

Fairness and Reciprocity in the Hawk-Dove Game ‡

by

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Abstract

We study fairness and reciprocity in a Hawk-Dove Game. A variety of recent models gives the same predictions for this game. This allows us to provide a general classification of individuals' types. Contrary to a large number of studies on different games over the last decade, we observe a large group of subjects behaving in a self-interested and rational way.

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1. Introduction

Economic theory traditionally assumed that agents only care about their own material well-being. Over the last decade, however, an abundance of evidence has appeared, showing that fairness and/or reciprocity considerations also play an important role in individual behavior (for a survey, see Fehr and Schmidt, 2003). To a large extent this has been based on laboratory experiments, many of which study behavior in bargaining, gift-exchange or public-good contribution games. In this note, we experimentally study both fairness and reciprocity in the Hawk-Dove Game. In some respects, this game may be considered to be more competitive than the games previously used (*cf.* Section 5). We test for the occurrence of both positive and negative reciprocity in this game. To do so, we elicit conditional strategies using the Becker-DeGroot-Marschak (1964) mechanism.

There are two approaches to fairness and reciprocity in the literature. The 'outcome-approach' assumes that people are concerned about the final distribution of income between themselves and fellow players (*e.g.*, Fehr and Schmidt, 1999, Bolton and Ockenfels, 2000). In this view, a player may take costly actions to bring about a more equal income distribution. The 'process-approach' focuses on players' attitudes towards the process yielding the distribution of incomes (*e.g.*, Rabin, 1993, Charness and Rabin, 2002, Dufwenberg and Kirchsteiger, 2004, Falk and Fischbacher, 2005). Actions are evaluated on the basis of what the player could alternatively have done (but did not do).

For our game a player is predicted to behave the same way, irrespective of whether fairness or reciprocity is the driving force or whether preferences are outcome- or process-oriented. Moreover, her behavior and preferences will be different from those of a player with no other-regarding preferences. Therefore, our game provides a simple and clean test of the occurrence of fairness and/or reciprocity considerations. Our main result is that most subjects revealed self-interested preferences and behaved in a money-maximizing manner.

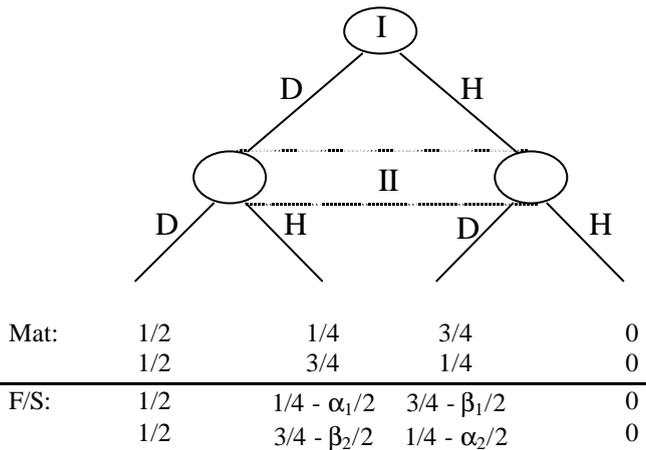
2. The Hawk-Dove Game

The extensive form of the game considered is given in Figure 1. One interpretation is that two players have to divide a pie of size one. Decisions are simultaneous: if both play action D (*Dove*), the pie is split equally. If one player plays D and the other H (*Hawk*), the pie is split unequally, with the hawk-player taking three quarters and the dove player getting only one quarter. Finally, if both play H (*i.e.*, there is disagreement) neither gets a share and monetary payoffs are zero.

If the players only care about material payoffs, the game has two asymmetric Nash equilibria in pure strategies, (D,H) and (H,D) , with an unequal split, and a mixed strategy equilibrium in which each player mixes between D and H with equal probabilities.

We distinguish between the following player types:

Figure 1: The Hawk -Dove Game*



*Mat=material payoffs; F/S: Fehr-Schmidt payoffs.

- ◆ M: *Materialist*: plays $H(D)$ if the partner plays $D(H)$.
- ◆ H: *Hawk*: always plays H . Hawk responds to ‘ H ’ with ‘ H ’, which can be interpreted as negative reciprocity.
- ◆ D: *Dove*: always plays D . Dove responds to ‘ D ’ with ‘ D ’, which can be interpreted as positive reciprocity.
- ◆ R: *Reciprocator*: responds to $D(H)$ with $D(H)$.

