore comes close to describing an inverse demand for information, predicting what pieces of information are explored by agents and which ones are left unexplored. Among many desirable properties, the appeal formula induces a complete ranking of information structures that extends Blackwell's classic ordering.

**Rann Smorodinsky** (Technion)  
*Subjective Perception Games and Privacy*  
(with Ronen Gradwohl)

21/6 - Session 1B

We analyze a general framework for modeling agents whose utility is derived from both their actions and the perceptions of others about their type. We show that such perception games always have equilibria and discuss two natural refinements. We demonstrate the applicability of our framework in a variety of contexts, with a particular emphasis on privacy-related issues.

**Ziv Hellman** (Bar-Ilan University)  
*Sex and Portfolio Investment*  
(with Omer Edhan and Dana Sherill-Rofe)

21/6 - Session 1B

We propose an answer to the question, “Why sex?,” a long-standing question stemming from the observation that asexual reproduction is ostensibly more efficient than sexual reproduction. From the perspective of a genetic allele, each individual bearing that allele is akin to a stock share yielding dividends equal to that individual’s number of offspring. The totality of individuals bearing the allele is its portfolio investment. Alleles compete over portfolio growth in stochastic environments. Using concepts from algorithmic game theory, evolutionary reproduction strategies are then seen to be on-line learning algorithms seeking improved portfolio growth. Sexual reproduction is a goal-directed algorithmic exploration of genotype space by sampling in each generation. We show that the algorithm of sexual reproduction yields higher expected growth than that of asexual reproduction, which is proposed as an explanation of why there is sex.

**Françoise Forges** (Université Paris-Dauphine)  
*Cheap Talk and Commitment in Bayesian Games*  
(with Ulrich Horst and Antoine Salomon)

21/6 - Session 1B

Let us allow the players of a one-shot Bayesian non-cooperative game to agree on a committed joint decision after having exchanged information through cheap talk. Simple examples show that, even if one player is uninformed and does not care for the other (informed) player's action (generalized sender-receiver game), no jointly agreed decision may be achievable. Sufficient conditions are given for the existence of allocations that can be implemented by means of (perfect Bayesian) equilibria involving cheap talk and unanimous approval. A crucial use is made of results that were originally established for repeated games with incomplete information by S. Sorin (1983), R. Simon, S. Spiez and H. Torunczyk (1995), and J. Renault (2000). The approach is thus similar to the one of Aumann and Hart (2003), who show how repeated games can be used to analyze the effects of cheap talk before the non-cooperative play of a Bayesian game.

**Elchanan Ben-Porath** (The Hebrew University of Jerusalem)  
*Disclosure and Choice*

21/6 - Session 1C

An agent chooses one among a set of projects with random outcomes. His payoff is increasing both in the outcome and in an observer's expectation about the outcome. With some probability the agent can disclose the true outcome to the observer. One example of this setup is a situation where the agent is an incumbent politician and the observer is a representative voter. A project is a policy. Before the outcome of the policy is observed by the voter the incumbent comes up for reelection. The probability that the voter retains the incumbent is increasing in the voter's beliefs about the value of the outcome. We show that in equilibrium choice is inefficient: the agent favors riskier projects even with lower expected returns. If information can be disclosed not only by the agent but also by a challenger (political competitor) who prefers lower beliefs of the observer, then the project chosen by the agent



is excessively risky when the agent has better access to information, excessively risk-averse when the challenger has better access, and efficient when both agent and challenger have equal access to information. We also characterize the agent's worst-case equilibrium payoff. In particular we show that in the case where the challenger has no access to information and the agent cares only about the beliefs of the observer ( i.e., he is indifferent to the outcome (then the expected value of the project that is selected in equilibrium can be half of the expected value of the first best) the project with the highest expected value (but not lower than that.

**Dieter Balkenborg** (University of Exeter)  
*Rationalizability and Logical Inference*

21/6 - Session 1C

In a model of modal propositional logic it is shown that the assumption of rationality and intelligence of the players implies that only rationalizable strategies can be played, and nothing more can be inferred. Hereby the assumption of intelligence refers to the familiar inference rule of necessitation and expresses that whatever an outside observer can deduce about the play of the game can be inferred by the players themselves, if they have the same information.

**Eric van Damme** (Tilburg University)  
*Rationality and the Golden Rule*

21/6 - Session 1C

I formalize the Golden Rule ("do unto others as you would like others to do unto you") in a standard rational choice framework. I show that, in a two-player context, a rational individual can follow the Golden Rule, but that, when society is larger, rationality and the Golden Rule may be inconsistent. I also show that a player that is following the Golden Rule may harm the other and that, in fact, if a rational individual follows the Golden Rule, the outcome may be Pareto inferior to when the individual neglects the Rule. Finally, I show that, in this rational choice interpretation, the Golden Rule and the Law of Love may be incompatible.

