CENTRE FOR DECISION RESEARCH & EXPERIMENTAL ECONOMICS

The University of Nottingham

Discussion Paper No. 2010-02

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February 2010

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CeDEx Discussion Paper Series
ISSN 1749 - 3293

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# Vendettas

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**Version: February 2010**

**Abstract**

Vendettas occur in many real world settings where rivals compete for a prize, e.g., winning an election or a competitive promotion, by engaging in retaliatory aggressive behavior. We present a benchmark experiment where two players have an initial probability of winning a prize. Retaliatory vendettas occur and lead agents to the worst possible outcomes in 60% to 80% of cases, counter to self interest predictions, and regardless of whether initial winning probabilities are equal or unequal. Negative emotions are important and interact with economic settings to produce large social inefficiencies. Venting emotions predicts aggression but also reduces it.
*Keywords*: trust, income inequality, market, social capital.
*JEL Classification Codes*: C72, C91, Z13.

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We wish to thank Fabio Galeotti, Marta Sernec, Kei Tsutsui and Eliza Tan for research assistance, and Shaun Hargreaves Heap and seminar participants in Bari, Berlin, East Anglia (Norwich), Innsbruck, Jena and LUISS (Rome) for advice and encouragement. The usual disclaimer applies. The financial support of the European University Viadrina, the University of Nottingham and the University of East Anglia is gratefully acknowledged. An electronic appendix contains the experimental instructions.

## 1. Introduction

Feuds occur all the time. Some are small, some are large. They may simply relate to reciprocal tit for tat between employees, the main effect of which is to make their employers unhappy with them. Two workers may engage in a sequence of sabotaging and counter-sabotaging activities towards each other in the process of competing for a promotion to an exclusive post, which however, in the end, neither may get exactly because of all the mudslinging that has occurred. Fights between kin for control of the family business and fortune may facilitate the loss of business and demise of such fortune (see Bertrand and Schoar, 2006). The quest for dominant power over a business partnership may degenerate into a series of retaliatory acts between business partners, a feud that ends the partnership. Other classic cases relate to political competitions for office, such as U.S. or U.K. first-past-the-post elections or U.K. political party leadership maneuverings. As an example of the latter, the war of attrition between Margaret Thatcher and Michael Heseltine in the late 1980s ended with Margaret Thatcher resigning her leadership in 1990, but being replaced not by Michael Heseltine but rather by a third party not directly involved in the feud– John Major.[1]

In social environments where blood vendettas have been allowed to thrive and escalate, actions determine life or death. Iconic examples in American history include the Pleasant Valley War, where the Graham and Tewksbury families initially quarreled over the use of grazing territory but the resulting tit for tat killed almost everyone in both clans (Dedera, 1988). Other cases such as mafia wars (as the Scampia feud recently plaguing Naples: Wilkinson, 2005), gang wars (e.g., Soares, 2009), inter-ethnic strife (e.g., BBC, 2009; Chehab, 2007)[2] and contemporary blood feuds in north Albania allegedly claiming the lives of over 6,000 people since 1991 (Clerix, 2008) are as grim. Besides these examples, there are other unrecorded feuds that occur and fester, the processes of which are as intriguing.[3]

This paper presents a simple and interpretable experimental setup in which feuds can, but need not, occur. The theoretical benchmark of our game that feuds do not occur is, perhaps counter to intuition, the result of an equilibrium analysis of a model that assumes self-

[1] As this and the other examples of this paragraph imply, in this paper we do not refer to feuds and vendettas as implying necessarily acts of physical violence. Many economic and political interactions of interest will, of course, involve neither.

[2] There is evidence suggesting that the Israeli-Palestinian conflict does not fit this paradigm (Jaeger and Paserman, 2008). We discuss this case further in section 5.

[3] For a sociological analysis of revenge, containing further examples, see Elster (1990).

interest and rationality. Our main research question asks *why* feuds occur. In our game, two players have an initial probability of winning a single prize. The winning probabilities that players start each game with are either equal or unequal depending on the treatment. Overall expected efficiency is determined by the cumulative probability of either player winning, as opposed to neither winning. Players can, in alternating turns, reduce the winning probability of their coplayer so as to increase their own, but gain only a fraction of what they have stolen. We find that subjects tend to engage in retaliatory vendettas until they are both left with less than a 10% chance of winning, and this is observed in two thirds of the time. Overall, mean final winning probabilities are just between 10% and 20%. The observed efficiency losses are common across treatments, for example whether subjects start the game with equal or unequal endowments. Outcomes are considerably inferior to what is implied by the self-interest benchmark which predicts that feuds, in the sense of counter-stealing, should never occur in any game.

Our experimental paradigm can be considered for further use by other researchers as a simple benchmark game that may be extended with manipulations to identify what other factors facilitate or suppress the emergence of socially inefficient feuds. This can potentially guide managers and policy makers interested in reducing conflict.[4] Here, we consider one experimental manipulation that could potentially alleviate aggression in such situations, which is to enable subjects to vent their emotions while the game is being played. Venting proves to be partially effective in reducing feuding activities. This method has potential applications in organizational business settings.[5]

Our design also has a more general motivation. The prevailing emphasis in economics has been on settings conducive to deviations from self-interest in the direction of cooperative and pro-social behavior. Cooperation in excess of the theoretical predictions based on self-interest is commonly observed in public good contribution experiments and of mechanisms. For example, Fehr and Gächter (2000) show that punishment opportunities effectively enforce cooperation (e.g., Fehr and Gachter, 2000). Also, Tan and Bolle (2007) experimentally show that cooperation within groups increases with the introduction of competition between groups,

[4] Of course, there have been a number of important theoretical models on the economics of conflict and war (e.g., Konrad and Kovenock, 2005 and Bester and Konrad, 2005), which have attempted to do something similar but from a theory viewpoint, whilst not focusing on the psychological dimension of feuds, which is instead relevant according to our experimental results.

[5] It also has methodological implications for experimental design, as we discuss in section 5.

even though that could potentially harm others in the rival group. There are signs, however, that even in public good contribution games, punishment can be 'antisocial' (e.g., Nikiforakis, 2008), especially in the absence of strong social norms of cooperation (Herrmann et al., 2008) and related to this perceptions of guilt (Hopfensitz and Reuben, 2009). However, the social dilemma context may induce a cooperative frame, in contrast to the conflict-ridden frame induced by our setup. This may lead to very different outcomes, a point we consider in the discussion section in comparing our results to those of Engelmann and Nikiforakis (2008) and Hopfensitz and Reuben (2009). When subjects are placed in a condition where they can eliminate or 'burn' money of other players at a cost to themselves, some of them will, especially in a multi-player environment or one with possible money burning by nature, both of which would reduce the moral cost of burning (see Abbink and Herrmann, 2009; Zizzo, 2003; Zizzo and Oswald, 2001). Our paper contributes to this small but growing literature, on what Herrmann and Orzen (2008) have recently dubbed *homo rivalis* behavior, by studying a dynamic setting that goes beyond public good contribution games.[6] Similarly to what is observed in the between groups Tullock rent seeking game experiment of Abbink et al. (2009), we find that the same motivations that yield more cooperation in cooperative situations (e.g., emotion driven tit for tat that enforces public good contribution) lead to large negative effects on efficiency in our conflict-ridden situation.

