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Reciprocal Preference Model for Two Player Dilemma Games

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Abstract

Results from behavioral economics show that individuals do not always maximize monetary payoffs. Within behavioral economics different models of *social preference* have been put forth to account for this deviation from standard assumptions of game theory and economics. Incorporating such models into agent decision making is increasingly relevant to design systems which interact with or on behalf of humans. Existing models, which correctly predict outcomes across a large set of games, are fairly complex. To this end, we present *aspiration* based social preference model and evaluate it by considering two player dilemma games. We show that the qualitative predictions of our model are consistent with results from behavioral economics.

Introduction

Game theory provides a rich platform for developing agent decision making models. But it assumes that individuals are self-interested and are concerned by their own payoffs. This assumption, although, explains behavior quite well in competitive settings like markets, it falls short of correctly predicting outcomes in social dilemma games. Examples include prisoner's dilemma, ultimatum game, dictator games etc (we consider these three games since most other dilemma games can be reduced to one of these). This has led to the development of social preference models (Camerer, Loewenstein, and Rabin 2004) which attempt to account for this anomaly between experimental results and theoretical predictions. These models start with the assumption that individuals are concerned by not only their own material payoffs but also the payoffs received by their opponents. Existing models that incorporate such *other-regarding* behavior can largely be categorized into altruistic preference models and reciprocal preference models.

Models of altruistic preferences (Andreoni and Miller 2002) assume individuals, unconditionally, care for the well-being of their opponents. Although this explains behavior in dictator games, it cannot explain the behavior in prisoner's dilemma and ultimatum games. Reciprocal preference models posit that individuals are kind to those who treat them kindly and are unkind towards those who treat them unkindly. Based on how kind and unkind behavior is formalized existing reciprocity models fall into three broad classes.

First are the distributive models (Fehr and Schmidt 1999; Bolton and Ockenfels 2000) where the relative well-being influences players actions. Players are assumed to only care for equity in payoffs in the final outcome. Second, an alternative to this consequentialist approach, is intention based reciprocity (Rabin 1993), where individuals take into account the intentions signaled by opponents' actions. Although intuitively more appealing, these models are relatively more complex since the notion of intentions needs to to be formalized. A third approach is type based reciprocity (Levine 1998). Individuals have belief about opponents' types and respond kindly or unkindly based on whether the opponent is nice or otherwise. However, existing models of reciprocity either fail to account for behavior in all three games mentioned earlier or are fairly complex which makes it difficult to incorporate them into multi-agent systems.

In this paper, we present an *aspiration-based reciprocal preference* model. We show that it is consistent with experimental results and tractable enough to be extended to multi-agent systems. Our model is built on the hypothesis that individuals sacrifice positive amounts to accommodate others' well-being. Thus, instead of maximizing their own payoffs they define a threshold payoff, called *aspiration* value, which is treated as satisfactory. The aspiration value serves as a reference payoff against which players evaluate whether opponents are kind or unkind and respond accordingly.

Incorporating such models into agent decision making is increasingly relevant to building systems which interact with or on behalf of humans. Examples include automated negotiations, auctions, resource allocation and sharing, etc. These environments are characterized by not just agent-agent interaction but also human-agent interaction. In such settings selfish maximization of material payoffs will lead to outcomes which fall short of human expectations (de Jong, Tuyls, and Verbeeck 2008).

The rest of the paper is organized as follows. First, we present existing reciprocity models within behavioral economics. We then present our model and evaluate the qualitative predictions of our model by considering prisoner's dilemma, ultimatum and dictator games. We then discuss the advantages and shortcomings of our model and then conclude.

Related Work

In this section, we review existing reciprocity models and comment on how social preference theory compares with alternative approaches that attempt to account for this anomalous behavior.