**Einav Hart** ( The Hebrew University of Jerusalem)  
*Single and Multi-field Asymmetric Competitions*  
(with Judith Avrahami and Yaakov Kareev)

21/6 - Session 1C

We study investments in competitions in which the resources spent are non-refundable: investments are not returned, regardless of win or loss. In two experiments, we examine asymmetric, repeated competitions, in which contestants differ in the resources at their disposal. We vary the value of the prize to be won, and the way the winner is determined: whether based on investment in a single field, or based on investment in an a-priori unknown field chosen from several fields. In Experiment, 1 contestants are measured in a single field; in Experiment, 2 contestants are measured on one field randomly chosen from four fields. In line with game-theoretic predictions, we show that for larger prizes there is a larger effect of asymmetry: the strong contestant invests more while the weak contestant invests less. We find that the discouraging effect of asymmetry diminishes when there is more than one possible field: there is a smaller difference between the strong and weak contestants' investments in multi-field competitions. In addition, the effect of the prize is less pronounced when there are multiple fields.

**Robert J .Aumann** (The Hebrew University of Jerusalem)  
*My Sergiu*

21/6 - Session 1C

A review of some of the works of Prof .Hart with which the speaker is familiar.

**Ron Siegel** (Northwestern University)  
*Effort-Maximizing Contests*  
(with Wojciech Olszewski)

22.6 - Session 2A

We study a contest environment with a large number of players and prizes that accommodates complete and incomplete information, and heterogeneity among players and prizes. We characterize the effort-maximizing prize structure when players may differ in their marginal valuations for prizes and when the valuation may differ from the designer's cost of providing the prizes. We also provide such a characterization when players' cost of effort differs from the designer's benefit from the effort, as in Moldovanu and Sela (2001).

**Ella Segev** (Ben-Gurion University)

22.6 - Session 2A

*Sequential Bidding in Asymmetric First-Price Auctions*

We study asymmetric first-price auctions in which bidders place their bids sequentially, one after the other and only once. We show that with a strong bidder and a weak bidder already with some asymmetry between the bidders, the expected revenue in the sequential bidding first-price auction (when the strong bidder bids first) may be higher than in the simultaneous bidding first-price auction as well as second-price auction. The expected payoff of the weak bidder is also higher in the sequential first-price auction. Therefore a seller facing asymmetric bidders and interested in increasing revenue may find it beneficial to order them and let them bid sequentially instead of simultaneously. In terms of efficiency the sequential bidding auction when the stronger bidder bids first achieves lower efficiency than the simultaneous auction. However, when the order is reversed and the asymmetry is large enough the sequential first-price auction achieves higher efficiency than the simultaneous auction. Finally we show that there exists no monotonicity in the number of bidders in the sequential bidding auction and discuss the optimal order of bidders.

**Moshe Babaioff** (Microsoft Research)

22.6 - Session 2A

*A Simple and Approximately Optimal Mechanism for an Additive Buyer*

(with Nicole Immorlica, Brendan Lucier, and S. Matthew Weinberg)

We consider a monopolist seller with  $n$  heterogeneous items, facing a single buyer. The buyer has a value for each item drawn independently according to (non-identical) distributions, and his value for a set of items is additive. The seller aims to maximize his revenue. It is known that an optimal mechanism in this setting may be quite complex, requiring randomization [HR12] and menus of infinite size [DDT13]. Hart and Nisan [HN12] have initiated a study of two very simple pricing schemes for this setting: item pricing, in which each item is priced at its monopoly reserve; and bundle pricing, in which the entire set of items is priced and sold as one bundle. Hart and Nisan [HN12] have shown that neither scheme can guarantee more than a vanishingly small fraction of the optimal revenue. In sharp contrast, we show that for any distributions, the better of item and bundle pricing is a constant-factor approximation to the optimal revenue. We further discuss extensions to multiple buyers and to valuations that are correlated across items.

**Vijay Krishna** (Penn State University)  
*Communication and Cooperation in Repeated Games*  
(with Yu Awaya)

22.6 - Session 2A

We examine the role of communication in repeated games with private monitoring. We first study the set of equilibrium payoffs without communication and develop an explicit bound for this set that depends on the payoffs in the one-shot game, the discount factor, and a measure of the quality of the monitoring. We then introduce “cheap talk” communication and identify sufficient conditions on the monitoring structure such that there are equilibria with communication that are nearly efficient, whereas all equilibria without communication are bounded away from the efficient frontier. Under our conditions, communication thus leads to greater cooperation.

**Ariel Rubinstein** (Tel Aviv University )  
*Players' Competition for the Attention of a 'Problem Solver'*  
(with Kobi Glazer)

22.6 - Session 2B

A new type of agent whom we refer to as a "problem solver" is introduced to interact with regular players. The problem solver does not put himself in the shoes of other players and does not form beliefs about the behavior that led to the data he receives. Rather, he behaves as if he were solving a puzzle to discover the combinations of actions that are consistent with what he observes. We insert such a problem solver into a simple model of competition for attention and analyze its equilibria. In particular, we demonstrate the possibility that in equilibrium the problem solver will always succeed in his task although he is not certain he will.