Section 2 presents the theory and predictions for the experimental games. Section 3 describes the experimental design. Section 4 reports the results. Section 5 provides a discussion and section 6 concludes.

## 2. Theory

### A. *The Vendetta Game*

The game has two players, indexed by $i$ = 1, 2. A player's payoff is determined by a lottery where either one player wins or nobody does. Define $p_{i,t}$ as the probability of winning a prize $S$, where $t$ is an index for round (or period). This game has multiple rounds with an endogenous horizon determined by the ending rule described below. Players move alternatingly from round to round, i.e. one player moves in even periods and the other in odd

[6] Nishimura et al. (2001) present an experiment where the efficiency losses due to overbidding can be explained by a model with spite. Saijo and Nakamura (1995) instead try to find evidence for spite in the difficult setting of public good experiment. For an example of perverse social capital, see Hargreaves Heap and Zizzo (2009).

periods. Either player can be assigned the first move. Each player receives an initial winning probability of $p_{i,0}$ at the beginning of the game. Player *i*'s payoff is $p_i{*}S$, where $p_i{*}$ is his winning probability at the end of the game, when the lottery is drawn and payoffs accrue.

The choice each player has to make is whether to steal some amount of winning probability from the other player. Stealing can occur only in blocks of $q$, i.e. a constant multiple of $q$ can be stolen. When it is player *i*'s turn to move at $t$, he or she can gain $\alpha q$ for each $q$ that is stolen from $j$, where $i \neq j$, and $\alpha < 1$. The efficiency loss from stealing is described by the conversion rate $\alpha$. The more players steal from each other, the less there is left of the total expected surplus. Stealing from $j$ is restricted by $m_t q \leq p_{j,t}$, where, $m_t$ is an integer denoting the number of $q$ blocks that $i$ steals from $j$ in round $t$, i.e. $i$ can steal integer multiples of $q$ and no more than what $j$ holds. Conversely, $n_t$ is the number of $q$ blocks that $j$ steals from $i$ in round $t$. The respective sums of $q$ blocks that are stolen by $i$ and $j$ in the game are $m = \sum_{t=1}^{T} m_t$ and $n = \sum_{t=1}^{T} n_t$ .

In every round of the game, both players are completely informed of the amount that was stolen and the standing $p$ of each player. The game ends either when there is less than $q$ left for both players to steal, or when stealing is still possible but, twice in a row, nothing is stolen by either player.

B. *Equilibrium Analysis*

For each $q$ that player $i$ steals, the vector $(\alpha q, -q)$ is added to the current state $p_t = (p_{1,t}, p_{2,t})$; each $q$ stolen by player $j$ adds $(-q, \alpha q)$. Consider a $(p_1, p_2)$ space with points spanned by these vectors stemming from the initial point $p_0 = (p_{1,0}, p_{2,0})$. Each feasible point is described by $p^{mn} = p_0 + m\cdot(\alpha q, -q) + n\cdot(-q, \alpha q)$ (see Figure 1, which is discussed in relations to one of our experimental games, Game 3, as an example). Every point that can be reached from $p_0$ by a sequence of $p_t$ $(= p^{mn}) \geq 0$ are feasible states of the game. No further stealing is possible if a *terminal state* $\overline{p} = (\overline{p}_i, \overline{p}_j) : (0,0) \leq (\overline{p}_i, \overline{p}_j) < (q, q)$ is reached. We call the set of terminal states $T$. In any game, $T$ depends on the initial state as well as $\overline{m}$ and $\overline{n}$ , which denote the respective maximal sums of $q$ blocks that can be stolen by $i$ and $j$ in the game.

*Lemma 1:* In each game, starting from a given initial point $p_0$, there is a unique terminal state $\overline{p} = p^{\overline{mn}} \in T$ that can be reached.

*Proof:* The sequence of stealing acts resulting in $p^{mn}$ is completely arbitrary, in that the same point can be reached with different sequences of stealing amounts per round, as long as the intermediate points $p_t$ have non-negative components. First, let us determine the maximal $m_1$ for which $p_{2,0} - m_1 q \geq 0$, and $m_1 \cdot (\alpha q, -q)$ results. In the following round, $j$ steals $n_2 q$ ($i$ does not move so $m_2 = 0$), and $n_2 \cdot (-q, \alpha q)$ results. Next, let us determine the maximal $m_3$ such that $p_{i,0} + m_1 \alpha q + m_3 \alpha q - n_2 q \geq 0$. Further values of $m$ are thus determined. This unique sequence either reaches a unique point in $T$, which depends only on $p_0$, or it stops before $T$ because $m_1 + m_2 + ... > \overline{m}$ or $n_1 + n_2 + ... > \overline{n}$, which contradicts our assumption that $\overline{p} \in T$. If the sequence reaches $T$, we must have $m_1 + m_2 + ... = \overline{m}$ and $n_1 + n_2 + ... = \overline{n}$, because by definition $(0,0) \leq (\overline{p}_i, \overline{p}_j) < (q,q)$ and so further acts of stealing are impossible. ■

We characterize the unique subgame perfect equilibrium of the stealing game by backward induction from $\overline{p}$. For this purpose we develop a new notation, starting from $\overline{p}$. Going backwards means adding multiples of -($\alpha q$, $-q$) and -($-q$, $\alpha q$) to $\overline{p}$. We now generally describe every feasible point on the ($p_1$, $p_2$) space as $p'_{mn} = \overline{p} - m(\alpha q, -q) - n(-q, \alpha q)$. Let us define $e_k = p'_{kk}$ and $P'_k = \{p' : \exists z = 0,1,2,... \text{ with } p' = p'_{k+z,k} \geq (0,0) \text{ or } p'_{k,k+z} \geq (0,0)\}$ as a subset of $p \neq e_k$ from which $e_k$ can be reached by one act of stealing.

*Lemma 2:* For every $p'_{mn}$ there is exactly one $e_k$ that can be reached by one act of stealing, i.e. every feasible $p'_{mn}$ belongs to exactly one $P'_k$.

*Proof:* If $m > n$ then Player 1 can steal $(m - n) \cdot q$, i.e. $(m - n) \cdot (\alpha q, -q)$ is added to $p'_{mn}$ so that $e_n = p'_{nn}$ is reached Every other amount of stealing would result in $p'_{mi}$, $i \neq m$ or $p'_{in}$, $i \neq n$.

*Proposition:* The unique subgame perfect equilibrium of this game is such that only the player who can reach an endpoint $e_k$ steals the amount required to reach this point. In all endpoints $e_k$ no stealing takes place.