As an illustration of a way to include a notion of fairness or reciprocity into the game, consider Fehr and Schmidt's (1999) model, in which *inequity averse* players appear.¹ The utility function of player $i=\{1,2\}$ is:

$$U_i(x_i, x_j) = x_i - \alpha_i \max[x_j - x_i, 0] - \beta_i \max[x_i - x_j, 0], \quad \alpha_i \geq \beta_i, \quad \beta_i \in [0, 1] \quad (1)$$

where x_i (x_j) denotes the monetary payoff to player i (j), $i, j = \{1, 2\}$, $i \neq j$. A difference in monetary payoffs decreases utility, the disutility being relatively greater if disadvantageous ($x_i < x_j$) than if advantageous ($x_i > x_j$). The (utility) payoffs of the Hawk-Dove Game with Fehr/Schmidt preferences (“F/S”) are given in figure 1. The model immediately accounts for three of the player types distinguished above. For $\alpha, \beta < 0.5$, the M-type emerges; $\alpha > 0.5$, $\beta < 0.5$ gives the H-type and $\alpha > \beta > 0.5$ yields the R-type. Finally, though Fehr and Schmidt disregard altruistic preferences (*i.e.*, $\alpha_i < \beta_i$), allowing such preferences is a straightforward extension. If $\beta > \alpha > 0.5$, the model once again gives the R-type, and for $\alpha < 0.5$, $\beta > 0.5$, the model describes the preferences of the D-type. Hence the preferences of each of the types distinguished can be described by the (extended version) of the Fehr-

¹ Similarly, one could apply other models to the game. We apply Fehr and Schmidt's model as an example because a straightforward link exists between its parameter space and the types we distinguish. Most of the models on fairness and/or reciprocity can accommodate at least some of our types.

Schmidt model. The equilibrium of the game now depends on the types playing it, and the information players have about the other's type. For example, for a game between a R and D [H] type, where R knows the other's type, (D,D) [(H,H)] is the unique pure strategy equilibrium.

Fehr and Schmidt adopt the outcome-approach to fairness and reciprocity. As for the process-approaches, precise predictions are quite involved due to the general structure of these models. They typically support the R-type, however: individuals who perceive H (D) as a hostile (friendly) action will respond to it with H (D).

Hence, both approaches work in the same direction in this game. Specifically, all models can account for the existence of R-types. This makes the Hawk-Dove Game an ideal candidate for the purpose of studying the role of reciprocity without needing to choose a particular model of it. Moreover, the game is straightforwardly related to other games that have been used to study reciprocity. Below, we compare our results to behavior in Ultimatum Games and Best Shot Games.

3. Experimental Design

94 students participated in a computerized experiment² in June 2001 at the ESSE laboratory at the University of Bari. Students were mainly Economics undergraduates. The experiment lasted 35 minutes and average payoff was 10,000 ITL (\approx €). The pie to be divided was 20,000 ITL.

The experiment consisted of three stages of preference elicitation. The first two stages were used to derive a “*final action*” for each player. These final actions were used to determine players' payoffs. In the first stage, subjects were asked to submit any number between 0 and 100, corresponding to the probability of playing H .³ Second, subjects were informed that the number submitted in stage 1 was their *initial action*. They were then asked to submit conditional strategies (numbers between 0 and 100) dependent on the action of the partner. Hence, each individual submitted two numbers, one for the case where the partner's action was H , and one for a D action by the partner.

Final actions and monetary earnings were determined as follows. The first player in each pair was randomly chosen. Her initial action was recorded, after which the second player's response was derived from his conditional strategy applied to her initial action. Next, the first player's response to the second player's action was determined on the basis of her conditional strategy. 200 computerized

² The computer program was developed using Urs Fischbacher's Z-Tree software.

³ A random draw, $y \in \{1, \dots, 100\}$ determined whether their action was D or H : let x be the number submitted. If $x < y$ ($y \leq x$) the subject's action was $D(H)$. We are aware that a Becker-DeGroot-Marschak procedure like the one used here is sometimes considered to be problematic (see, e.g., Davis and Holt, 1993). We only use it in order to elicit mixed strategies. It turns out that 70% of our subjects submit pure strategies in stage 1, anyway. In stage 2, this is close to 80%. Below, we report results of additional sessions where only pure strategies were elicited.

iterations were conducted in this way, 100 actions for each player.⁴ Then, the number of computer-simulated D -actions was compared to the number of computer-simulated H -actions for each player. If the number of D -responses exceeded the number of H -responses the *final action* of the subject was D , otherwise it was H . In case of an equal number (50 each) of D and H , the *final action* was determined randomly. The final actions of the two players determined payoffs.