**Yakov Babichenko** (Technion)  
*One-Shot Bargaining Mechanisms*

22.6 - Session 2B

We consider the situation that two players have cardinal preferences over a finite set of alternatives. These preferences are common knowledge to the players, and they engage in bargaining to choose an alternative. In this they are assisted by an arbitrator who does

not know the preferences (a mechanism). Our main positive result suggests a satisfactory-alternatives mechanism where each player reports a set of alternatives. If the sets intersect, then the mechanism chooses an alternative from the intersection uniformly at random. If the sets are disjoint, then the mechanism chooses an alternative from the union uniformly at random. We show that a close variant of this mechanism succeeds in selecting Pareto efficient alternatives only, as pure Nash equilibria outcomes. Thereafter, we characterize the possible and the impossible with respect to the classical bargaining axioms. Namely, we characterize the subsets of axioms that can be satisfied simultaneously by the set of pure Nash equilibria outcomes of a mechanism. We provide a complete answer to this question for all subsets of axioms. In all cases of possibility, we present a simple and intuitive mechanism that achieves this goal. The satisfactory-alternatives mechanism constitutes a positive answer to one of these possibility cases (arguably the most interesting case). Our negative results exclude the possibility of an efficient mechanism with unique equilibrium outcome, and exclude the possibility of an efficient symmetric mechanism that is invariant with respect to repetition of alternatives.

**Roberto Serrano** (Brown University)

22.6 - Session 2B

*Slutsky Matrix Norms and the Size of Bounded Rationality*

(with V. Aguiary)

Given any observed demand behavior by means of a demand function, we quantify by how much it departs from rationality. Using a recent elaboration of the "almost implies near" principle, the measure of the gap is the smallest Frobenius norm of the correcting matrix function that would yield a Slutsky matrix with its standard rationality properties (symmetry, singularity, and negative semidefiniteness). A useful classification of departures from rationality is suggested as a result. Variants, axiomatics, examples, and applications are discussed, and illustrations are provided using several bounded rationality models.

**Francis Bloch** (Paris School of Economics)

22.6 - Session 2C

*Dynamic Allocation of Objects to Queueing Agents*  
(with David Cantala)

This paper analyzes the optimal allocation of objects which arrive sequentially to agents organized in a waiting list. Applications include the assignment of social housing, deceased donor organs, and daycare slots. A mechanism is a probability distribution over all priority orders which are consistent with the waiting list. We consider three efficiency criteria: first-order stochastic dominance in the vector of agents' values, the probability of misallocation and the expected waste. We show that the strict seniority order dominates uniform random order according to the first two criteria, and the uniform random order dominates strict priority according to the third criterion. If agents' values are perfectly correlated, strict priority dominates all other probabilistic mechanisms for all agents' values.

**Tomás Rodríguez Barraquer** (MOVE Barcelona)

22.6 - Session 2C

*Revisiting Games with Strategic Complements in Networks*

Consider a setting in which agents can take one of two ordered actions and in which the incentive to take the high action increases in the number of other agents taking it. Furthermore, assume that we do not know anything else about the game being played. What can we say about the details of the interaction between actions and incentives when we observe a set or a subset of all possible equilibria? In this paper, we study this question by exploring two nested classes of games: (a) binary games of strategic complements; (b) games in (a) that admit a network representation. Building on Rodríguez-Barraquer (2013) we provide a characterization of all collections of behaviours that are a subset of the set of equilibria of some binary game of thresholds admitting a network representation. We also provide a geometric version of the characterization.

**Federico Valenciano** (Universidad del Pais Vasco)

22.6 - Session 2C

*Strategic Network Formation*

(with Norma Olaizola)

We provide a model that merges two basic models of strategic network formation and incorporates them as extreme cases: Jackson and Wolinsky's connections model based on bilateral formation of links, and Bala and Goyal's two-way row model, where links can be unilaterally formed. In our model a link can be created unilaterally, but when it is only supported by one of the two players the flow through it suffers some friction or decay, but more than when it is supported by both players. When the friction in singly-supported links is maximal ( i.e., there is no row) we have Jackson and Wolinsky's connections model ,while when flow in singly-supported links is as good as in doubly-supported links we have Bala and Goyal's two-way row model. In this setting, a joint generalization of the results relative to efficiency and stability in both seminal papers is achieved, and the robustness in both models is tested with positive results.

**Andreu Mas-Colell** (Universitat Pompeu Fabra)

22.6 - Session 2C

*Trying Hard but No Regrets*

A summary, bird's-eye presentation of some of my joint work with Sergiu Hart, in particular on equitable imputations in large games and on regret-matching.

**Igal Milchtaich** (Bar-Ilan University)

23.6 - Session 3A

*Polyequilibrium*

Polyequilibrium is a novel generalization of Nash equilibrium that is applicable to any strategic game, whether finite or otherwise, and to dynamic games, with perfect or imperfect information. It differs from equilibrium in specifying strategies that players do not choose and by requiring an (after-the-fact) justification for the exclusion of these strategies rather than the retainment of the non-excluded ones. Specifically, for each excluded strategy of each player there must be a non-excluded one that responds to every profile of non-excluded strategies

of the other players at least as well as the first strategy does. A polyequilibrium's description of the outcome of the game may be more or less specific, depending on the number and the identities of the non-excluded strategy profiles. A particular property of the outcome is said to hold in a polyequilibrium if it holds for all non-excluded profiles. Such a property does not necessarily hold in any Nash equilibrium in the game. In this sense, the generalization proposed in this work extends the set of justifiable predictions concerning a game's outcomes.