*Proof:* The proposition is true for $e_0 = \bar{p}$ because the maximum possible stealing has taken place and $p \in P_0$. At a point $p' \neq e_0$ where only one of the players can steal and $e_0$ is the only feasible alternative state, he will steal to reach $e_0$ because this increases his probability of winning and a response by his coplayer is not possible. Now let us assume that the proposition has been proven up to $k - 1$. In $e_k$ no stealing occurs because if $i$ steals $m'q$, $j$ will steal back $n'q = m'q$, resulting in $e_{k-m'}$, which is an inferior endpoint where $i$ is worse off than in $e_k$. In $p \in P_k$ the player who can reach $e_k$ will steal the amount required to reach that point, say $m^k q$, because he is better off afterwards and no further stealing will occur. The player who cannot reach $e_k$ will not steal because, if he steals $n'q$, the other player will steal $(m^k + n')\cdot q$ such that they reach an endpoint $e_{k-m'}$, where both players are worse off than in $e_k$. ■

This implies that no stealing occurs in endpoints. The subgame perfect equilibrium requires the game to end at the most efficient endpoint that is feasible given the state of play and that the required number of induction steps is applied. In non-endpoint states, the smallest amount required to reach the next most efficient endpoint is stolen by the relevant player. The underlying intuition is that each player has no incentive to unilaterally deviate from an endpoint as doing so cannot possible yield to a better final winning probability because the other player can credibly retaliate. That is, the other player can do better in response to the deviation by moving to another (Pareto inferior) endpoint that makes the deviator worse off than if he or she had not deviated.

C. *Predictions for Experimental Games*

For practical experimental reasons explained in section 3, we set $q = 10\%$ in all the four games tested in the experiment. To provide a better intuition of the equilibrium analysis, we demonstrate its application to game 1 with $\alpha = 2/3$ as an example. Thereafter, we present the solutions of the other experimental games.

*Game 1: α = 2/3 and $p_0$ = (45%, 45%).*

The ($p_1$, $p_2$) space is represented by the grid shown in Figure 4, which serves as a visual aid for this example (it is also later used in Section 4 as a sample of an actual game observed in the experiment). The shaded cells represent feasible states of the game. Referring to the grid, let us now begin the backward induction process, starting from the terminal state.

*Induction round 0*: Consider all points in the region {(8.33%, 8.33%), (18.33%, 1.67%), (1.67%, 18.33%)}. In $e_0$ = (8.33%, 8.33%), which is the terminal state reached by $\overline{m} = \overline{n} = 11$, no further stealing is possible. In the other states the disadvantaged player steals a further unit of $q$ so that $e_0$ is reached.

*Induction round 1*: Consider all points in {(11.67%, 11.67%), (21.67%, 5%), (5%, 21.67%)}. The state $e_1$ = (11.67%, 11.67%) is an endpoint, because any unilateral deviation of either player by stealing one more unit of $q$ (= 10%) from the other to get to (18.33%, 1.67%) or (1.67%, 18.33%) are not equilibria, since it then pays off for the coplayer to move to the Pareto inferior endpoint $e_0$ = (8.33%, 8.33%) – as per induction round 0. In the other states in this region, the disadvantaged player steals 10% so that $e_1$ is reached.

By iteration, it can be shown that the endpoints of this game are states along the diagonal stretching from (8.33%, 8.33%) to (45%, 45%). The subgame perfect equilibrium requires players to stay at $e_{11} = p_0$ = (45%, 45%), which is the initial state of the game, i.e. $m = n = 0$. There is no incentive for unilateral deviation, which will result in subsequent movements to inferior states. The same form of reasoning applies to the remaining experimental games.

*Game 2: α = 2/3 and $p_0$ = (25%, 65%).*

The terminal state of this game is $e_0$ = (1.7%, 8.3%), which is reached with $\overline{m} = 13$ and $\overline{n} = 11$ of stealing. At the initial state (25%, 65%), player 1 can do better by stealing 2$q$ from player 2 so that the highest feasible endpoint $e_{11}$ = (38.33%, 45%) is reached. At this endpoint, player 2 has no incentive to unilaterally deviate, e.g. by stealing $q$ to increase $p_2$ to 51.67% and decrease $p_1$ to 28.33%, because player 1 can do better by counter-stealing, e.g. taking $q$ thereby increasing $p_1$ to 35% and decreasing $p_2$ to 41.67% thus reaching $e_{10}$, an endpoint in which both are left worse off relative to acquiescing at $e_{11}$. In equilibrium, player

2 will not steal as that renders $e_{11}$ unfeasible. Thus, the subgame perfect equilibrium is one where $m = 2$ and $n = 0$.

*Game 3: α = 1/3 and $p_0$ = (45%, 45%).*

Here, $e_0$ = (8.33%, 8.33%) with $\overline{m} = \overline{n} = 6$. The subgame perfect equilibrium requires players to stay at $e_6$ = $p_0$, i.e. the highest feasible endpoint is the initial state and $m = n = 0$ – no stealing ever occurs.

*Game 4: α = 1/3 and $p_0$ = (25%, 65%).*

The terminal state of this game is $e_0$ = (8.33%, 8.33%), which is reached with $\overline{m} = 7$ and $\overline{n} = 4$. Player 1 can do better relative to the initial state, which is not an endpoint, by stealing $3q$ from player 2 to gain 10% to reach the endpoint $e_4$ = (35%, 35%), following which no further stealing occurs in equilibrium, i.e. $m = 3$ and $n = 0$.

## 3. Experimental Design

The experiment was conducted in November and December of 2008 at a British university. The experiment was fully computerized. Experimental instructions were provided both on the computer screen and in print. There were 4 treatments and 6 sessions for each treatment. Each session had 8 subjects. A total of 192 subjects participated in the experiment. Subjects were randomly seated in the laboratory. Computer terminals were partitioned to avoid communication by facial or verbal means. Subjects read the experimental instructions and answered a control questionnaire, to check understanding of the instructions, before proceeding with the tasks. Experimental supervisors individually advised subjects with incorrect answers in the questionnaires. The instructions employed a neutral frame, e.g. using terms such as ‘taking away’ rather than ‘stealing’ winning probabilities. The experimental instructions are provided in an online appendix.

*The games*. The experiment was divided into four *stages*, and in each stage one game with an endogenously determined number of rounds was played. Subjects were randomly and anonymously matched anew with another subject at the start of each stage. In each session, subject pairs played one of the four treatments mentioned below four times. They were assigned an initial probability of winning a prize of 10 pounds, and were told that this assignment will be constant across all four stages of the experiment, and that the computer display showed both subjects' winning probabilities. Subjects then took turns in making choices; the first mover was chosen randomly. They were asked to choose how much winning probability to 'take away' from their coparticipant. Amounts taken had to be multiples of 10% (so they could be 0%, 10%, 20% and so on), and up to as much as the coparticipant had at present.[7] Conversion rates were either 1/3 or 2/3. Specifically, in half of the sessions in each treatment, the first two stages had a conversion rate of 1/3 and the second half one of 2/3, while the reverse order was used in the other half. An example computer display is provided in Figure 2.

(Insert Figure 2 about here.)

As with the games described in section 2, the stage terminated if both subjects either did not steal for two consecutive rounds each (for robustness to mistakes, allowing for a change of mind) or were not able to continue stealing winning probabilities. The first case occurred if both subjects could still take away winning probabilities but chose not to for two consecutive times. The second case occurred if both subjects were in a terminal state, i.e. they both had less than 10% winning probabilities: if so, no positive multiple of 10% could be stolen from both of them.