In distributive models or inequity aversion models (Fehr and Schmidt 1999; Bolton and Ockenfels 2000) agents are motivated by equity concerns. Agents minimize the payoff difference between self and others. The adjusted utility function for player i is given by

$$U_i(\pi_i,\pi_j) = \pi_i - \frac{\alpha_i}{(n-1)}\sum_{j\neq i} max\{\pi_j - \pi_i, 0\}$$

$$-\frac{\beta_i}{(n-1)}\sum_{j\neq i} max\{\pi_i - \pi_j, 0\}$$

where $\pi_i,\ \pi_j$ are the material payoffs for player $i,\ j$ respectively, $0 < \beta_i \leq \alpha_i$ and $0 \leq \alpha_i < 1$ and n is the number of players. The parameters $\beta_i,\ \alpha_i$ are a measure of negative utility experienced by player i due to inequity in payoffs. Since $\beta_i \leq \alpha_i$ player i experiences more negative utility when its payoff is less than player j. Equitable payoffs are a reference point against which players measure fairness. Inequity aversion models correctly predict the qualitative outcomes in prisoner's dilemma and dictator game. But these models fail to account for behavior in mini-ultimatum games, since they ignore that fairness of an outcome depends not only on payoff distribution but also on the alternatives available to each player. Falk, Fehr, and Fischbacher (2003) show that, across four different mini-ultimatum games, the same offer is rejected at different rates depending on the alternatives available to the proposer.

Intention based reciprocity models (Rabin 1993), are based on the assumption that agents reward kind intentions with kindness and punish unkind intentions. Rabin accounted for intentions by incorporating second order beliefs over actions into fairness function. Denote a_i as the action taken by player i, b_j is its belief about the action taken by player j and c_i be player i's belief about player j's belief about the action taken by player i. The adjusted utility for player i, when its material payoff is $\pi_i(a_i, b_j)$, is given by

$$U_i(a_i, b_j, c_i) = \pi_i(a_i, b_j) + f_j(b_j, c_i)(1 + f_i(a_i, b_j))$$

where $f_i(a_i, b_j), f_j(b_j, c_i) \in [-1, 1/2]$. $f_j(b_j, c_i)$ is player i's belief about how kind player j is in taking action b_j when its belief about i's action is c_i. It is positive if the payoff received by player i is greater than the average of maximum and minimum possible payoffs in Pareto-efficient outcomes in action c_i. $f_i(a_i, b_j)$ is player i's belief about its own fairness to j. It is positive if the payoff received by j is greater than the average of maximum and minimum possible payoffs in Pareto-efficient outcomes in action b_j. Thus player i maximizes its experienced utility if it reciprocates player j's kind or unkind behavior. The model requires players to sacrifice non-zero amount if there is any kindness to be associated with their action. It fails to account for behavior in dictator games. Rabin's model is specific for simultaneous move games. Dufwenberg and Kirchsteiger (2004) extend the above model to sequential games.

Levine (1998) proposes a relatively simpler model for reciprocity by defining *altruism coefficient*, $-1 < a_i < 1$. Altruism coefficient defines players' type. Player's willingness to reward or propensity to punish depends on its own altruism coefficient and its belief about opponents altruism coefficient. If a_j is i's belief about player j's altruism coefficient and $\pi_i,\ \pi_j$ are the material payoffs for $i,\ j$ respectively, the adjusted utility for player i is given by,

$$U_i(\pi_i) = \pi_i + \sum_{j\neq i} \frac{a_i + \lambda a_j}{1+\lambda}\pi_j$$

where $\lambda \in [0, 1]$ is reciprocity coefficient. $\lambda = 0$ implies pure altruism. A positive value implies players are more altruistic towards those who are more altruistic towards them. The model explains data in ultimatum games but fails to account for dictator games.

More recent models of reciprocity, Falk and Fischbacher (2006), Charness and Rabin (2002), incorporate both intentions and distributive concerns into a unified model but at the cost of simplicity. The number of parameters involved makes it difficult for these models to be extended to multiagent setting. Our goal here is to develop a reciprocity model which is tractable, and "which can be estimated from available data" (Cox, Friedman, and Gjerstad 2007).

It should be noted that, the reciprocity in social preference theory differs from 'reciprocal altruism' in evolutionary game theory where individuals reciprocate, positively or negatively, for gaining future rewards (Fehr and Fischbacher 2002). In reciprocal preference models, future rewards or losses are a consequence and not the motivation to reciprocate.

