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June 2008

Research

Published and Forthcoming Papers

- **Bayesian Learning in Social Networks** (with Douglas Gale, NYU). *Games and Economic Behavior*, November 2003, 45(2), pp. 329-346.

In this paper, we extend the standard model of social learning in two ways. First, we introduce a social network and assume that agents can only observe the actions of agents to whom they are connected by this network. Secondly, we allow agents to choose a different action at each date. If the network satisfies a connectedness assumption, the initial diversity resulting from diverse private information is eventually replaced by uniformity of actions, though not necessarily of beliefs, in finite time with probability one. We look at particular networks to illustrate the impact of network architecture on speed of convergence and the optimality of absorbing states. Convergence is remarkably rapid, so that asymptotic results are a good approximation even in the medium run.

- **Observational Learning under Imperfect Information** (with Boğaçhan Çelen, Columbia B-School). *Games and Economic Behavior*, March 2004, 47(1), pp. 72-86.

This paper explores Bayes-rational sequential decision making in a game with pure information externalities, where each decision maker observes only her predecessor's binary action. Under perfect information, the martingale property of the stochastic learning process is used to establish convergence of beliefs and actions. Under imperfect information, in contrast, beliefs and actions cycle forever. However, despite the instability, over time the private information is ignored and decision makers become increasingly likely to imitate their predecessors. Consequently, we observe longer and longer periods of uniform behavior, punctuated by increasingly rare switches. These results suggest that the kind of episodic instability that is characteristic of social behavior in the real world makes more sense in the imperfect-information model, and that the imperfect information premise provides a better theoretical description of fads and fashions.

- **Distinguishing Informational Cascades from Herd Behavior in the Laboratory** (with Boğaçhan Çelen, Columbia B-School). *American Economic Review*, June 2004, 94(3), pp. 484-497.

This paper reports an experimental test of how individuals learn from the behavior of others. By using techniques only available in the laboratory, we elicit subjects' beliefs. This allows us to distinguish informational cascades (convergence of beliefs) from herd behavior (convergence of actions). By adding a setup with continuous signal and discrete action, we enrich the ball-

and-urn observational learning experiments paradigm of Anderson and Holt (1997). We test a model that explains subjects' behavior as a form of generalized Bayesian behavior that incorporates limits on the rationality of others. We find strong evidence that, in Bayesian terms, subjects put too much weight on their own information and too little weight on the public information. Put differently, subjects are overconfident in the precision of their private information. To put the observed behavior into perspective, we use a simple modification of the Bayesian model, which provides a framework that enables us to understand individual behavior in the laboratory.

- **An Experimental Test of Observational Learning under Imperfect Information**, (with Boğaçhan Çelen, Columbia B-School). *Economic Theory*, October 2005, 26(3), pp. 677-699.

To explore the difference between social learning under perfect and imperfect information, this paper takes an experimental look at a situation in which individuals learn by observing the behavior of their immediate predecessors. Our experimental design is based on the theory of Çelen and Kariv (Observational Learning under Imperfect Information) and uses the procedures of Çelen and Kariv (Distinguishing Informational Cascades from herd Behavior in the Laboratory) with the exception that the history of actions observed by subjects is different. We find is that imitation is much less frequent when subjects have imperfect information, even less frequent than the theory predicts. Further, while we find strong evidence that under perfect information a form of generalized Bayesian behavior adequately explains behavior in the laboratory, under imperfect information behavior is not even consistent with this generalization of Bayesian behavior. To reconcile this with the conclusions under perfect information, we undertake a modification of the model that abandons the assumption of common knowledge of rationality.

- **Behavioral Aspects of Learning in Social Networks: An Experimental Study** (with Syngjoo Choi, UCL, and Douglas Gale, NYU). *Advances in Applied Microeconomics*, Volume 13, Behavioral and Experimental Economics, 2005, edited by John Morgan.

Networks are natural tools for understanding social and economic phenomena. For example, all markets are characterized by agents connected by complex, multilateral information networks, and the network structure influences economic outcomes. In an earlier study, we undertook an experimental investigation of learning in various three-person networks, each of which gives rise to its own learning patterns. In the laboratory, learning in networks is challenging and the difficulty of solving the decision problem is sometimes massive even in the case of three persons. We found that the theory can account surprisingly well for the behavior observed in the laboratory. The aim of the present paper is to investigate important and interesting questions about individual and group behavior, including comparisons across networks and information treatments. We find that in order to explain subjects' behavior, it is necessary to take into account the details of the network architecture as well as the information structure. We also identify some black spots where the theory does least well in interpreting the data.

- **Financial Networks** (with Douglas Gale, NYU). *American Economic Review*, Papers & Proceedings, May 2007, 97(2), pp. 99-103.