**Yuval Salant** (Northwestern University)

23.6 - Session 3A

*Generalized Sampling Equilibrium*

(with Josh Cherry)

We propose a solution concept called Generalized Sampling Equilibrium (GSE), where players use statistical rather than strategic reasoning when making decisions. This concept is rooted in the sampling equilibrium of Osborne and Rubinstein (1998, 2003), and accommodates a variety of other statistical reasoning procedures. For a large class of two-action games, we show that the GSE is unique, compare its predictions to those of Nash equilibrium, and characterize how the GSE changes with the size of the sample players obtain. We also demonstrate the predictions of GSE in several applications, including a labor matching application in which sampling introduces a friction that results in a larger unemployment than in Nash equilibrium.

**Ron Holzman** (Technion)

23.6 - Session 3A

*Strong Equilibrium in Network Congestion Games:*

*Increasing versus Decreasing Costs*

(with Dov Monderer)

A network congestion game is played on a directed, two-terminal network. Every player chooses a route from his origin to his destination. The cost of a route is the sum of the costs of the arcs on it. The arc cost is a function of the number of players who use it. Rosenthal proved that such a game always has Nash equilibrium in pure strategies. Here we pursue a systematic study of the classes of networks for which a strong equilibrium is guaranteed to exist under two opposite monotonicity assumptions on the arc cost functions. Our main results are:



(a) if costs are increasing, strong equilibrium is guaranteed on extension-parallel networks, regardless of whether the players' origins and destinations are the same or may differ. (b) If costs are decreasing, and the players have the same origin but possibly different destinations, strong equilibrium is guaranteed on series-parallel networks. (c) If costs are decreasing, and both origins and destinations may differ, strong equilibrium is guaranteed on multiextension-parallel networks. In each case, the network condition is not only sufficient but also necessary in order to guarantee strong equilibrium. These results extend and improve earlier ones by Holzman and Law-Yone in the increasing case, and by Epstein et al. in the decreasing case.

**Yossi Rinott** (The Hebrew University of Jerusalem)

23.6 - Session 3A

*On Measuring and Comparing Usefulness of Statistical Models*

(with David Azriel)

Statistical models in econometrics, biology, and most other areas should not be expected to be "correct," and often are not very accurate, but may still be useful. The choice of a model for the analysis of data depends on the purpose of the analysis, the nature of the data, and also on the sample or data size. Erev, Roth, Slonim, and Barron (2007) [Economic Theory, 33, 29–51] studied models for prediction of future play in game-theoretic experiments and proposed an approach for quantification of the value of a model. Combining ideas from the latter article and the well-known AIC criterion, we propose another quantification of the chosen model's relative predictive value, which depends on the data and its size. Our research was first motivated by data from experimental economics, and we also study the Hardy–Weinberg model in biology.

**Noam Nisan** (The Hebrew University of Jerusalem)

23.6 - Session 3B

*On the Borders of Border's Theorem*

(with Parikshit Gopalan and Tim Roughgarden)

Border's theorem characterizes the possible (interim) allocation probabilities in a single-item auction. It has received much interest lately in algorithmic mechanism design as it allows optimization in mechanism design using polynomial-size linear programs rather than the natural exponential-size ones. Known generalizations of Border's theorem beyond the simple case of

single-item auctions are either very limited or are only approximate. This talk will explain why significant extensions of Border's theorem are impossible, assuming standard computational complexity assumption. The proof will take us on a journey from simple questions regarding marginal probabilities in probability spaces to revenue maximization in mechanism design, to Boolean function analysis, to #P, and back.

**Ran Spiegler** (Tel Aviv University)  
*Search Design and Broad Matching*  
(with Kfir Eliaz)

23.6 - Session 3B

We study the problem of designing a mechanism that allocates firms into search pools, when consumers can only give a noisy signal of what they are looking for. Under random sequential search, we show that it is always possible to design a mechanism that incentivizes firms to behave in a way that maximizes consumer surplus (taking their search costs into account). We then establish a necessary and sufficient condition – in terms of the joint distribution of consumer tastes and signals – for the existence of consumer-optimal mechanisms that also extract the entire surplus of firms. The condition is a simple set of inequalities that involve the relative fractions of consumers who like different products, and the Bhattacharyya coefficient of similarity between their conditional signal distributions.

**Aloisio Araujo** (FGV, Rio de Janeiro)  
*Refining Dynamic Equilibria*  
(with M. Choubdar, W. L. Maldonado, D. Pinheiro, and A. A. Pinto)

23.6 - Session 3B

In this paper we propose a refinement of dynamic equilibria based on small random deviations from the perfect foresight equilibrium in a class of one step forward dynamic models. Specifically, when the backward perfect foresight (bpf) map is a unimodal function exhibiting cycles or complex dynamics, we define a small random deviation from the perfect foresight equilibrium as a sequence of random variables generated from small stochastic errors on the perfect prevision of the future state variable value. First, we show that the stochastic process generated in that way is stationary provided on that the support of the perturbation is

small enough. Second, when the bpf map exhibits ergodic chaos, we show that the stationary measures converge to the Bowen–Ruelle–Sinai invariant measure of the bpf map as the size of the perturbations approaches zero. Third, if the bpf map has an attracting cycle, then the stationary measure is close to a convex linear combination of Dirac measures supported on that cycle. Therefore, depending on the parameter value which defines the bpf map, small random deviations are close to combination of Dirac measures supported on a determinate cycle or to the stationary measure of the chaotic sunspot equilibrium defined by Araujo and Maldonado (2000). Neither indeterminate cycles nor other kinds of sunspot equilibrium are found as the limiting behavior of the small random deviations. Finally, we provide two examples – the classical overlapping-generations model with fiat money and the Shapley–Shubik market game – to illustrate the refinement of the dynamic equilibria in those models given by the small random deviations from the perfect foresight equilibrium.