*Experimental treatments*. We used a standard between sessions 2 × 2 factorial design crossing two dimensions: the initial winning probabilities and the availability of between rounds emotion elicitation ('BREE' in what follows). Initial winning probabilities were either equal at 45% each, or unequal at 25% for one subject and 65% for the other. In both cases the sum of winning probabilities was equal to 90%. The other dimension was whether or not subjects were asked to rate the extent to which they felt one of three emotions, on a Likert scale between 0 (no emotion) and 7 (high intensity of the emotion). Subjects were advised that there were no right or wrong answers. The types of emotion were drawn from Bosman and van Winden's (2002) study. To provide balance and to avoid leading subjects in a specific emotional direction, we chose to elicit one negative emotion (anger), one positive emotion

[7] In piloting we set the unit of stealing to blocks of 5%, but found that experimental sessions ran in much excess of two hours and had to be aborted, because of the longer cycles of retaliation of counter-retaliation thus allowed. More generally, the reason for forcing stealing to be in blocks is due to practical considerations. By introducing smoothness to the action space, a longer series of smaller tit for tat steals would be possible, but this would lead to overlong experimental sessions. Furthermore, if this results in overlong feuding on the part of some pairs and not in those of others, all in the same session, there would be a large variance of activities, namely some play while others wait, possibly for a long time.

(happiness), and one neutral emotion (surprise), simultaneously presented to the subjects in alphabetical order. The BREE screen was displayed each round after the coparticipant had made his or her decision. As BREE was done repeatedly throughout the session (in the relevant treatments), only three emotions were chosen to ensure that the task was done with minimal disruption to the flow of experimental game play and to facilitate attention.

We label the four treatments EN (equality of initial winning probabilities, no BREE), IN (inequality, no BREE), EB (equality, BREE) and IB (inequality, BREE). The experimental structure is summarized in Table 1.

(Insert Table 1 about here).

*Final questionnaire*. After all four stages were completed, the computer administered a final questionnaire which asked subjects to rate the extent to which they had felt on average during the experiment each of a set of eleven emotions, again on a Likert scale between 0 (no emotion) and 7 (high intensity of the emotion). It was noted that there were no right or wrong answers. The eleven emotions were all of those used by Bosman and van Winden (2002), and were listed in alphabetical order. This final questionnaire was administered in all treatments.

*Payments*. At the end of the experiment, the computer performed random draws based on final winning probabilities to determine whether, and if so which, one of the subjects for each game in each stage won the prize draw of £10 or whether neither did. Payments were cumulative across stages, and so subjects could earn 0, 10, 20, 30 or 40 pounds based on their choices, those of their coparticipants, and luck.[8] All subjects also received a participation fee of 4 pounds. Average payments were 10 British pounds for up to about 1 ½ hours of work. Note that this low average payment is very much due to the actual incentive compatible decisions of the subjects. If subjects had played in equilibrium, each session would have lasted no longer than 45 minutes with expected average payments of approximately 21 pounds, i.e. about half the time for twice the money.

## 4. Results

We begin by reporting descriptive statistics and univariate statistical tests on the differences in behavior across treatments. This is followed by regression analysis trying to get

[8] We preferred cumulative earnings to a random task payment system because of recent experimental evidence by Stahl and Haruvy (2006) showing how the latter may overstate the measured extent of non self-interest motivated behavior.

a better understanding of how inequality in initial endowments, between-round emotional elicitation and the coplayer's actions determine stealing actions and vendetta dynamics.

A. *Overview of Behavior*

The final winning probability is the winning probability that each subject has at the end of each stage (game), when either both agents have less than 10% or they have both not stolen for two consecutive turns. Based on the analysis of section 2, the benchmark theoretical prediction of final winning probabilities is 45% in treatments with equality of initial winning probabilities (EN and EB) and an average of 38.33 % in the treatments with unequal initial winning probabilities (IN and IB).[9] Figure 3 compares mean final winning probabilities against these theoretical benchmarks, and Table 2 provides more information on them.

(Insert Figure 3 and Table 2 about here.)

*Vendettas and inefficiency*. As shown by Figure 3, in all sessions mean stealing was well in excess of the benchmarks ($p < 0.001$ in a sign test).[10] The mean absolute endpoint error term, capturing the absolute deviation of stealing from the theoretical benchmark of amounts stolen (required to reach an endpoint for that state), ranged from 26.7% in IB to 33.6% in EN. Table 2 illustrates that mean final winning probabilities were close to 10% in the treatments with no between rounds emotion elicitation (EN and IN), and still hovering at most around 20% in the treatments with emotion elicitation (EB and IB). The terminal state values presented in Table 1 indicate that in seven out of ten games ended in their terminal states, i.e. stealing recurred until both players had less than 10% and could steal no more. In the EN and IN treatments, vendettas went on until the terminal state was reached some 70% or 80% of the time even in the last stage, with the percentage being closer to the 55% or 60% range for the EB and IB treatments. If we define (expected) social efficiency in terms of the sum of the winning probabilities of the two coplayers, we can conclude that we observe vendettas that lead to socially inefficient outcomes in a majority of cases.

[9] In half of each session (i.e., when the conversion rate was 1/3) the outcome should have been (35%, 35%) and in the other half (i.e., when the conversion rate was 2/3) it should have been (45%, 38 1/3%), giving an average of 38 1/3%.
[10] All statistical tests in this section are at the session level to control for the non independence of observations within each session.

RESULT 1. There was considerable stealing in excess of prediction. Efficiency was reduced to the minimum possible level around 70% of the times as the result of vendettas.

Figure 4 exemplifies the vendetta dynamics by considering vendetta game outcomes in the EN and IB treatments under a conversion rate of 2/3.[11]

(Insert Figure 3 about here.)

The example shows that in the absence of emotion elicitation, subjects did not steal or stole only minimally only in 6 out of 48 games,[12] with 40 out of 48 games ending at the terminal state. With emotion elicitation, the picture is more nuanced, but still with a majority of games of vendettas until the terminal state (26 of them), with 9 games without stealing, mostly on the diagonal of equal final winning probabilities, and only 2 games just outside the terminal state region.

*Across treatment differences*. The example, and the casual eyeballing of Figure 3 and Table 2, also point in the direction that between rounds emotion elicitation, as present in the EB and IB treatments, reduced stealing. Overall, final winning probabilities were significantly higher in the EB and IB treatments than in the EN and IN treatments (Mann Whitney $p = 0.035$). Define *stealing ratio* as the proportion between amount stolen and the total winning probability of the coplayer. There was a significantly lower ($p = 0.011$) stealing ratio when emotions are elicited between rounds (70.3%) than otherwise (57.5%). Another way of looking at the same stylized finding is that subjects took the opportunity to steal less often, when this was available, when subject to between rounds emotion elicitation (EB: 66.1%; IB: 71.6%) than in the other treatments (EN: 82.6%; IN: 79.7%; $p = 0.033$).