We used this iterative method because it diminishes the direct effect of the initial action and of the random procedure used to determine the action following from a mixed strategy. A possible disadvantage is that it may be difficult for subjects to comprehend. In order to check whether this process of eliciting mixed strategies for first and second movers affected decisions, we ran an additional session with 24 subjects where only pure strategies were elicited.⁵ One player in each of 12 pairs was appointed the role of first mover and submitted a pure strategy. The other was second mover and reported conditional pure strategies for each of the two possible choices by the first mover. Below we refer to these sessions as the “pure strategy” sessions. We will compare the results of these additional sessions to our original results in the following section.

Finally, in stage 3 subjects were asked to rank the possible outcomes (D,D) , (D,H) , (H,D) and (H,H) according to their preferences. No salient rewards were connected to this choice. Therefore, we will refer to this choice as the subjects’ *stated preferences* while we refer to the second stage choice as *revealed preferences*.

4. Experimental Results

Stage 1

5 participants (5%) submitted a 50-50 mix of D and H (the mixed strategy equilibrium). Most submitted a pure strategy: 41 (44%) submitted D and 24 (26%) submitted H . 24 subjects (26%) submitted a different mixed strategy than 50-50. A two-tailed Wilcoxon signed ranks test rejects the hypothesis that subjects mix D and H with equal probabilities: D is played significantly more frequently than H ($p=.043$).

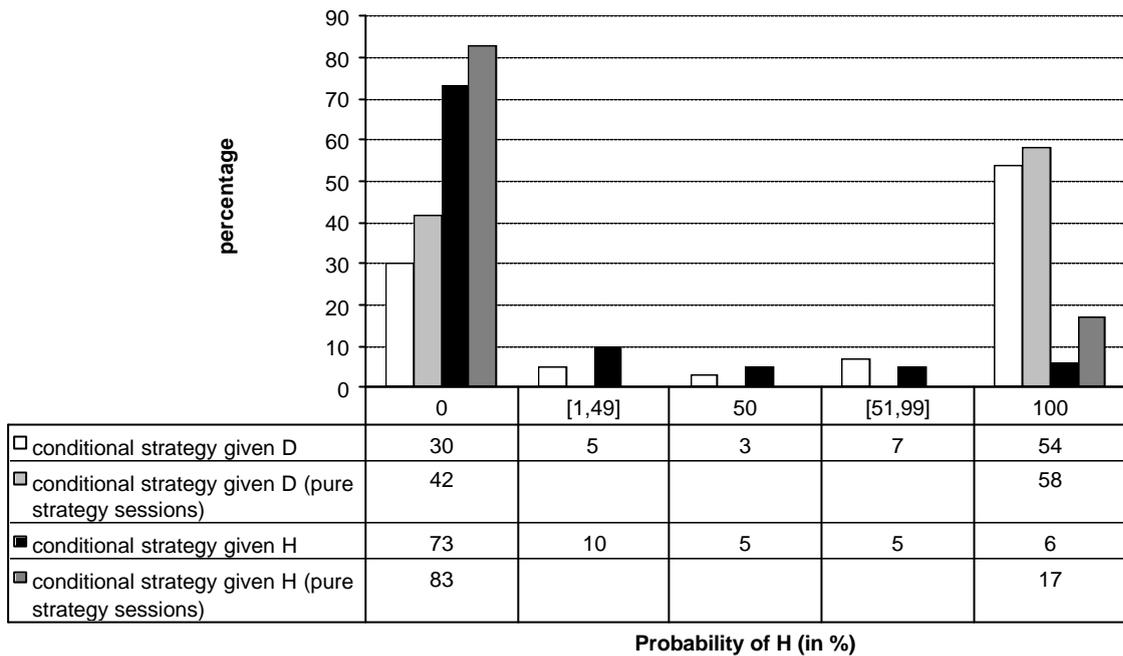
Stage 2

Figure 2 gives the conditional strategies submitted.

⁴ Note that these 200 iterations did not involve any decisions by the players after the initial and conditional strategies had been submitted.

⁵ We are grateful to one of the anonymous reviewers for suggesting this additional treatment. It was run at the University of Hanover in May, 2005.

Figure 2: Conditional Strategies*



* Percentage of subjects choosing D ('0'), H ('100'), or mixing strategies ('[1-49]', '50', '[51-99]').