One alternative to social preference theory that attempts to account for this anomalous behavior is bounded rationality theory (Simon 1957), but, as noted by Camerer and Thaler (1995), the simplicity in dictator games and ultimatum games rules out bounded rationality. A second alternative is adaptive learning approach (Roth and Erev 1995), but these approaches cannot explain the experimental results where individuals reciprocate negatively to unfair offers in ultimatum games (Camerer and Thaler 1995).

Model

We present our model for $2-$player games. Agents have fixed coefficient of altruism, $\gamma \in [0, 1]$, which defines their type, because of which they lower their *aspiration* value to accommodate others welfare. Aspiration value, denoted by m_i, defines the material payoff the agent considers as satisfactory. This lowering of aspiration value is proportional to γ. A higher γ leads to lower aspiration value, implying the player is willing to sacrifice more for the opponent.

Consider players i, j. Let γ_i be the altruism coefficient of player i. Let S_i be the set of aspiration values player i can have. For simplicity we set S_i equal to pure strategy payoffs player i gets in Pareto-efficient outcomes. Player i

calculates its aspiration as function of altruism coefficient as follows:

$$m_i = \underset{m \in S_i}{\arg\max}\,[\gamma_i.\pi_j^{max}(o_s) + (1-\gamma_i).\pi_i(o_s)]$$

where $\pi_j^{max}(o_s)$ is maximum payoff of player j across all (pure strategy) outcomes $o_s \in O$ such that $\pi_i(o_s) \geq m$. If γ_i is non-zero it implies player i sets its aspiration value less than the maximum possible payoff to accommodate player j's well-being.

If $\pi_i(o_s), \pi_j(o_s)$ are the material payoffs of player i, j, respectively, in outcome o_s, the adjusted utility received by player i is :

$$U_i(o_s) = \begin{cases} \pi_i + M\pi_j & \text{if } \pi_i(o_s) \geq m_i \\ \pi_i - k\pi_j & \text{if } \pi_i(o_s) < m_i \end{cases}$$

where M is a large positive constant $M >> 0$ and $k \in [0, 1)$ is the players *envy*. The aspiration value serves as a reference payoff for players. If the payoff it receives is greater than aspiration value, it interprets opponents behavior as being kind and reciprocates with kindness. If the payoff is less than the aspiration value, it considers the other player as being unfair and responds enviously (Kirchteiger 1994). For $k = 0$ players are self-interested and as k increases the strategy converges to minimax strategy, where each player is playing to minimize opponents payoff. Restricting $k < 1$ implies players are envious but each cares for its own payoff. Players maximize the adjusted utility and the Nash equilibrium, of the adjusted utility matrix, constitutes a reciprocal equilibrium. The following example illustrates the discussion, Consider the Battle of Sexes(BoS) game shown in Table-1.

	B	O
B	$(2, 1)$	$(0, 0)$
O	$(0, 0)$	$(1, 2)$

Table 1: Battle of Sexes

Husband is along the row and prefers going to boxing (B) to opera(O) and wife, along column, prefers vice-versa but each would prefer being with the other than being alone. The Nash equilibrium outcomes are $\{(B, B), (O, O)\}$.

For the above game, the Pareto-efficient outcome payoffs for both player $i,\ j$ are $\{1, 2\}$ and hence the aspiration value set is $S_i \equiv S_j = \{1, 2\}$. Each player sets the aspiration as follows:

$$m_i = \arg\max\,[\gamma_i.(1) + (1-\gamma_i).(2), \gamma_i.(2) + (1-\gamma_i).(1)]$$

Thus, if $\gamma_i < 1/2$, i sets its aspiration value to 2. If j sets its aspiration value to 2, the *psychological game* matrix is given in Table-2. If both players are envious enough, $k > 1/2$, the Nash equilibrium of the psychological game is (B, O). It highlights the stylized fact that unless husband (or wife) attaches higher weight to wife's (or husband's) payoff than himself (or herself) ($\gamma_i \geq 1/2$), in Nash equilibrium, each will walk away feeling envious towards other. It should be noted that player i will feel envious towards an opponent with aspiration value 2 only when its own aspiration value is 2. Since we have assumed the belief over aspiration values are consistent, when player i sets its aspiration value to 2, j's aspiration value of 2 will appear to i as an 'unyielding' demand on part of player j. Player i attaches a positive weight to the same opponent when its own aspiration value is 1.