RESULT 2. Efficiency was reduced less and stealing ratios were higher in treatments with between rounds emotion elicitation than in treatments where an opportunity to express emotions between rounds was not available.

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[11] The electronic appendix provides corresponding pictures for the other cases.

[12] An outcome of (41 2/3, 41 2/3) results from each subject stealing 10% from subjects comparing a 1/3 conversion rate unfavorably in stages 3 and 4 relative to the earlier more efficient rate of 2/3; and/or vice versa comparing a 2/3 conversion rate favorably in stages 3 and 4 relative to an earlier less efficient rate of 1/3. In other words, the earlier conversion rate would have a (small) impact as a preference shaping reference value (e.g., Loomes et al., 2003; Sitzia and Zizzo, 2009).

Figure 3 and Table 2 indicate only a marginal impact of unequal initial winning probabilities on final winning probabilities: there is no statistically significant difference (Mann Whitney p = 0.319). This is reflected also in similar incidences of terminal states, and the lack of statistically significant differences in, say, the stealing ratio. Equally, the extent of vendettas was insensitive to whether the conversion rate was 1/3 or 2/3. Mean stealing ratios were respectively 63.4% and 64.3% under a 1/3 and 2/3 conversion rate, and the corresponding final winning probabilities were 12.830 and 14.479 in turn: the differences are not statistically significant. There is suggestive evidence that final winning probabilities might have been slightly higher (Wilcoxon p = 0.06) when a conversion rate of 2/3 came in the first two stages and that of 1/3 came in the last two, but the effect was quantitatively small (15.095 vs. 12.214), and there was no difference in stealing ratios (2/3 first: 63%; 1/3 first: 64.8%; Wilcoxon p = 0.453).

RESULT 3. Stealing ratios were robust to initial winning probabilities, the two conversion rates and order effects. Final winning probabilities were robust to initial winning probabilities and the two conversion rates, while a quantitatively small order effect may have been present.

*Time trend*. Table 2 shows that final winning probabilities and the incidences of the terminal state were very similar across all treatments in stage 1, and the divergence between EB and IB on the one side and EN and IN on the other – as mirrored in Result 2 above – emerged only from stage 2. Taking a closer look at the data, we find that there is no systematic pattern in the time trend of mean stealing ratios in the set of sessions with no between rounds emotion elicitation (Spearman ρ is negative in 7 sessions, positive in 5 sessions: sign test p = 0.774). There is, however, a clear downward trend in sessions with between rounds emotion elicitation (ρ is negative in 10 sessions out of 12: sign test p = 0.039). This suggests a dynamic effect of allowing subjects to vent emotions between rounds, a dynamic effect that we shall consider further in the regression analysis. Table 2 also shows, however, that the decrease in stealing ratio and increase in final winning probabilities in the EB and IB treatments tends to level out with time. This is also true in the aggregate: for example, the mean final winning probability was 9% in stage 1, and increased to 14% in stage

2, but only by 2% to 16% in stage 3, before leveling out completely at 15% in stage 4 (see Table 2 and Figure 5).

(Insert Figure 5 about here.)

RESULT 4. There was a statistically significant reduction in stealing ratios with time in sessions with between rounds emotion elicitation, although the effect tends to level out.

*Emotions and behavior*. Was there any apparent relationship between elicited emotions and vendettas? Figure 6 shows a session level scatterplot between round emotion elicited anger and mean stolen ratio: expressed within experiment anger was strongly positively correlated with the stolen ratio (Spearman $\rho = 0.601$, $p = 0.039$); there was conversely no significant correlation of the stealing ratio with within experiment surprise ($\rho = 0.420$, $p = 0.175$) or happiness ($\rho = -0.329$, $p = 0.297$).

(Insert Figure 6 about here.)

This correlation analysis cannot disentangle direction of causality: the correlation is certainly suggestive that expressed anger caused vendetta stealing, but it is also plausible that vendettas caused anger. The regression analysis below will try to disentangle the two. However, there is no significant relationship between stealing ratio and end of experiment elicited anger (and, if anything, it operates in the opposite direction: $\rho = - 0.265$, $p = 0.211$), suggesting the potential usefulness of between round measures of emotions.

None of the end of experiment measures was correlated at the 5% significance level with stealing, with the exception of end of experiment anxiety ($\rho = 0.446$, $p = 0.029$). To determine or interpret what within experiment measure of anger capture, it is useful to see how such measures correlate with end of experimental measures. Intriguingly, within experiment measured anger had higher correlations with end of experiment measures of envy ($\rho = 0.765$, $p = 0.004$), irritation ($\rho = 0.783$, $p = 0.003$) and jealousy (0.835, $p = 0.001$) than it did with end of experiment measured anger (0.678, $p = 0.015$). This suggests that within experiment measured anger might, at least in part, be capturing more complex emotions (such as envy or jealousy) that may be driving the anger.

RESULT 5. Between rounds elicited anger responses are correlated with stealing behavior, unlike end of experiment anger responses. They may proxy for other negative emotions.

B. *Regression Analysis*

We run our regression analysis using the stealing ratio as a dependent variable. The use of the ratio variable rather than the absolute level of stealing is essential because, obviously, as stealing occurs, the cap on the absolute later value of possible stealing changed as the game progressed. There are a large number of observations at 0 or 1 (corresponding to no stealing and full stealing): for example, in models 1 and 1' of Table 3, out of 2572 observations, 529 corresponded to zero stealing and 1329 to full stealing. Because of this, we employ Tobit regressions, and further control for either subject level or session level specific effects.[13]

(Insert Table 3 about here.)

*All treatments*. Table 3 contains our overall regressions, Model 1 and 1', looking at the impact of the main treatment variables: *BREE* (= 0 in the treatments without between rounds emotion elicitation; = 1 in the presence of between rounds emotion elicitation), *Inequality* (= 0 if initial winning probabilities of both subjects are equal; 1 if otherwise), *ConversionRate* (= 1/3 or 2/3). It also controls for whether, in the treatment with unequal initial winning probability, the disadvantaged subject behaves differently (*Disadvantaged* = 1 for initially disadvantaged subjects, = 0 otherwise); for whether first movers behave differently (*FirstMover* = 1 for the first mover in each stage); and for whether there are time trends (by the means of *Stage* = 1, 2, 3, or 4, and *StageSquared*, the square of Stage to control for non-linearity in the time trend).

time effects with a *Stage* (= 1, 2, 3, or 4) variable and a *StageSquared* (= Stage$^2$) – this quadratic term allows for the non-linear time trend shown in Figure 5. A potentially important component of causal effect in the vendetta dynamics that is an obvious proxy for the subject's anger or other negative emotions is the variable *LStolen*, the proportion of one's own winning probability last stolen by the coplayer. Besides including *LStolen*, we also include interaction terms of *BREE* with *Stage*, *StageSquared* and *Inequality.*

[13] We have tried other specifications, including multi-level random effects regressions simultaneously controlling for subject and session level non independence of observations, and our key findings are generally robust.