Apart from centralized exchanges such as the NYSE, most financial transactions take place in networks where one or more intermediaries link the initial seller and final buyer. This paper presents a model of financial networks, in which financial exchange is intermediated by traders who form a chain of links between the initial owner of the assets and ultimate owner of the assets. Networks are incomplete in the sense that each trader can only exchange assets with a limited number of other traders. The greater the incompleteness of the network, the more intermediation is required to transfer the assets between initial and final owners. Intermediation takes time and time is costly, so incompleteness constitutes a potentially important market imperfection. The cost and uncertainty of trade in networks may give rise to other problems and, in extreme cases, lead to a market breakdown. The results are applicable not just to financial networks but to any model of exchange which shares the same basic network structure.

- **Revealing Preferences Graphically: An Old Method Gets a New Tool Kit** (with Syngjoo Choi, UCL, Ray Fisman, Columbia B-School, and Douglas Gale, NYU). *American Economic Review*, Papers & Proceedings, May 2007, 97(2), pp. 153-158.

This paper describes the necessary tools, both methodological and analytical, for providing a comprehensive individual-level analysis of decision-making under risk. Two distinctive features of the paper are the new experimental technique, and the application of the tools of the theory of consumer demand to individual decision-making in the laboratory. To characterize an individual's decision-making under risk, it is necessary to generate many observations per subject over a wide range of choice sets. An innovative graphical interface was developed for this purpose, where subjects see on a computer screen a geometrical representation of a portfolio choice problem. Subjects choose portfolios through a simple point-and-click. This intuitive and user-friendly interface allows for the quick and efficient elicitation of many decisions per subject under a wide range of choice scenarios. The experimental platform and analytical techniques that have been developed can also be applied to many types of individual choice problems.

- **Individual Preferences for Giving** (with Ray Fisman, Columbia B-School, and Daniel Markovits, Yale Law School). *American Economic Review*, December 2007, 97(5), pp. 1858-1876. (Previously distributed in three different papers titled Individual Preferences for Giving, and Distinguishing Social Preferences from Preferences for Altruism and Pareto Damaging Behaviors.)

We utilize graphical representations of Dictator Games which generate rich individual-level data. Our baseline experiment employs budget sets over feasible payoff-pairs. We test these data for consistency with utility maximization, and we recover the underlying preferences for giving (tradeoffs between own payoffs and the payoffs of others). Two further experiments augment the analysis. An extensive elaboration employs three-person budget sets to distinguish preferences for giving from social preferences (tradeoffs between the payoffs of others). And an intensive elaboration employs step-shaped sets to distinguish between behaviors that are compatible with well-

behaved preferences and those that are compatible only with not well-behaved cases.

- **Consistency and Heterogeneity of Individual Behavior under Uncertainty** (with Syngjoo Choi, UCL, Douglas Gale, NYU, and Ray Fisman, Columbia B-School). *American Economic Review*, December 2007, 97(5), pp. 1921-1938. (Some of the results reported here are also distributed in *Substantive and Procedural Rationality in Decisions under Uncertainty*.)

By using graphical representations of simple portfolio choice problems, we generate a very rich data set to study behavior under uncertainty at the level of the individual subject. We test the data for consistency with the maximization hypothesis, and we estimate preferences using a two-parameter utility function based on Faruk Gul (1991). This specification provides a good interpretation of the data at the individual level and can account for the highly heterogeneous behaviors observed in the laboratory. The parameter estimates jointly describe attitudes toward risk and allow us to characterize the distribution of risk preferences in the population.

- **Sequential Equilibrium in Monotone Games: Theory-Based Analysis of Experimental Data** (with Syngjoo Choi, UCL, and Douglas Gale, NYU). Version: February 28, 2008. Forthcoming, *Journal of Economic Theory*.

A monotone game is an extensive-form game with complete information, simultaneous moves and an irreversibility structure on strategies. It captures a variety of situations in which players make partial commitments and allows us to characterize conditions under which equilibria result in socially desirable outcomes. However, since the game has many equilibrium outcomes, the theory lacks predictive power. To produce stronger predictions, one can restrict attention to the set of sequential equilibria, or Markov equilibria, or symmetric equilibria, or pure-strategy equilibria. This paper explores the relationship between equilibrium behavior in a class of monotone games, namely voluntary contribution games, and the behavior of human subjects in an experimental setting. Several key features of the symmetric Markov perfect equilibrium (SMPE) are consistent with the data. To judge how well the SMPE fits the data, we estimate a model of Quantal Response Equilibrium (QRE) (McKelvey and Palfrey 1995, 1998) and find that the decision rules of the QRE model are qualitatively very similar to the empirical choice probabilities.

Working Papers

- **Substantive and Procedural Rationality in Decisions under Uncertainty** (with Syngjoo Choi, UCL, Douglas Gale, NYU, and Ray Fisman, Columbia B-School). Version: March 31, 2006 [under revision].

We report a laboratory experiment that enables us to study systematically the substantive and procedural rationality of decision making under uncertainty. By using novel graphical representations of budget sets over bundles of state-contingent commodities, we generate a very rich data set well-suited to studying behavior at the level of the individual subject. We test the data for consistency with the maximization hypothesis, and we recover underlying preferences using

both nonparametric and parametric methods. We find considerable heterogeneity in individual behaviors across subjects. In spite of this heterogeneity, we identify prototypical heuristics that inform subjects' decision rules. To account for these heuristics, we propose a type-mixture model based on Expected Utility Theory employing only combinations of three heuristics which correspond to the behavior of individuals who are infinitely risk averse, risk neutral, and expected utility maximizers with intermediate risk aversion. This links the procedural rationality that is evident in the data to substantive rationality, and supports the use of Expected Utility Theory for both normative and descriptive purposes.