**Martin Shubik** (Yale University)

23.6 - Session 3C

*From General Equilibrium to Schumpeter*

A simple model of cost innovation in a monetary economy is presented that illustrates the essentially dynamic model of Schumpeter involving breaking the circular flow of capital is logically consistent with the General Equilibrium (GE) model of an exchange and production economy. The GE model as presented by Arrow, Debreu, and McKenzie is a non-process model; and the original theory deals with the non-constructive proofs of existence of competitive equilibria (CEs). In order to associate this theory with innovation several steps are required. It is necessary to recast the basic model as a process model. The GE model is enlarged and specified as a playable game. This involves adding rules to describe the mechanisms that carry process. These may be regarded as the basic economic institutions of the society. It has been shown that markets and the existence of money are the natural outcomes of seeking efficiency in trade. When an economy utilizes money in trade the rules of its production and destruction become of economic importance. The economy may be modeled as a Strategic Market Game (SMG) with one large atomic player, the government that has considerable influence over the money supply, and many small competitive agents. It is shown that the opportunity for process innovation can be described minimally and formally modeled by considering the availability of a new process as a function of a controlled stochastic variable where success depends on

chance modified by the level of investment. The Schumpeterian concept of "breaking the circular flow of capital" appears naturally as a disequilibrium phenomenon where the extra resources are captured by a strategic disequilibrating allocation of money. A study of the equations of motion is required to show whether or not the transient state converges to a new equilibrium.

**Yishay Mansour** (Tel Aviv University)

23.6 - Session 3C

*Bayesian Incentive-Compatible Bandit Exploration*

(with Alex Slivkins and Vasilis Syrgkanis)

Individual decision-makers consume information revealed by the previous decision makers, and produce information that may help in future decision makers. This phenomena is common in a wide range of scenarios in the Internet economy, as well as elsewhere, such as medical decisions. Each decision maker when required to select an action, would individually prefer to exploit, select the highest expected reward action given her information. At the same time, each decision maker would prefer previous decision makes to explore, producing information about the rewards of various actions. A social planner, by means of carefully designed information disclosure, can incentivize the agents to balance the exploration and exploitation, and maximize social welfare. We formulate this problem as a multi-arm bandit problem (and various generalizations thereof) under incentive-compatibility constraints induced by agents' Bayesian priors. We design an incentive-compatible bandit algorithm for the social planner with asymptotically optimal regret. Further, we provide a black-box reduction from an arbitrary multi-arm bandit algorithm to an incentive-compatible one, with only a constant multiplicative increase in regret. This reduction works for very general bandit settings, even ones that incorporate contexts and arbitrary partial feedback.

**T.E.S Raghavan** (University of Illinois at Chicago)

23.6 - Session 3C

*Some Remarks on a Proof of the Existence of Correlated Equilibria  
by Hart and Schmeidler*

Completely mixed games were first studied by Kaplanski for zero-sum two-person matrix games. The proof of Hart and Schmeidler on the existence of correlated equilibria (1989) without the use of Nash equilibria involves two critical lemmas. One uses Ky Fan's general minimax theorem and the other uses a construction of a zero-sum game out of general n-person game. The first lemma can be given an alternate proof using Kaplanski's theorem for completely mixed matrix games. The second lemma and its reduction of the existence of correlated equilibria for n-person games to a suitable two-person game has some similarities to a paper of Bubelis (International J Game Theory 1976) where he converts the study of Nash equilibria for any general n-person game to the study of Nash equilibria for a three-person game constructed out of the n-person game. At least for bimatrix games we do know that an extreme correlated equilibrium is Nash equilibrium.

**Werner Hildenbrand** (University of Bonn)

23.6 - Session 3C

*Demand Functions*

We characterize the structure of budget share functions derived from a homogeneous and continuous demand system: either every continuous function on  $(0, \infty)$  is limit of linear combinations of budget share functions (limits are with respect to uniform convergence on bounded intervals) or every budget share function is limit of linear combinations of functions of the form  $\cos(b \log(x))$  or  $\sin(b \log(x))$ ,  $b \geq 0$ , and the budget share is constant provided it admits a limit for  $x \rightarrow 0$  or  $x \rightarrow \infty$ .

**Avi Shmida** (The Hebrew University of Jerusalem)  
*Bombus Colony: All Social Conflicts in One Box*  
(with Guy Bloch and Jonathan Cnaani)

We will present the life of a *Bombus* colony and raise some basic open questions that bridge biology and economics. (I) Conflicts within a *Bombus* colony: 1. Who produces the colony males (the queen or the workers)? 2. How can an individual bee know what kind of task to perform? (II) Explanations for altruism: 1. Reciprocity (Trivers 1971). 2. Kin selection (Hamilton 1964). 3. Signaling of Spence (1973) = handicap of Zahav (1975). 4. Correlated equilibrium. (III) Why does polymorphism exist in *Bombus* but not in the honeybee? Differences exist in cell size, body size, and pheromone control. Who makes the decision: the queen, the workers, or both? (IV) The “competition point” of a *Bombus* colony: 1. When to switch from female to male production. 2. The worker: when to start competing with the queen over male production. 3. The queen: when to switch from rearing workers to new queens? (5) Why are Hymenoptera (bees, wasps, ants) social? Because they are HaploDiplo!