	B	O
B	$(2 + M, 1 - 2k)$	$(0, 0)$
O	$(0, 0)$	$(1 - 2k, 2 + M)$

Table 2: Psychological game matrix for BoS with γ_i and $\gamma_j < 1/2$

We now consider three standard games from behavioral economics and study the qualitative predictions of our model.

Prisoner's dilemma

Consider the 2×2 game shown in Table-3. For prisoner's dilemma $c > a > d > b$. Both players can either choose to cooperate(C) or defect(D). If both cooperate they receive Pareto dominant payoff, (a, a). But irrespective of whether opponent cooperates or defects, each has an incentive to defect (D) and receive a higher payoff than by cooperating. Thus playing D, to defect, is the dominant strategy and results in Pareto dominated outcome. Standard assumption of self-interested behavior would imply no cooperation. Experimental results on the other hand have revealed that individuals cooperate, even in single shot games. Following stylized facts summarize the experimental results for prisoner's dilemma game.

- With other payoffs fixed, cooperation decreases as incentive to defect, c, increases (Rapoport and Chammah 1965; Lave 1965).
- Cooperation increases with increase in cooperative outcome payoff, a (kyeong Ahn et al. 2001).
- Players cooperate more often in sequential prisoner's dilemma than in simultaneous dilemma (Clark and Sefton 2001).

For the above game $S_i \equiv S_j = \{a, b, c\}$. Note that, for any $k \geq 0$ both players will defect if either sets its aspiration value to c. If players are sufficiently altruistic, the psychological game matrix has two Nash equilibrium $\{(C, C), (D, D)\}$ and cooperative outcome dominates the defect outcome. As coefficient of altruism decreases, the Nash equilibrium outcome is for players to defect. The following observation gives the relationship between the altruism coefficient and the payoffs.

- *Observation-1a:* For $2a > b + c$, players i, j cooperate iff both γ_i and $\gamma_j \geq \frac{(c-a)}{(c-b)}$

The above results can be interpreted by considering a population of reciprocal agents with uniform distribution of γ. Since we are only highlighting the qualitative prediction,

	C	D
C	(a, a)	(b, c)
D	(c, b)	(d, d)

Table 3: Prisoner's Dilemma

this initial distribution is not so relevant as long as the distribution is not skewed $i.e.$ probability of a random agent with $q \leq \gamma \leq q + \epsilon$ is non-zero for $q \in [0, 1)$. For uniform distribution of γ, the probability that two randomly selected agent will cooperate is $(1 - \frac{c-a}{c-b})^2$. For a fixed $\{a, b, d\}$, as the incentive to defect increases, the probability that two randomly selected agents will cooperate decreases. As c increases, players have to be more altruistic towards each other to continue cooperating. Additionally, if a increases, γ_i decreases. Thus, the probability that two randomly selected agents cooperate, increases.

This result can be extended to traveler's dilemma which has similar a payoff-matrix structure. Traveler's dilemma involves two players claiming an amount m for lost luggage. If both claim the same amount they receive m. If one player quotes $m' < m$ then, the player claiming smaller amount is 'rewarded' an amount p and receives a payoff $m' + p$ and the other player is charged p, and receives a payoff $m - p$. As the amount p increases the outcomes converge to Nash equilibrium (Capra et al. 1999) . Our model predicts the same pattern.