Table 3 shows no evidence that inequality of initial endowments, or the conversion rate, or being the first mover, matter. *LStolen* is strongly positive and statistically significant: an increase of the stealing ratio by the coplayer by 10% induces a *more than proportional* vendetta response, with the stealing ratio increasing by roughly 15% in response.

RESULT 6. Having been a victim of stealing, i.e. having been stolen from, induces retaliatory vendettas on a more than one to one basis. The stealing ratio increases by approximately 15% for each 10% of winning probability stolen from the subject.

*Stage* and *StageSquared* are not statistically significant as such, but the interaction terms are significant: these findings replicate Result 4: there is a reduction in stealing ratios with time in treatments with between rounds emotion elicitation only (the negative *BREE* × *Stage* coefficient), though this reduction progressively levels out and disappears (the positive *BREE* × *StageSquared* coefficient).

*Emotion variables regressions*. If we restrict our attention to the treatments with between rounds emotion elicitation (EB and IB), we can use the elicited emotional responses as independent variables in our regression analysis. The regressions of Table 4 include the lagged between rounds verbal emotion responses in terms of *Happiness*, *Anger* and *Surprise*.

(Insert Table 4 here.)

Models 2 and 2' exclude *LStolen*; Models 3 and 3' include it back in. The other models add interaction terms between *LStolen* and the verbal emotion responses. Surprise is generally statistically insignificant, but the interaction term from Models 6 and 6' suggests that declaring oneself surprised in the past might reduce stealing in response to stealing by the coplayer. With the only exception of Model 5', greater declared happiness reduces later stealing across all regression models ($p < 0.001$ in all but two models where $P < 0.1$). However, the greater declared happiness actually *increases* stealing if one got stolen more (*LStolen* × *LHappiness*, $p < 0.05$ in Model 4 and $p = 0.001$ in Model 4'). Anger tends to predict future stealing ($p < 0.01$ in Model 2 and $p < 0.1$ in Model 2'), but, in the presence of *LStolen*, its predictive power with subject level random effects disappears.[14] As noted earlier,

[14] This is one result that appears sensitive to the regression specification, for it is not replicated with session level random effects. The results of multi-level random effects regressions controlling for subject and session level

the stealing that one has been a victim of can be by its own right a proxy for one's negative emotions: this connection between *LStolen* and verbally elicited anger responses suggests that verbally elicited anger responses are a less effective measure than the behavioral proxy constituted by *LStolen*. More interesting, and chiming with the results on LStolen × *LHappiness*, is the finding that *LStolen* × *LAnger* has a negative statistically significant coefficient ($p < 0.05$ in Model 5 and $p = 0.001$ in Model 5'): the greater the expressed anger, the *less* subjects will react to the stealing by coplayers by engaging in retaliatory vendettas.

*Emotion Index regressions*. The findings on the interaction terms are consistent with the hypothesis that, the more open subjects are in venting their negative emotional state and channeling it this way, the less aggressive they later are in terms of retaliatory vendettas. This venting hypothesis, in turn, would explain the effectiveness of the between rounds emotion elicitation mechanism in reducing social efficiency losses, as noted in Result 2.

To test the venting hypothesis further, we computed an *Emotion Index* variable equal to the average of anger and the *negative of* happiness.[15] The *Emotion Index* acts as a simple proxy of the extent subjects let themselves express negative emotions. Table 5 contains the regressions with the *Emotion Index*, without *LStolen* (Models 7 and 7'), with *LStolen* (Models 8 and 8') and with also the interaction term *Emotion Index* × *LStolen*. There is consistent evidence that, the greater the negative emotions, the greater the stealing that ensues ($p < 0.001$ in all models but Model 8', where $p < 0.05$). However, the interaction term *Emotion Index* × *LStolen* is negative and statistically significant ($p < 0.001$); furthermore, the size of the coefficient off-weights the positive coefficient on *Emotion Index*. Venting off one's negative emotional state helps reduce retaliatory vendettas.

RESULT 7. There is support for the emotion venting hypothesis. For any given amount one has been stolen of, channeling one's negative emotional states in verbal declarations of anger and unhappiness helps subjects contain (to some degree) the scale of the retaliatory vendetta, thereby increasing efficiency.

## 5. Discussion

non independence of observations simultaneously mirror those of the subject level random effects Tobit regressions, however.

[15] For example, if a subject stated 6 for Anger and 2 for Happiness, then her Emotion Index = (6 – 2)/2 = 2.

Our key finding is that subjects tend to engage in retaliatory vendettas until overall efficiency is reduced to the lowest possible level in around 80% of the cases when subjects are not allowed to express their emotions between rounds and in around 60% of the cases when they can. Equilibrium analysis predicts either zero or minimal efficiency losses – games should end at equitable and more efficient endpoints where even a self interested subject is better off by not unilaterally deviating. Invoking the alternative assumption of inequality aversion yields the same predictions because equilibrium outcomes, namely the endpoints, are equitable in nature. In games with initial unequal distributions of winning probabilities, we theoretically expect an act of stealing by the initially disadvantaged subject to reach the endpoint (thus equalizing), while the other does not steal. In contrast, we typically observed bouts of stealing and counter-stealing by both subjects resulting in the depletion of the expected surplus until there was nothing left to steal. More surprisingly, we observed a similar display of mutual aggression in games that started with equal winning probabilities across players, i.e. at endpoints where the game should have ended without any stealing. These results are also robust to the parameter variations in conversion rates.[16] Instead, it was the allowance for subjects to vent their emotions that made a significant difference: it reduced stealing.

The incidence of feuds is significantly more extensive than that observed in the experiments of Engelmann and Nikiforakis (2008) and Hopfensitz and Reuben (2009), where potential indefinite punishment and counter-punishment were allowed after social dilemma play took place. There are a number of differences between their setup and ours. In their experiments, punishments and counter-punishments were in response to preceding play in a game of cooperation, i.e. a social dilemma where cooperation is socially desirable. Due to structural differences, in their games neither cooperation nor retaliation was expected, whereas in our games cooperation was expected but retaliation was not. These differences might have induced certain fairness perceptions and primed subjects towards cooperating

[16] The large extents of stealing explain for why it was difficult to find a difference between treatments with initial equality versus those of initial inequality: since so much was already being stolen in the inequality treatment not more could have been stolen in the equality treatment. Support for this argument, which we call a 'ceiling effect', might be found in regression Models 2 and 7, where stealing is found to increase with inequality ($p < 0.05$) when subjects are allowed to vent their anger and so relatively less was stolen in, at least, the equality treatment thereby reducing this ceiling effect.