- **An Experimental Test of Advice and Social Learning** (with Boğaçhan Çelen, Columbia B-School, and Andrew Schotter, NYU). Version: November 15, 2007.

Social learning is the process of individuals learning by observing the actions of others. In the real world, however, although people learn by observing the actions of others, they also learn from advice. This paper introduces advice giving into a standard social-learning problem. The experiment is designed so that both pieces of information - actions and advice - are equally informative (in fact, identical) in equilibrium. Despite the informational equivalence of advice and actions, in the laboratory, subjects are more willing to follow the advice given to them by their predecessors than to copy their actions. In addition, when advice is given subject behavior is more consistent with the prediction of the theory. Consequently, advice is both more informative and welfare improving.

- **Trading in Networks: A Normal Form Game Experiment** (with Douglas Gale, NYU). Version: April 17, 2007.

This paper reports an experimental study of trading networks, in which exchange is intermediated by traders who form a chain of links between the initial owner of the assets and ultimate owner of the assets. Traders choose bid and ask prices and trades are executed by the computer once subjects have submitted their strategies. Networks are incomplete in the sense that each trader can only exchange assets with a limited number of other traders. The greater the incompleteness of the network, the more intermediation is required to transfer the assets between initial and final owners. The uncertainty of trade in networks constitutes a potentially important market imperfection. As a result, the inferences subjects must draw in order to make optimal decisions are quite subtle. Nevertheless, we find that the competitive prices can account for the pricing behavior observed in the laboratory in variety of networks and trading protocols. Furthermore, significant differences can be identified in the pricing behavior of subjects in different networks, and different trading protocols lead to different dynamics.

- **Estimating Ambiguity Aversion in a Portfolio Choice Experiment** (with David Ahn, Berkeley, Syngjoo Choi, UCL, and Douglas Gale, NYU). Version: December 17, 2007.

We report a laboratory experiment that enables us to estimate four prominent models of ambiguity aversion -- Subjective Expected Utility (SEU), Maxmin Expected Utility (MEU), Recursive Expected Utility (REU), and α -Maxmin Expected Utility (α -MEU) -- at the level of the individual subject. We employ

graphical representations of three-dimensional budget sets over bundles of Arrow securities, one of which promises a unit payoff with a known probability and two with unknown (ambiguous) probabilities. The sample exhibits considerable heterogeneity in preferences, as captured through parameter estimates. Nonetheless, there exists a strong tendency to equate the demands for the securities that pay off in the ambiguous states. This feature is more easily accommodated by the α -MEU model than by the REU model.

- **Social Learning in Networks: A Quantal Response Equilibrium Analysis of Experimental Data** (with Syngjoo Choi, UCL, and Douglas Gale, NYU). Version: May 14, 2008.

Social learning describes any situation in which economic agents learn by observing the behavior of others. Social learning in networks applies this idea to situations in which agents observe the other agents to whom they are connected in a social network. Whether agents can rationally process the information available in a network is ultimately an empirical question. This paper reports an experimental investigation of learning in networks and uses the theoretical framework of Gale and Kariv (2003) to interpret the data generated by the experiments. We find that the theory can account for the behavior observed in the laboratory in variety of networks and informational settings. To explicitly allow for the possibility of errors in our theoretical model, we adapt the model of Quantal Response Equilibrium (QRE) of McKelvey and Palfrey (1995, 1998) and find that its restrictions are confirmed.

- **Network Architecture, Salience and Coordination** (with Syngjoo Choi, UCL, Douglas Gale, NYU, and Thomas Palfrey, Caltech. Version: June 18, 2008.

This paper reports the results of an experimental investigation of monotone games with imperfect information. Players are located at the nodes of a network and observe the actions of other players only if they are connected by the network. These games have many sequential equilibria; nonetheless, the behavior of subjects in the laboratory is predictable. The network architecture makes some strategies salient and this in turn makes the subjects' behavior predictable and facilitates coordination on efficient outcomes. In some cases, modal behavior corresponds to equilibrium strategies.

- **Overconfidence and Informational Cascades**. Version: March 21, 2005 [under revision].

This paper combines behavioral economics and social learning. Overconfident agents overweigh their private information relative to the public information revealed by the decisions of others. Therefore, when following a herd, they broadcast more of the information available to them. However, overconfidence trades the additional information revealed by overconfident decisions against more information that is being suppressed by rational decisions. This paper shows that the presence of overconfident agents intensifies the free-rider problem of rational agents, since, even if overconfident agents have very limited information, by making it public, they trigger an uninformative everlasting cascade stage, that otherwise need not start. With the help of numerical simulations, this paper shows that having overconfident agents cannot break the poor information flow intrinsic to erroneous uniform behavior.