We first compare the original mixed strategy sessions (black and white bars) to the additional pure strategy sessions (gray bars). Note that the results are very similar for the two cases, especially if we interpret the mixed strategies of $<50\%$ or $>50\%$ as 'leaning towards D ' and 'leaning towards H ', respectively. For example, $54+7=61\%$ of subjects responded to D with H in the original sessions, compared to 58% in the pure strategy sessions. The percentage responding to H with D is exactly equal (83%) in both cases. Hence, we conclude that subject responses are not biased by the way in which we elicit mixed strategies. In the following, we therefore focus on the original data (with reported mixed strategies).

In these data, 54% of the subjects responded to D with H (chose '100') and 73% chose D in response to H . In both cases, Wilcoxon tests reject the null-hypothesis of equal likelihood of playing H or D . Using the conditional strategies, subjects can be classified according to the types defined above.⁶ 53% are classified as M-types, 30% as D; 6% as H and 5% as R. We could not classify the remaining subjects (5%) because they chose to play D and H with equal probability. Note that 83% reply to H with D . Furthermore, the preferences of the 30% of our subjects that fall into the D -category can only be described by the Fehr& Schmidt model if we extend it to allow for $\beta > \alpha$.

We can compare the results to those observed in the literature, for other games. Consider the response to the other player choosing H . Only 11% of our subjects choose H with a probability greater than 50% in this case. This decision is comparable to that of a responder in the Ultimatum

⁶ Subjects are classified as choosing ' H ' (' D ') if their submitted strategy is greater than (smaller than) 50 .

Game when the proposer offers $\frac{1}{4}$ of the pie. In this respect, our observed rejection rate of 11% is low, compared to what is typically observed in Ultimatum Games (*cf.* Camerer, 2003, table 2.3). Note that this difference cannot be explained by the opponent's *intentions*, because the alternative for the proposer would have been to choose *D*. Hence, if anything, a choice of *H* would be considered to be intentionally unfair. This adds to the distributional unfairness of a (3/4,1/4) offer. Therefore, a player concerned about intentions should reject at least as often as in the Ultimatum Game. We will return to this point in the concluding discussion.

It is also interesting to compare our results with those obtained for the Best Shot game (Harrison and Hirshleifer, 1989). A simple version of the Best Shot game is the following sequential voluntary contribution game: one player moves first and decides whether to make a Low or High contribution. The other person observes the first player's contribution and then decides between a Low or High contribution. The amount of the public good produced is determined by the maximum of the two contributions. The theoretical prediction is that the first mover will choose the Low contribution (zero in a continuous version), thus forcing the second mover to make the High contribution. Experimental evidence for the Best Shot game shows that the theoretical prediction is very accurate; see Harrison and Hirshleifer (1989) and Roth (1995). A choice of *H* in the Hawk-Dove Game may be compared to a choice of Low in the Best Shot game. The optimal (selfish) response is *D* (High). Our results (the conditional responses to *H*) show that 73% do indeed respond with *D*. Another 15% choose *D* with a probability of at least 50%. Though this is quite supportive of the theoretical (self-interested) prediction, we find a slightly higher level of deviation than in Harrison and Hirshleifer (1989).⁷

Stage 3

87% of the stated preferences were M-type, 11% were D and 2% were H. No R-type preferences were reported. Hence, a large proportion of stated preferences is explained by the standard self-interest model. Finally, most subjects who did not choose a materialistic best reply behavior in stage 2 state their preference profile at stage 3 inconsistently with their revealed preferences (most deviate by stating materialistic preferences).

5. Discussion and Conclusions

The Hawk-Dove Game enables us to measure fairness and reciprocity as defined in various models in one experimental set-up. A majority of players in our experiments show materialistic preferences, however. The only other large group plays *D* in response to either move and may be classified as 'altruists'. Though the response to *D* with *D* may be interpreted as positive reciprocity, the fact that

these subjects also respond to H with D makes it hard to see their whole preference profile as reciprocal. Moreover, when this group is asked to state their preference orderings at stage 3, most of them revert to materialistic preferences.

Note that our results that players have materialistic preferences is different than the conclusion of Fehr and Schmidt (1999), that a *given* distribution of preferences for fairness across a heterogeneous population may give rise to different results in distinct games. Our results show that revealed preferences for reciprocity or fairness may depend on the game itself. Whereas Fehr and Schmidt show that in some environments money maximizers dominate equilibrium behavior, we show that in this game most subjects act as money maximizers.