(e.g., Dufwenberg et al., 2008; Tan and Zizzo, 2008).[17] In the same way in which public good contribution experiments may induce an inbuilt cognitive demand towards cooperating (e.g., Ferraro and Vossler, 2008; Zizzo, 2009), the salience of conflict in our setting of prize competition might create an inbuilt cognitive demand towards acting aggressively. We believe that situations with a conflict-ridden frame – despite a structure which theoretically yields cooperation – of the kind we model are, by their own rights, stylized representations of a number of real world contexts, which may have as a result the same inbuilt demand.[18]

The behavior that we have observed may be due to a combination of various factors such as rivalry and associated clusters of negative emotions (e.g. Herrmann and Orzen, 2008), preventive retaliation against expected aggressive coplayer behavior (e.g. Zizzo and Oswald, 2001), noisy play (e.g. Breitmoser et al., 2009), or limited depth of reasoning (e.g. Stahl and Wilson, 1994). Since fewer induction steps are required for reaching inferior endpoints, relative to those required for reaching superior ones, a possible explanation for why games end in inferior states is that subjects have limited depths of reasoning. Unless the population contains a majority incapable of even one inductive round of best response, however, limited depth of reasoning cannot fully explain why we observe that most games cease at the terminal state (which requires no inductive reasoning). Since actions are perfectly observable, a subject needs only to best respond to his lower level coplayer (as opposed to forming beliefs of his coplayer's rationality), and so games should cease at endpoints determined by the subject capable of less rounds of inductions in that pair. Most cases ceased at the terminal state, but almost none at endpoints requiring one or two induction steps, even though from other studies we know that subjects are capable of at least one or two steps (e.g. Stahl and Wilson, 1994; 1995) and that those incapable of even one step hardly exist (e.g. the level-0 types in Crawford and Iriberri, 2007). Further, the observed extent of stealing and final outcomes were not significantly different across different games where, theoretically, the same number of induction steps should yield outcomes with different expected surpluses. Finally, there is no *a*

[17] There are other differences between our prize competition game and the social dilemmas of Engelmann and Nikiforakis (2008) and Hopfensitz and Reuben (2009). For example, in Hopfensitz and Reuben (2009), if a subject does not punish, no counter-punishment is possible, therefore removing an obvious source of feuds (namely, preventative attacks) and creating an obvious reason not to feud (namely, the fear of losses).

[18] This is what Zizzo (2009) labels an external validity defense, and may apply equally to social dilemmas and to prize competition games. Furthermore, in our setup there is experimental evidence that is difficult to reconcile with an initial nudge to steal, including why, once it gets started, feuds tend to continue until the end, or why venting is effective in reducing it. Zizzo (2009) contains a methodological discussion of how indirect experimental evidence can be used to address demand criticisms.

*priori* link established by the literature between the depth of reasoning and emotions that can explain our finding of less stealing when subjects are allowed to vent their emotions. Our results clearly demonstrates the intrinsic fragility of the equilibrium solution in a prize competition setup: small deviations from it for whatever reason lead to self-perpetuating feuds resembling anger drive tit for tat.[19]

The desire for revenge has been associated to activation of the dorsal striatum area of the brain (de Quervain et al., 2004).[20] It is an evolutionarily stable trait that human beings may share with some higher primates such as *bonnet macaque* monkeys (Silk, 1992). Venting provides an opportunity for subjects to channel their feelings, which is an alternative to that of engaging in destructive behavior.[21] That the size of venting is inversely related to later aggression is consistent with the traditional catharsis theory perspective in psychology that expressions of anger help to restrain eventual expressions of anger (see Lee, 1995). Bushman et al. (1999) and Bushman (2002) have cast doubt on the theory in experiments that use a punching bag task as a way of expressing anger followed by emotion of anger as a dependent variable. Our experiment differs from theirs because of the mildness of the emotional expression technique (simple emotion elicitation) and for using *behavior* (as opposed to verbal responses) as the dependent variable showing the effectiveness of the technique. If it is validated in future work, our research has obvious potential applications for reducing conflict, e.g. in business settings. For example, providing some non-destructive ways for workers to channel their own negative feelings can be used by managers as a tool to reduce the incidence of aggressive behavior on the workplace. Staff appraisal mechanisms operating in U.K. universities are an obvious example of institution that helps achieve just that.

Of course, the effectiveness of venting was limited, and not all feuds may follow a cycle of retaliation and counter-retaliation. For example, using field data, Jaeger and Paserman (2007) have cogently argued that the Israeli-Palestinian conflict does not: while Israeli responses follow from Palestinian attacks, Palestinian responses do not seem to follow from Israeli attacks. A key feature of this environment, recognized by Jaeger and Paserman, is the

[19] Our finding of potentially more than proportional retaliation (Result 6) is in line with Hopfensitz and Reuben's (2009) result that, when it occurred, punishment was more than proportional.

[20] For a discussion of the neuroeconomics of anger, see Zizzo (2004).

[21] An alternative explanation for why there were lower efficiency losses under BREE is that emotion elicitation allowed subjects to cool down between tasks. If this were the case, however, we would expect that stolen ratios would be a negative function of the amount of time taken to make a decision, whereas the reverse was generally true: subjects who stole more spent more time making a decision

asymmetry (in technological capabilities and decision making mechanisms) of the positions of Israeli and Palestinians. This feature is absent from our context.

Our experimental paradigm provides a simple benchmark that could be used and expanded to consider the role of additional mechanisms and features that may enable to reduce or prevent socially inefficient feuding. Many such mechanisms, we expect, already exist in the real world, and explain why some societies or organizational environments may be less prone to vendettas than others. That being said, our experiment provides additional support for the view that, when agents are put in settings where feuds are allowed to develop, they may well do so thus leading to very negative outcomes for everyone concerned. Put it differently, our results echo those for example of Abbink et al. (2009) and Herrmann and Orzen (2008) on the importance of better understanding *homo rivalis* and on how this aspect of human nature may interact with the economic situation at hand, which may not always lend itself to be seen as a game of cooperation.

Our experiment further complements research showing that emotions can be a relevant motivator for action in relevant economic settings (e.g., Frank, 1988; Bosman and van Winden, 2002; Hopfensitz and Reuben, 2007; Reuben and van Winden, 2008). It also has three methodological lessons for the design of experiments using verbal emotion elicitation techniques. First, and least controversially, end of experiment elicitation is clearly less effective than emotion elicitation as the experiment progresses. Second, care needs to be paid that verbally elicited emotions are not proxies of other emotional states; for example, we found that BREE anger was more correlated with end of experiment envy or contempt than it was with end of experiment anger. Third, emotion elicitation as the experiment progresses, while more effective, distorts behavior. In our experiment we addressed this by having control treatments without BREE that enabled us to isolate the impact of this distortion, but this has not necessarily been the case in the existing literature (e.g., Reuben and van Winden, 2008). As argued in Zizzo (2009), experimenter demand effects of this kind do not necessarily imply that experiments that do not control for them are not meaningful or relevant, but nevertheless their impact should obviously be identified.

## 6. Conclusions

Vendettas occur in the real world in many settings where rivals compete for a prize (e.g., winning an election or a war or a competition in prestige with multiple factions) and thus engage in retaliatory aggressive behavior (e.g., negative advertising or military aggression) that risk causing long term damage to their own prospects. We presented an experiment where two players had an initial probability of winning a single prize. Initial winning probabilities were either equal or unequal depending on the treatment. We found that between around 60% and 80% of the games ended up with both subjects being left with less than 10%, and average end of stage winning probabilities were between 10% and 20%. This implied an efficiency loss of as much as 2/3 of the initial winning probabilities.