**Zibo Xu** (Singapore University of Technology and Design)  
*Best-Response Dynamics in Zero-Sum Stochastic Games*  
(with David Leslie and Steven Perkins)

24.6 - Session 4A

Given a two-player zero-sum discounted-payoff stochastic game, we introduce three classes of continuous-time best-response dynamics, stopping-time best-response dynamics, closed-loop best-response dynamics, and open-loop best-response dynamics. We show the global convergence of the first two classes to the set of minimax strategy profiles, and the convergence of the last class when the players are not patient. We also show that the payoffs in a modified closed-loop best-response dynamic converge to the asymptotic values in the zero-sum stochastic game.

**Peter J .Hammond** (University of Warwick)

24.6 - Session 4A

*Designing a Strategy-Proof Spot Market Mechanism:  
Twenty-Four Steps to Walrasian Equilibrium*

To prove their Walrasian equilibrium existence theorem, Arrow and Debreu (1954) devised an abstract economy that Shapley and Shubik (1977) criticized as a market game because, especially with untrustworthy traders, it fails to determine a credible outcome away from equilibrium. All this earlier work also postulated a Walrasian auctioneer with complete information about traders' preferences and endowments. To ensure credible outcomes, even in disequilibrium, warehousing is introduced into a multi-stage market game. To achieve Walrasian outcomes in a large economy with incomplete information, even about traders' endowments, a strategy-proof demand revelation mechanism is considered, and then extended to include warehousing.

**Andriy Zapechelnyuk** (University of Glasgow)

24.6 - Session 4A

*Persuading a Heterogeneous Audience*  
(with Anton Kolotilin, Ming Li, and Tymofiy Mylovanov)

We study Bayesian persuasion of a heterogeneous audience. An example is a government that would like to persuade the public to reduce the amount of public smoking by commissioning an educational campaign about the health risks of cigarettes. We allow for targeted persuasion in which the government can provide different information to different consumers and public persuasion in which all consumers are exposed to the same information. We establish equivalence of targeted and public persuasion, characterize optimal persuasion rules, and consider several applications.

**George Mailath** (University of Pennsylvania)

24.6 - Session 4A

*The Curse of Long Horizons*

(with V. Bhaskar)

We study a model of dynamic moral hazard with symmetric ex ante uncertainty about the difficulty of the job. Over time, both the principal and agent update their beliefs about the difficulty of the job as they observe output. As usual, effort is private and so incentives must be provided for the agent to exert effort. Moreover, the agent may have an additional incentive to shirk when the principal expects the agent to exert effort, because by shirking, the agent causes the principal to have incorrect beliefs. We show that this possibility can result in the effort incentive efficient contract needing incentives that become increasingly high powered as the length of the relationship increases. We show that this can imply that it is never optimal to always induce effort in very long relationships.

**José Manuel Zarzuelo** (Universidad del País Vasco)

24.6 - Session 4B

*Characterization of Solutions of Highway Cost-Sharing Problems*

(with Peter Sudhölter)

The problem of how to distribute the total cost of a highway among its customers may be modeled as a cost allocation TU game. Its coalition function assigns to each coalition of customers the aggregate cost of those sectors of the highway used by the members of the coalition. In the basic model it is assumed that each customer uses segments that form a connected part of the highway, whereas customers may use disconnected parts in a generalized highway problem. We show that a TU game is a generalized highway game if and only if it is a nonnegative linear combination of unanimity games. By suitably translating well-known simple properties like the Davis–Maschler reduced game property (consistency) and its converse (that are, in our context, less powerful as in the traditional case) we show that the core on highway games is characterized by unanimity for two-person problems, individual rationality, consistency, and converse consistency. Moreover, taking advantage of the fact that the nucleolus is the unique element of the kernel if the game is convex, we show, thereby generalizing the corresponding result for airport games, that the nucleolus is the unique single-valued solution that assigns equal cost shares to equal customers (satisfies ETP), charges the total



cost of an exclusively used segment to the customer who exclusively uses it, is scale covariant, consistent, and only depends on the cost allocation game. Finally, we formulate the property of strong monotonicity (S-MON) for this class of cost allocation problems and show, similarly as in the case of arbitrary TU games, that the Shapley rule is characterized by SIVA, ETP, Pareto efficiency, and S-MON.

**Peter Sudhölter** (University of Southern Denmark)  
*On Bargaining Sets of Convex NTU Games*  
(with Bezalel Peleg)

24.6 - Session 4B

We show that the Aumann–Davis–Maschler bargaining set and the Mas-Colell bargaining set of a non-leveled NTU game that is either ordinal convex or coalition merge convex coincide with the core of the game. Moreover, we show by means of an example that the foregoing statement may not be valid if the NTU game is marginal convex.

