à la Harsanyi and Selten (1988), and for rationalizing focal points *à la* Kramarz (1996) or Janssen (2001b). Yet, even the addition of several compelling principles need not result in a unique solution for every game. For instance, in the Battle of the Sexes game, the equilibrium in mixed strategies is ruled out by payoff dominance, and there is no obvious way to select between the two equilibria in pure strategies. It seems that there always remains some residual indeterminacy – unless it is stipulated by law how to play certain games. Thus, the ambitious goal of orthodox game theory, broadly defined, to identify a unique solution for each game, has been almost, but not completely, reached.

But do players play as they should? As the author of the target article observes, it takes a further bridging hypothesis of weak rationality – that people try to act rationally – to turn the normative theory into a positive one. Then, as a rule, the recommendations of normative theory are treated as predictions. On a more fundamental level, the common knowledge and rationality (CKR) assumptions may be tested. Although I agree that the literature on experimental gaming testifies to the fruitfulness of empirical research, I would add that empirical research in industrial organization tends to rely on natural rather than laboratory experiments. This is worth noting, because economics, and in particular industrial economics, has been the main area of applied game theory and has immensely contributed to the development and proliferation of game-theoretical modeling.

Obviously, one would not necessarily observe the predicted outcome, if the participants played a game that was different from the one specified by the analyst or experimentalist. This would be the case if the monetary payoffs, or hypothetical payoffs according to the instructions, did not represent the subjects' preferences. Such instances are altruism or fairness considerations not accounted for in the original payoff functions. In such a case, the "neoclassical repair kit" can be applied, to use a popular, albeit somewhat derogatory, term: After a payoff transformation or, more generally, substitution of suitable utility functions for the original payoff functions, the data no longer reject the model. Thus, although the original model proved numerically mis-specified, the theory at large has not been rejected.

Yet, there are plenty of instances where the specified payoffs do represent player preferences, and orthodox and not-so-orthodox game theory is rejected in laboratory experiments. The first response to discrepancies between theory and evidence would be to perform further experiments, to corroborate or reevaluate the earlier evidence. After all, the immediate response to reports of cold fusion was additional experimentation, not a rush to revise theory. It appears that deliberate attempts at duplication are rare and poorly rewarded in experimental gaming. Still, certain systematic violations of individual rationality are abundant, like playing one's strictly dominated strategy in a one-shot PDG and the breakdown of backward induction in a variety of games.

In response to concerns rooted both in theory and evidence, game theory has become fairly heterodox. The recent developments suggest an inherent tension between the goals of explaining additional phenomena and of making more specific predictions (Haller 2000). Less stringent requirements on solutions can help explain hitherto unexplained phenomena. In the opposite direction, the traditional, or if you want, orthodox literature on equilibrium refinements and equilibrium selection has expended considerable effort to narrow the set of eligible equilibrium outcomes, to make more accurate predictions. Apart from the tradeoff mentioned, achieving a gain of explanatory power at the expense of predictive power, novel solution concepts may be compelling in some contexts and unconvincing under different but similar circumstances. One reason is that many experiments reveal a heterogeneous player population, with a substantial fraction evidently violating individual rationality, and another non-negligible fraction more or less conforming to orthodoxy. This raises interesting questions; for example, whether the type of a player is time-invariant or not.

Among the host of tentative and ad hoc suggestions falling under the rubric of psychological game theory, Stackelberg reasoning can explain specific payoff dominance puzzles, but yields detrimental outcomes when applied to other classes of Stackelberg solvable games. For instance, in a Cournot duopoly with zero costs and linear demand, the Stackelberg solution yields the perfectly competitive outcome, which is payoff-dominated by the Cournot-Nash outcome. Hence, the Stackelberg solution illustrates that the appeal of alternative solutions may be context-specific. Incidentally, a Stackelberg solution is a special case of a conjectural variation equilibrium. The latter concept can be traced back to Bowley (1924). It introduces a quasidynamic element into a static game. It has been utilized in models of imperfect competition and strategic trade from time to time, and has seen a revival recently. Despite its appeal, this modeling approach has been frequently dismissed on the grounds that it makes ad hoc assumptions and constitutes an unsatisfactory substitute for explicit dynamics.