Why, then, do our results differ from previous results, which typically find (much) higher levels of reciprocity? The most obvious explanation lies in the game we use. In the Hawk-Dove Game, ‘cooperative’ play (D) does not bring about any Pareto-gains. There are no incentives for subjects who wished to maximize group payoff to cooperate (contrary to the games by Fehr and Gaechter, 2000). This points to efficiency as opposed to fairness as a leading explanation of behavior observed in other experiments (cf. Charness and Rabin, 2002, for a model that incorporates both).

This, however, does not explain why subjects behave differently in this game (conditional on observing H) than in the Ultimatum Game (where fairness is regularly observed to be important). One reason may be that the Hawk-Dove Game is more competitive than the classic Ultimatum Game. In the latter, a proposer who offers one-half gives the opponent a choice between a $(1/2, 1/2)$ and $(0, 0)$ division. The second mover is very likely to accept the former since it is both fair and efficient and it gives her the most money. In the Hawk-Dove Game, on the other hand, offering one-half means choosing Dove. But a player who chooses D gives the opponent the choice between $(1/2, 1/2)$ and $(1/4, 3/4)$. In this case, fairness induces the second mover to choose the first allocation, efficiency has no bite, and money maximization directs him to the second. Suppose an individual’s fairness (and efficiency) preference component is equally strong in both games. Then, as soon as the preference for own earnings is sufficiently high, the individual will choose $(1/2, 1/2)$ in the Ultimatum Game, but $(1/4, 3/4)$ in the Hawk-Dove game. In sum, a fair offer in the Ultimatum Game is almost sure to be accepted, and is hence almost sure to lead to a balanced (fair) outcome. In the Hawk-Dove Game, on the other hand, the Dove action is much less likely to lead to a balanced outcome. In other words: the price of positive reciprocity is higher in the Hawk-Dove Game than in the Ultimatum Game.⁸

⁷ The sequential Hawk-Dove Game has a strong resemblance to this Best Shot game, but is not identical. As in the Best Shot game, a money maximizing reply to D (H) is H (D). However, whereas (D, D) is not efficient in the Best Shot game, it is in the Hawk Dove game.

⁸ An alternative explanation due to Schotter and Sopher, 2002, is that expectations about others’ fairness are not fulfilled in the ultimatum game (and offers are therefore rejected), whereas subjects do not expect fair behavior in the Hawk-Dove Game. Of course, this begs the question why expectations differ in the two games. Another possibility lies in the strategy-method used. Brandts and Charness (1998) found that experimental outcomes might vary substantially when playing ‘hot’ or ‘cold’ (as here). To test this latter explanation, we ran an additional session (suggested by an anonymous referee) at the University of Hanover in May, 2005. These were done in the same way as the pure strategy sessions discussed above, with one exception. This is that each of 11

Respondents realize this and, as a consequence, consider $(3/4, 1/4)$ to be a more reasonable “offer” in the Hawk-Dove Game than in the Ultimatum Game.

With the results of the conditional choices in stage 2 in mind, we can interpret the observed behavior in stages 1 and 3. In stage 1, D was chosen significantly more often than H . This may be due to the differences in the numbers of H and D -players. Stage 2 results show that 30% of our subjects always play D , whereas only 6% play H irrespective of what the other subject plays. As a consequence, even with uninformative priors on the others’ preferences, we would expect more D -plays in stage 1.

In stage 3, stated preferences were predominantly of the M -type (self-interested). This is partly due to the fact that subjects with M -preferences in stage 2 were consistent in reporting the same in stage 3 whereas subjects with other stage 2 preferences often changed when asked to report an ordering in stage 3. We do not wish to dwell too long on these stated preferences results, because this part of the experiment had no financial incentives. Nevertheless, the difference in consistency for distinct types is noteworthy.

All in all, the extent of reciprocity observed in many other studies does not carry over completely to the strategic environment set by the Hawk-Dove Game. This is important because a variety of theories on fairness and reciprocity predict the same outcome for this game, allowing us to test them in a uniform setting. Our results show that the predictive power of each of these theories is dependent on the context in which it is studied.

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second movers knew his partner’s choice before deciding. We observed that 2 out of the 5 (40%) subjects that observed H responded with H and 3 out of 6 that observed D (50%) responded with D . This implies slightly more reciprocity in this ‘hot’ environment than in the ‘cold’ strategy environment. More data are needed for further judgment, however.

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