In sequential prisoner's dilemma, player i plays cooperate or defect, and player j in full knowledge of player i's action can choose to cooperate or defect. The Nash equilibrium again is for both players to defect. (One important assumption we make for sequential games is that, player j defines its aspiration value w.r.t outcomes across both sub-games, or it has the aspiration value in both the sub-games.) We can now make following observation

- *Observation-1b:* For $2a > b + c$ players i, j cooperate iff
  - γ_i and $\gamma_j \geq \frac{(c-a)}{(c-b)}$ or
  - $\gamma_i < \frac{(c-a)}{(c-b)}$ and $\frac{(a-b)}{(c-b)} \geq \gamma_j \geq \frac{(c-a)}{(c-b)}$

Sequential prisoner's dilemma increases cooperation relative to simultaneous prisoner's dilemma since players cooperate even when player i sets its aspiration value to c and j sets its aspiration value to a. Since $k < 1$, irrespective of its own aspiration value, it is dominant strategy for player i to cooperate as long as player j sets its aspiration value to a. Thus our model is consistent with all three stylized facts we presented earlier. (The payoff structure of sequential prisoner's dilemma and gift-exchange game is similar, the results here thus extend to gift exchange game).

Dictator game

For dictator games and ultimatum games our model gives skewed results since we have assumed linearity in payoffs. Instead we now assume a concave function over material payoffs. Let $v_i(\pi_i)$ be the concave function for material payoff π_i, the aspiration value function is given by,

$$m_i = \arg\max_{m \in S_i} [\gamma_i.v_j(\pi_j^{max}(o_s)) + (1 - \gamma_i).v_i(\pi_i(o_s))]$$

For simplicity, we assume both players have the same value function $v_i = v_j = v$

Dictator games model charity giving. The game involves a dictator, i, donate an amount $s \in [0, 1]$ to player j. Nash equilibrium strategy is for player i to offer 0 amount. In contrast, experimental results show individuals make non-trivial offers. On an average individuals donate 20% of their endowment. Further, it has been shown that the amount donated depends on the information available to dictator about the recipient. Eckel and Grossman (1996) report an increase of 20% in the amount donated when an anonymous receiver is substituted with American Red Cross. Among 48 subjects, about 10% subjects donate all their amount compared to none when the receiver is anonymous. Even with anonymity in games, donations increase when the "deservingness" of recipient increases (Braas-Garza 2006). Braas-Garza reports 46% of subjects donate all their amount when they are informed that recipients are 'poor'. This increases further to 76% when they are informed that the amount will be used to buy medicines for recipients. We can conclude safely from these results that, for a fixed amount to be donated, if the value attached by recipient increases, donations also increase.

Further, donations also increase when, for a fixed increases in j's welfare, the amount to be donated is less. This is substantiated by results from (Charness and Rabin 2002). Charness and Rabin conduct experiments wherein a dictator has to choose between payoffs $\{(200, 700)\ vs\ (600, 600)\}$ in game G_1, and between $\{(0, 800)\ vs\ (400, 400)\}$ in G_2 with payoff order being $(other, self)$. 73% of dictators choose $(600, 600)$ in G_1 compared to 22% who choose $(400, 400)$ in G_2. In both games receiver's payoff increases by the same amount, but in game G_2 the cost to dictator is higher than in G_1.

We formalize dictator game as follows. Player i has an amount w_i and can choose to offer an amount $s \in [0, w_i - 1]$ (integer values) to j . Player j has an initial amount w_j. w_i, w_j measure the initial welfare of both players. As w_j decreases, "deservingness" of player j increases. The material payoffs if i donates s, are $(w_i - s, w_j + s)$ to i, j respectively. Denote $\triangle v(\pi_i, \pi_i') = v(\pi_i) - v(\pi_i')$ as difference function.

- *Observation-2*: Player i will donate to player j an amount s if $\gamma_i \geq \frac{\triangle v(w_i - s + 1, w_i - s)}{\triangle v(w_j + s, w_j + s - 1) + \triangle v(w_i - s + 1, w_i - s)}$.

For a fixed w_i, s as w_j decreases $\triangle v(w_j + s, w_j + s - 1)$ increases, and γ_i decreases. As the value function is concave, the value attached by player j to the same amount increases as w_j decreases. Thus, for a given population with fixed γ_i distribution and s, the probability that a randomly selected agent i will donate increases as w_j decreases.