Colman's article is thought-provoking and touches on several of the most pressing challenges for game theory, without pretending to be comprehensive or definitive. It will be fascinating to see which new theoretical concepts will emerge to address these challenges, and which ones will last.

What's a face worth: Noneconomic factors in game playing

Peter J. B. Hancock[a] and Lisa M. DeBruine[b]

[a]*Department of Psychology, University of Stirling, Stirling, FK9 4LA United Kingdom;* [b]*Department of Psychology, McMaster University, Hamilton, Ontario L8S 4K1, Canada.* **pjbh1@stir.ac.uk** **debruilm@mcmaster.ca**
http://www.stir.ac.uk/psychology/staff/pjbh1
http://homepage.mac.com/debruine/

Abstract: Where behavior defies economic analysis, one explanation is that individuals consider more than the immediate payoff. We present evidence that noneconomic factors influence behavior. Attractiveness influences offers in the Ultimatum and Dictator Games. Facial resemblance, a cue of relatedness, increases trusting in a two-node trust game. Only by considering the range of possible influences will game-playing behavior be explained.

Whenever a game is played between two people, there are many potential motives for particular forms of behavior. One player may wish to impress or defer to the other. One may feel vindictive towards or sorry for the other player. Such motivations and others, in various combinations, can add many layers of complexity to a game-theoretic analysis of the payoffs. Where people behave in an apparently irrational manner, it is possible that their perception of the payoff does not equate to the economic one because of these other factors. Players may also use cues to predict the behavior of playing partners. For example, images of smiling partners are trusted more than those who are not smiling (Scharlemann et al. 2001).

The Ultimatum Game is one where behavior defies a simple payoff analysis (e.g., Thaler 1988). One player (the proposer) can allocate some proportion of a sum of money to the second player (the responder), who may accept or refuse the offer. If the offer is refused, the money is returned and neither player gets anything. Usually the game is played single-shot, where the players do not know or even see each other. A payoff analysis suggests that any offer should be accepted, but in typical western societies anything less than about 35% is refused. This is usually explained as enforcement of "fair play" by the responder. In the related Dictator Game, the second player has no choice. Now, the first player is free to offer nothing, but in practice, usually does make some offer. It appears that something inhibits purely selfish behavior. The situation is more complicated when the players know something of each other, as the other kinds of factors mentioned above may affect decisions.

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Attractiveness is one of these factors. Apart from being desirable in its own right, the halo effect causes many assessments of another, such as their intelligence and character, to be estimated more highly. Thus, Solnick and Schweitzer (1999) found that more was expected of attractive faces. Joergensen and Hancock (2001) reported an Ultimatum Game where proposers saw a picture of the responder. Offers were higher to faces rated as attractive, echoing results from Solnick and Schweitzer (1999), but with a stronger effect for attractive women. The correlation between rated attractiveness and offer level was 0.83. However, the effect of attractiveness was transient, it disappeared in a second round of the game following information about who had refused low offers. Hancock and Ross (2002) investigated the Dictator Game with similar results: The correlation between offer levels within the game and independently rated attractiveness was 0.91.

These experiments use anonymous faces, but what effect might the perception that someone is related to you have? Hamilton's theory of kin selection (Hamilton 1964) suggests that people should be favorably disposed toward relatives. Any gene promoting altruistic behavior can influence its own success by benefiting those most likely to share a copy of itself. Thus, a gene causing altruism will be favored if the benefit (b) to the recipient multiplied by the relatedness[1] (r) between the altruist and recipient is greater than the cost (c) to the altruist.

Given this logic, cues of relatedness between individuals may change the payoffs attributed to different behaviors. DeBruine (2002) explored behavior in a two-person, two-node sequential trust game (after Eckel & Wilson 1998b, and related to the Centipede game described by Colman). The first player can decide either not to trust the second, in which case both get a sure payoff of $3, or to trust the second player with the decision. The second player can decide between selfish behavior, keeping $5 and giving $2 to player one, or unselfish behavior, allocating $4 to each. Given no information about the second player, the first player's expected payoff is $3 for either choice, so a rational player should be indifferent. However, if the other player is a relative with relatedness of 0.5,[2] then the structure of the game is changed to a choice between a sure payoff of $4.50 ($3 to self plus 0.5 times $3 to the other) and a risky payoff with an expected value of $5.25 ($3 to self plus 0.5 times $4.50 to the other). In addition, assessment of the second player's trustworthiness may bias the expected payoff of trusting.