**Oscar Volij** (Ben-Gurion University)  
*Consensus*  
(with M. Mahajne and S. Nitzan)

24.6 - Session 4B

We propose the concept of level  $r$  consensus that involves a weakening of unanimity, the most extreme form of consensus. It is shown that if a preference profile exhibits level  $r$  consensus around a given preference relation, there exists a Condorcet winner. In addition, if the number of individuals is odd the majority relation coincides with the preference relation around which there is such consensus and consequently it is transitive. Furthermore, if the level of consensus is sufficiently strong, the Condorcet winner is chosen by all the scoring rules.

## POSTER SESSION

**Avishay Aiche** (Haifa University)

*The Mas-Colell Bargaining Set for Mixed Production Games with Two Types of Players*

In this paper, we show that for mixed oligopolistic markets with two types of players that the "equal-treatment" imputations in the Mas-Colell bargaining set, denoted by, satisfies the exploitation property against the uniform "ocean" of small traders. We also characterize the latter set with the competitive equilibriums in the sub markets of that contains partial sets of the atoms' set and the uniform "ocean". Further, we give the exact conditions for equal treatment imputations to be in the Mas-Colell bargaining set for duopolistic markets.

**Nadav Amir** (The Hebrew University of Jerusalem)

*Uniqueness of Optimal Strategies in Captain Lotto Games*

We consider the class of two-person zero-sum allocation games known as Captain Lotto games (Hart 2014). These are Colonel Blotto-type games in which the players have capacity constraints. We show that the players' optimal strategies are unique in most cases.

**Mathias Barra** (Akershus University Hospital)

*Representations of Preferences over Quantified Spaces*

In this work we first discuss, conceptually, expected utility (EU) theory. The reader is expected to have at least a superficial understanding of both game theory and expected utility theory à la von Neumann and Morgenstern [vN&M44]; a friendly introduction is given in [L&R57]. We next introduce the health economic concept of quality adjusted life years (QALYs), which ideally should constitute a means for understanding the utility derived from life lived in various health states. We next point to some problems in adapting EU theory to that of QALYs. We proceed to give an axiomatization of preferences over certain spaces with an aim to develop a utility-representation of this preference when some structure is inherent in the set (a semi-group). The main result is a purely topological (in the preference topology) axiomatization of

the concept that “sufficiently small quantities are indistinguishable” and restrict the models of the theories to models in which an objective zero exists, in the sense that any utility function representing the preference vanish at a certain point, so that the resulting utility measure will be a ratio-scale, and not only an interval scale, as is the case with classical EU.

**Emiliano Catonini** (International College of Economics and Finance)

*Non-Binding Agreements and Forward Induction Reasoning*

In dynamic games, players may observe a deviation from a pre-play, possibly incomplete, non-binding agreement before the game is over. The attempt to rationalize the deviation may lead players to revise their beliefs about co-players behavior in the continuation of the game. This instance of forward induction reasoning is based on interactive beliefs not just about rationality, but also about the compliance with the agreement itself. Here I study the effects of such rationalization on the self-enforceability of the agreement. Accordingly, outcomes of the game are deemed to be enforceable by some agreement or not. Conclusions depart substantially from the equilibrium refinement tradition suggests. A subgame imperfect Nash equilibrium may represent a self-enforcing agreement, while a subgame perfect equilibrium may not. Yet, every game possesses an outcome that is compatible with both forward and backward induction. Moreover, the incompleteness of the agreement may be crucial to implement an equilibrium outcome.

**Endre Csóka** (University of Warwick)

*Efficient Teamwork*

We model multi-agent projects where each agent has a private workflow including hidden actions and chance events, which can influence each other through publicly observable actions and events. We design an efficient and prior-independent mechanism for this novel environment that is quasi-dominant strategy incentive-compatible, collusion resistant, individually rational, and that avoids free-riders.

**David Lagziel** (Tel Aviv University)

*Bankruptcy in Second-Price Auctions and the Bid Caps Solution*

The paper deals with second-price auction where, with a certain probability, the bidders fail to pay the agreed price to the seller. In such auctions, both the seller and the bidders might gain in expectation if the bidders lower their bids relative to the equilibrium bids. Under some assumptions on the probability to default, we show that a bid cap, an upper bound on the bids imposed by the seller, increases the expected payoff of all the parties involved.

**Artyom Jelnov** (University of Ariel)

*Attacking the Unknown Weapons of a Possible Provocateur:*

*How Intelligence Affects the Strategic Interaction*

(with Yair Tauman and Richard Zeckhauser)

We consider the interaction of two enemy nations. Nation 1 wants to develop a nuclear bomb (or other weapons of mass destruction). Nation 2 wants to prevent such a development through the deterrence of a threatened attack, or an actual attack if it thought the bomb was produced. Nation 2 has an intelligence system that imperfectly indicates the presence of a bomb. Nation 1, if lacking the bomb, can open its facilities to prevent an attack. A further uncertainty is that nation 2 does not know nation 1's type. He could be a Deterrer, whose prime goal is to avoid an attack, or he could be a Provocateur who prefers an unjustified attack if he does not possess the bomb, so as to build support from inside his nation or the outside world. The game has a unique sequential equilibrium. The qualitative nature of that equilibrium depends on parameters on preferences and information conditions. A number of initially counterintuitive results emerge. For example, it may sometimes be rational (an equilibrium strategy) for 2 to attack even though 1 does not have a bomb, and even though 2's high-quality intelligence system indicates that a bomb is not present. Fortunately, intuitive explanations can be provided for all such results. Illustrations of the model's implications are provided from the experiences of the West (nation 2) with Saddam Hussein and the Ayatollah Khomeini (nation 1).