Figure-1 shows the donations along X-axis, and the γ_i values along Y-axis when the value function is set to $v(\pi_i) = \pi_i^{0.5}$ for $w_j = \{0, 4, 9\}$ and $w_i = 10$. For $w_j = 9$, player j has an initial amount 9, player i will donate a positive

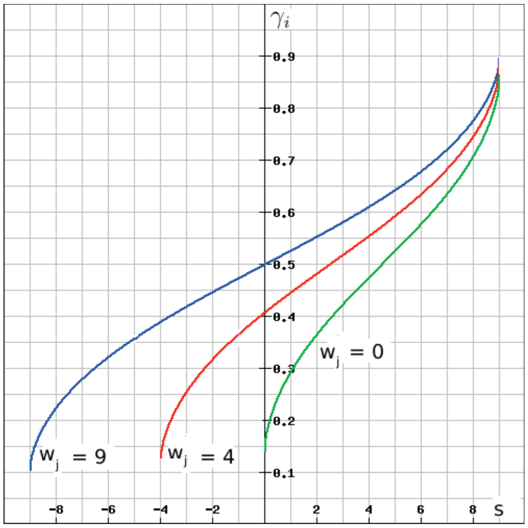

Figure 1: Donations vs γ_i.

amount if $\gamma_i > 0.5$ and for $\gamma_i < 0.5$ the donation values are negative, implying it will take away from the player j. Bardsley (2005) reports a similar behavior with the extended dictator game. When the dictator is endowed with an additional option of taking away an amount from their opponent, instead of donating, players take away a positive amount. We interpret the result as being the case that, when such an option is available to the dictator, it assumes the opponent has a positive endowment to begin with. This is sufficient enough for dictators to take away non-zero amounts from opponents.

Also note that, as w_j decreases the minimum threshold altruism coefficient above which players donate decreases. For $w_j = 0$, player i donates an amount 2 if $\gamma_i > 0.3$. This value increases to 0.45 for $w_j = 4$. Also for $\gamma_i < 0.5$, players always donate less than half their share.

Ultimatum game

The Ultimatum game involves a proposer, i, who offers to split a fixed amount M. The responder, j, can either accept or reject the offer. If the offer is accepted, the payoffs are $(x, M - x)$ to proposer and responder respectively. If it is rejected both receive zero. The Nash equilibrium outcome is for the proposer to make smallest feasible offer and for responder to accept it. This prediction is inconsistent with experimental results. Proposers often make significantly higher offers, average offers being $30 - 40\%$ of total, with 50% being the mode and responders reject non-trivial amounts, offers less than 20% of the total are rejected quite frequently (Camerer and Thaler 1995). Moreover, the rejection of positive offers depends not only on the amount offered but also on the alternatives available to the proposer. Consider the behavior across following two mini-ultimatum games. In mini-ultimatum games, each player has a binary choice. The proposer has to choose between two splits, and the responder can either accept or reject. Denote G_1 as the game in which proposer has to choose between $(8, 2)$ vs $(2, 8)$ split. Denote G_2 as game in which proposer has to choose between $(8, 2)$ vs $(5, 5)$. (Falk, Fehr, and Fischbacher 2003) show that rejection rate of $(8, 2)$ is 44% in G_1 compared to 26% in G_2. For the same offer by proposer, responders reaction differs across the two games. In game G_2, $(8, 2)$ split is relatively more unfair compared to G_1, since in game G_1 the alternative option available to the proposer is equally unfair. Additionally, the percentage of proposals in which O_1 is offered reduces from 73% in G_1 to 31% in G_2.

We evaluate our model by considering behavior across two mini-ultimatum games similar to (Falk, Fehr, and Fischbacher 2003). Denote as G_1 a game in which proposer i can only make one of these two offers, $O_1 = (x, M - x)$ or $O_2 = (M - x, x)$ where $x > M/2$ i.e. i can either keep the larger share for itself or give it to player j. Denote as G_2 a game in which $O_2 = (M/2, M/2)$ i.e. i can either keep the larger share for itself or make an equitable offer. In both games, if responder j accepts the offer each gets the respective amounts in the offer, else both receive zero. Intuitively, O_1 is more fair in G_1 than in G_2, since i can make an equitable offer in G_2. Therefore, if players' envy coefficient is kept constant across both games, O_1 should be rejected more often in G_2. We now make following observation, when player's reciprocity is as defined in our model,

- *Observation-3:* For a fixed envy coefficient across games G_1 and G_2,
  - The probability that O_1 is offered by a randomly selected agent is less in G_2 than in G_1.
  - The probability that O_1 is rejected by a randomly selected agent is greater in G_2 than in G_1.