DeBruine (2002) digitally morphed images of the other player to manipulate one possible cue of relatedness, facial resemblance. Players in this trust game chose the riskier option more often when the image of the opponent had been morphed to resemble the first player than when the image had been morphed to resemble an unknown person. This is consistent with an increase in either the expected payoff of trusting or the expected probability of trustworthy behavior. Analysis of the responses indicated that independently rated attractiveness of the second player did not influence behavior in this situation, although current research by DeBruine indicates that resemblance to self increases the attractiveness of faces (also see Penton-Voak et al. 1999).

In an unpublished study, DeBruine randomized the computer-generated second players' responses in the trust game. Players were less likely to trust opponents in games immediately after they had been cheated than in games after the opponent was unselfish. This echoes findings by Eckel and Wilson (1998a) that the previous opponent's response influences the current choice, even when the current opponent is a different person. Within the sets of games played after either a selfish or unselfish response, players were still more likely to trust faces morphed to resemble themselves.

In any social situation, people evaluate others. We have shown that even a static photograph of another player can cause significant differences to behavior in simple games. A playing partner's attractiveness may introduce noneconomic motivations to the game or change the player's predictions of the partner's behavior. The perception that someone may be related to you introduces further complications, because of the shift of possible inclusive fitness payoffs. The inclusion of such factors will broaden the scope of a psychological game theory.

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NOTES

1. Relatedness refers not to the total proportion of genes shared, but to those shared by identical descent. In this case, r is the probability that the recipient shares a gene for altruism with the altruist.

2. The conclusion holds for any $r > 0$ with this particular game payoff structure.

Rational belief and social interaction

Daniel M. Hausman

Department of Philosophy, University of Wisconsin-Madison, Madison, WI 53706-1474. **dhausman@wisc.edu**
http://philosophy.wisc.edu/hausman

Abstract: Game theory poses problems for modeling rational belief, but it does not need a new theory of rationality. Experimental results that suggest otherwise often reveal difficulties in testing game theory, rather than mistakes or paradoxes. Even though the puzzles Colman discusses show no inadequacy in the standard theory of rationality, they show that improved models of belief are needed.

The theory of rational choice takes choice to be rational when it tracks preferences. Preferences are rational when they are, in a precise sense, consistent. When there is risk or uncertainty, preferences and hence choices depend on beliefs; and neither preference nor choice is rational unless belief is rational. Rational beliefs must conform to the calculus of probabilities. When they do, and preferences satisfy relevant consistency and technical axioms, then preferences can be represented by expected utilities, and choice is rational if and only if it maximizes expected utility.

Expected utility maximization is defined whenever rational beliefs and preferences are defined. The fact that an interaction is strategic by itself causes no problem. If I am playing the pure coordination game in Colman's Figure 1 and believe that the other player will play Tails, then I should choose Tails, too.

But suppose I have no beliefs about what strategies other players will choose other than those that I can deduce from (1) beliefs about the other players' preferences over the payoffs, (2) beliefs about the other players' beliefs concerning both the game and its players, and (3) beliefs about the other players' rationality. All of these beliefs of mine have to be rational – that is, they have to be consistent with the calculus of probabilities – but this constraint permits many different sets of beliefs to count as rational. One way of developing game theory that greatly narrows the set of rational beliefs has been to assume that the players are all perfectly rational, that they all share the same subjective prior probabilities, that they have complete knowledge of the extensive form of the game, and that all of this is common knowledge. Call this "the total rationality representation" (TRR). TRR is not required by the standard theory of rational belief, and the fact that it leads to surprising and sometimes arguably paradoxical results is no indictment of the standard theory.

Colman also objects that game theory employing TRR may be uninformative. In the Hi-Lo Matching game of Figure 2, the theory fails to predict and recommend that players choose strategy H. As Colman correctly points out, if TRR requires common prior point probabilities, then no argument can be given for the rationality of playing H. But the remedy here is just a mild relaxation of the idealizations. If one does not require that the players have point priors, then Player I can believe that the probability that Player II will play H is not less than one-half, and also believe that

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