**Eiichiro Kazumori** (University at Buffalo)

*Bayesian Games with Baire Class 1 Payoff Functions*

This paper considers Bayesian games where a player's payoff functions as a Baire class 1 function. A Baire class 1 function (Baire 1905) is defined as a pointwise limit of a sequence of continuous functions and include semicontinuous functions, step functions, functions of bounded variations, and monotone functions. Bayesian games with Baire class 1 payoffs generalize the canonical model of Milgrom and Weber (1985) and encompass a large class of auction games and mechanism design problems. A Bayesian game with Baire class 1 payoffs has Bayesian equilibrium via continuous approximations when the better reply security condition of Reny (1999) is satisfied. This continuous approximation approach can be regarded as a generalization of the path-following method to games with discontinuous payoffs. Using the continuous approximation method, we characterize the optimal auction mechanism with heterogeneous objects and multidimensional types with continuous distributions by unifying Myerson (1981), Mussa and Rosen (1978), and Rochet and Chone (1998). We illustrate the method by solving an example where the buyers' private values are uniformly distributed on a square.

**Marius Ochea** (Université Cergy-Pontoise)

*Heterogeneous Heuristics in 3x3 Bimatrix Population Games*

We investigate numerically population-level evolutionary dynamics resulting from individual-level, adaptive play both under homogeneous ("self-play") and heterogeneous ("mixed play") scenarios. The set of heuristics includes imitation rules, perturbed best replies, and the unconditional regret-matching of Hart and Mas-Colell (2000). In a class of bi-matrix 3x3 normal form games Sparrow and van Strien (2009), for which Rock-Scissor-Paper is a special case, rich limit behavior unfolds as certain heuristics and/or game parameters are modulated.

**Brian Powers** (University of Illinois)

*An Analysis of Multi-Issue Final-Offer Arbitration*

First proposed in 1966, Final-Offer Arbitration has become a popular alternative to conventional arbitration public-sector disputes. Unlike conventional arbitration, the arbitrator does not have the ability to craft a compromise decision between the two parties' demands; he must choose one offer or the other. The game theoretic model used by Farber (1980), and Brams and Merrill (1983) showed the existence of pure strategy equilibria in the case where a single issue is under arbitration under certain assumptions about arbitrator behavior. We extend this model to the "multi-issue" case, and find the solution under various decision criteria the arbitrator may use.

**Andres Salamanca** (Toulouse School of Economics)

*An Egalitarian Value for Cooperative Games with Incomplete Information*

A bargaining solution concept generalizing the Nash (1950) bargaining solution and the Harsanyi (1963) NTU value is defined for cooperative games with incomplete information. Our bargaining solution is efficient and equitable when interpersonal comparisons are made in terms of virtual utility scales. By using the concept of virtual utility, our egalitarian value reflects the fact that players negotiate at the interim stage. When compared with Myerson's (1984a) value, both solutions concepts coincide for games with at most two players, however they may differ for three-person games. As a consequence, our egalitarian value reduces to the Myerson's (1984b) neutral bargaining solution in two-person Bayesian bargaining problems.

**Valeriu Ungureanu** (State University of Moldova)

*Linear Discrete PNS Control Processes with Echoes and Retroactive Future*

Pareto–Nash–Stackelberg game-control theory can embrace mathematical models of various real dynamic control processes with particular features and parameters. An important case of such types of decision processes may be formalized mathematically as the problem of linear discrete-time Pareto-Nash-Stackelberg control of decision processes that evolve as Pareto–Nash–Stackelberg games with constraints (a mixture of hierarchical and simultaneous games) under the influence of echoes and retroactive future ( $\Psi$  phenomena). We analyze and investigate this problem. The obtained results include mathematical models, solution concepts, conditions for Pareto–Nash–Stackelberg control existence, and method for Pareto–Nash–Stackelberg game-control computing, as well as Wolfram Mathematica applications, demonstrations, and benchmarks.

**Peio Zuazo Garin** (Universitat Rovira i Virgili)

*Uncertain Information Structures and Backward Induction*

In everyday economic interactions, it is not clear whether each agent's sequential choices are visible or not to other participants: the former might be deluded about the latter's capacity to acquire, interpret or keep track of data. Following this idea, this paper introduces uncertainty about players' capacity to observe each others' past choices in dynamic games. We prove that if players are rational and there is common strong belief in opponents' rationality and opponents' perfect information, then, the backward induction outcome is obtained regardless of which of her opponents' choices each player observes. That is, under proper restrictions on the rationalization process, forward inducting according to Battigalli's (1996) best rationalization principle always yields the same outcome irrespective of the information structure of the game. Consequently, the flow of information regarding agents' choices is found irrelevant in strategic terms. The analysis extends the work by Battigalli and Siniscalchi (2002), who provide sufficient epistemic conditions for the backward induction outcome for the perfect information case.