Since we have assumed players have same value functions, in game G_1, i will make an offer O_1 if $\gamma_i < 1/2$. This reduces to $\gamma_i < \frac{\triangle v(x, M/2)}{\triangle v(M/2, M-x) + \triangle v(x, M/2)}$ in game G_2. Hence, the probability that a randomly selected agent makes offer O_1 reduces. Similarly, player j will accept offer O_1 in G_1 if $\gamma_j > 1/2$ which increases to $\gamma_j > \frac{\triangle v(M/2, M-x)}{\triangle v(x, M/2) + \triangle v(M/2, M-x)}$ in game G_2. Thus, in G_2 fewer players will accept O_1. Note that, in analyzing the behavior across the above mini-ultimatum games we assumed the envy coefficient is constant across both games. If envy coefficient is dependent on the outcomes ($k \propto \pi_i/\pi_j$), it will only reinforce the above results (Kirchteiger 1994).

For the continuous ultimatum game, with $x \in [0, M]$ taking integer values, we observe that, for two players with same envy coefficient, if $\gamma_i < 1/2$ proposers do not offer more than $M/2$. And since $k < 1$, responders do not reject offers greater than or equal to $M/2$. Thus our model is consistent with experimental results.

Discussion and Conclusion

Our model differs from previous reciprocity models in defining the reference payoff against which players evaluate fairness. Unlike distributive models (Fehr and Schmidt 1999), the reference payoff is not fixed as equity. It is a function of Pareto-efficient alternatives available to the player and its

	Share	Grab
Trust	$(6, 6)$	$(0, 12)$
Dissolve	$(5, 5)$	$(5, 5)$

Table 4: Partnership game

own altruism coefficient. Thus we are able to account for behavior across games when the alternatives are varied.

Unlike Rabin's model, where players have to sacrifice a positive amount for any kindness to be associated with their actions, our model associates kindness based on aspiration value. The partnership game (Rabin 1993), in Table-4, highlights the consequence of this simplification.
Players i, j, along row and column respectively, are partners in a project. Player i has to choose to either dissolve the partnership and withdraw its resources from the project, in which case both receive a payoff of 5. But, if it chooses to continue the partnership and invest its resources it has to trust player j to share the additional profit at the end of project. Rabin's model predicts player i to dissolve the partnership. Since, if it plays trust, player j will not associate any kindness with it, as player i would do so to only increase its own payoffs. Thus fairness equilibrium is for play j to grab and player i to dissolve. Rabin (1993) argues that modeling alternative emotions like trust can account for cooperative outcome $(Trust, Share)$.

Instead, consider our aspiration-based reciprocity model. $S_i = \{0, 6\}$ for player i and $S_j = \{6, 12\}$. Player i's demand of 6 will be considered as unkind only if player j sets its own aspiration value to 12. Thus if we assume player i to set an aspiration value of more than zero, a cooperative outcome depends entirely on how altruistic or selfish player j is. Our model implicitly addresses the notion of trust. If player i sets its aspiration value to m_i it implies, it will not deviate from an outcome in which it gets a payoff greater than or equal to aspiration value, unless it increases payoff for both the players.

To conclude, we have presented a social preference model for reciprocity in two player dilemma games. Developing these models is especially relevant in settings which require agents to be aware of fairness considerations. Examples include negotiations, limited resource sharing, etc. Unlike other models introduced earlier, the qualitative predictions of our model are consistent with experimental results across all three standard games. We have considered the prisoner's dilemma, both sequential and simultaneous, the dictator game, and the ultimatum games. Although the model is relatively simpler compared to existing models, it requires consistency in belief about aspiration values and envy. In the future, we intend to develop learning algorithm which, in repeated games, can guarantee convergence to correct beliefs. We also intend to evaluate our model against a larger set of games. Our assumption for sequential games, that the aspiration values are same across all sub-games also needs to be evaluated.

References

Andreoni, J., and Miller, J. H. 2002. Giving according to garp: An experimental test of the consistency of preferences for altruism. *Econometrica* 70(2):737–753.

Bardsley, N. 2005. Dictator game giving: altruism or artefact? *Experimental Economics* 11(2):122–133.

Bolton, G., and Ockenfels, A. 2000. Erc: A theory of equity, reciprocity, and competition. *American Economic Review* 90(1):166–193.

Braas-Garza, P. 2006. Poverty in dictator games: Awakening solidarity. *Journal of Economic Behavior & Organization* 60(3):306–320.

Camerer, C., and Thaler, R. 1995. Anomalies: Ultimatums, dictators and manners. *Journal of Economic Perspectives* 9(2):209–219.

Camerer, C.; Loewenstein, G.; and Rabin, M. 2004. *Advances in behavioral economics*. Princeton University Press.

Capra, C. M.; Goeree, J. K.; Gomez, R.; and Holt, C. A. 1999. Anomalous behavior in a traveler's dilemma? *The American Economic Review* 89(3):678–690.

Charness, G., and Rabin, M. 2002. Understanding social preferences with simple tests. *Quarterly Journal of Economics* 117(3):817–869.

Clark, K., and Sefton, M. 2001. The sequential prisoner's dilemma: Evidence on reciprocation. *The Economic Journal* 111(468):51–68.

Cox, J.; Friedman, D.; and Gjerstad, S. 2007. A tractable model of reciprocity and fairness. *Games and Economic Behavior* 59(1):17–45.

de Jong, S.; Tuyls, K.; and Verbeeck, K. 2008. Artificial agents learning human fairness. In *7th International joint conference on Autonomous agents and multiagent systems*, 863–870. Richland, SC: IFAAMAS.

Dufwenberg, M., and Kirchsteiger, G. 2004. A theory of sequential reciprocity. *Games and Economic Behavior* 47(2):268–298.

Eckel, C. C., and Grossman, P. J. 1996. Altruism in anonymous dictator games. *Games and Economic Behavior* 16(2):181–191.

Falk, A., and Fischbacher, U. 2006. A theory of reciprocity. *Games and Economic Behavior* 54(2):293–315.

Falk, A.; Fehr, E.; and Fischbacher, U. 2003. On the nature of fair behavior. *Economic Inquiry* 41(1):20–26.

Fehr, E., and Fischbacher, U. 2002. Why social preferences matter - the impact of non-selfish motives on competition, cooperation and incentives. *The Economic Journal* 112(478):1–33.

Fehr, E., and Schmidt, K. M. 1999. A theory of fairness, competition, and cooperation. *Qarterly Journal of Economics* 114(3):817–868.

Kirchteiger, G. 1994. The role of envy in ultimatum games. *Journal of Economic Behavior and Organization* 25:373–389.

kyeong Ahn, T.; Ostrom, E.; Schmidt, D.; Shupp, R.; and Walker, J. 2001. Cooperation in prisoner's dilemma games:

Fear, greed, and history of play. *Public Choice* 106(1-2):137–155.

Lave, L. B. 1965. Factors affecting co-operation in the prisoner's dilemma. *Behavioral Science* 10(1):26–38.

Levine, D. K. 1998. Modeling altruism and spitefulness in experiments. *Review of Economic Dynamics* 1(3):593–622.

Rabin, M. 1993. Incorporating fairness into game theory and economics. *The American Economic Review* 83(5):1281–1302.

Rapoport, A., and Chammah, A. 1965. *Prisoner's Dilemma*. Ann Arbor: University of Michigan Press.

Roth, A. E., and Erev, I. 1995. Learning in extensive-form games: Experimental data and simple dynamic models in the intermediate term. *Games and Economic Behavior* 8(1):164–212.

Simon, H. 1957. *Models of Man*. John Wiley.