Our evidence suggests that, when people are put into settings where feuds are allowed to develop, they may well do so well beyond what is predicted by rational self interest. Tools such as punishment opportunities that are useful for cooperation in some contexts might have disastrous implication in this context: the *homo rivalis* aspect of human nature may interact with the economic situation at hand, which may not always lend itself to be seen as a game of cooperation. Negative mood, as operationalized by our anger and unhappiness measure, was a predictor of future aggressive behavior.

Our experimental paradigm provides a simple benchmark for further studies on the determinants of feuding and on how to reduce socially inefficient feuds. We found that venting was partially effective in reducing feuds as the experiment progressed, and noted both the methodological implications that this may have for the design of experiments and for the practical organizational applications it may have in the reduction of conflict. Our results are stronger than those found in other experiments where feuding has been allowed, such as Engelmann and Nikiforakis (2008) and Hopfensitz and Reuben (2009), where feuds have been allowed in connection to social dilemmas, unlike our setup. Obviously, further experimental research is needed.[22]

[22] One direction this would be useful would be to determine how feuding is a function of the game context and of institutional design features. Another direction would be to study feuds with between rounds belief elicitation, as obviously beliefs may play a significant role in the choice whether, and the extent to which, to feud, and may interact with emotions.

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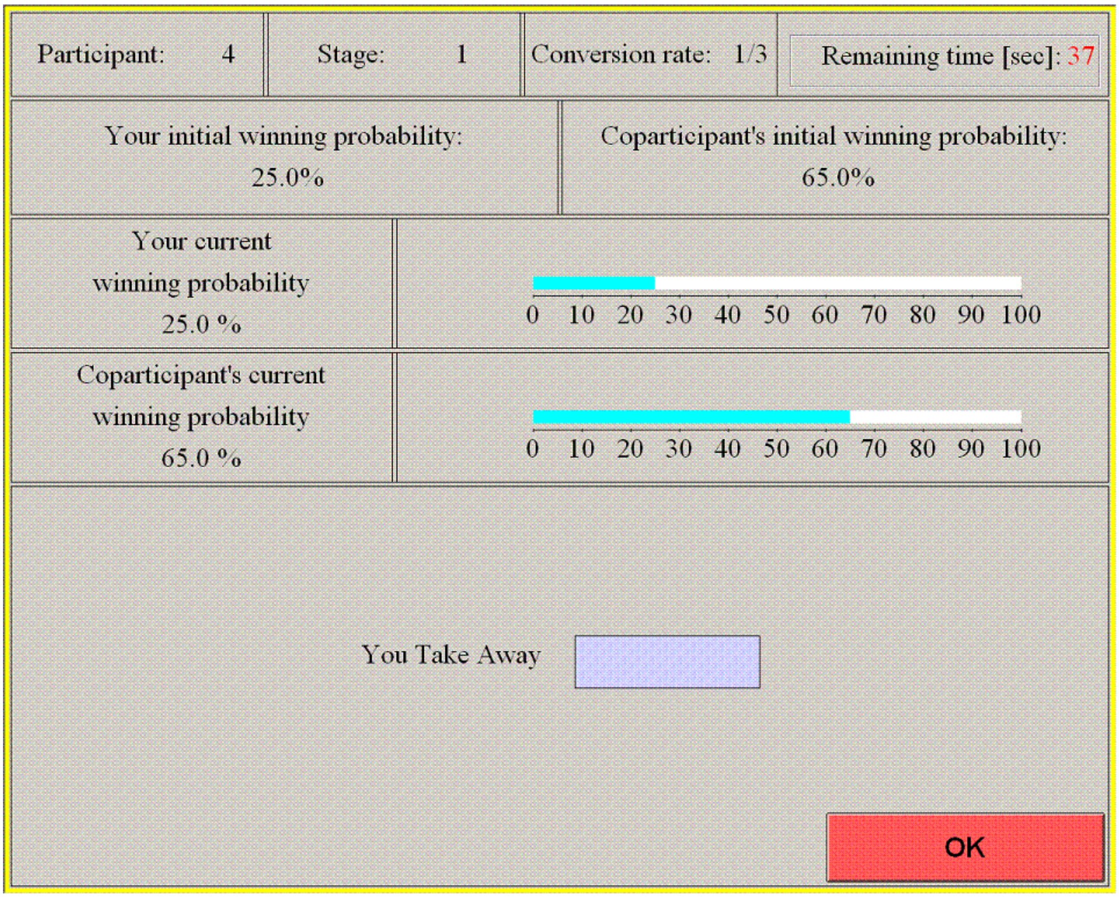
FIGURE 1. EXAMPLE OF FEUDING GAME

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **61.7** | | | | | | | | | | | | | | | | | | | |
| **58.3** | | 0,4 | | | | | | | | | | | | | | | | | |
| **55** | | | | | 0,3 | | | | | | | | | | | | | | |
| **51.7** | | | | | | | | 0,2 | | | | | | | | | | | |
| **48.3** | | | 1,4 | | | | | | | | 0,1 | | | | | | | | |
| **45** | | | | | | 1,3 | | | | | | | | **0,0** | | | | | |
| **41.7** | 2,5 | | | | | | | | 1,2 | | | | | | | | | | |
| **38.3** | | | | 2,4 | | | | | | | | **1,1** | | | | | | | |
| **35** | | | | | | | 2,3 | | | | | | | | 1,0 | | | | |
| **31.7** | | 3,5 | | | | | | | | **2,2** | | | | | | | | | |
| **28.3** | | | | | 3,4 | | | | | | | | 2,1 | | | | | | |
| **25** | | | | | | | | **3,3** | | | | | | | | 2,0 | | | |
| **21.7** | | | 4,5 | | | | | | | | 3,2 | | | | | | | | |
| **18.3** | | | | | | **4,4** | | | | | | | | 3,1 | | | | | |
| **15** | 5,6 | | | | | | | | 4,3 | | | | | | | | 3,0 | | |
| **11.7** | | | | **5,5** | | | | | | | | 4,2 | | | | | | | |
| **8.3** | | | | | | | 5,4 | | | | | | | | 4,1 | | | | |
| **5** | | **6,6** | | | | | | | | 5,3 | | | | | | | | 4,0 | |
| **1.7** | | | | | 6,5 | | | | | | | | 5,2 | | | | | | |
| | **1.7** | **5** | **8.3** | **11.7** | **15** | **18.3** | **21.7** | **25** | **28.3** | **31.7** | **35** | **38.3** | **41.7** | **45** | **48.3** | **51.7** | **55** | **58.3** | **61.7** |

*Notes*: The figures assumes initial winning probabilities of 45%, a conversion rate α = 1/3 and q = 10% (i.e., players can steal in blocks of 10%). The (m, n) pairs on the grid correspond to all possible outcomes of the game, where m represents the number of 10% blocks stolen by player i and q represents the number of 10% blocks stolen by player j to get to any given outcome. The terminal state is where (m, n) = (6, 6), i.e. it corresponds to an outcome where no further stealing is possible.

FIGURE 2. SAMPLE COMPUTER DISPLAYS



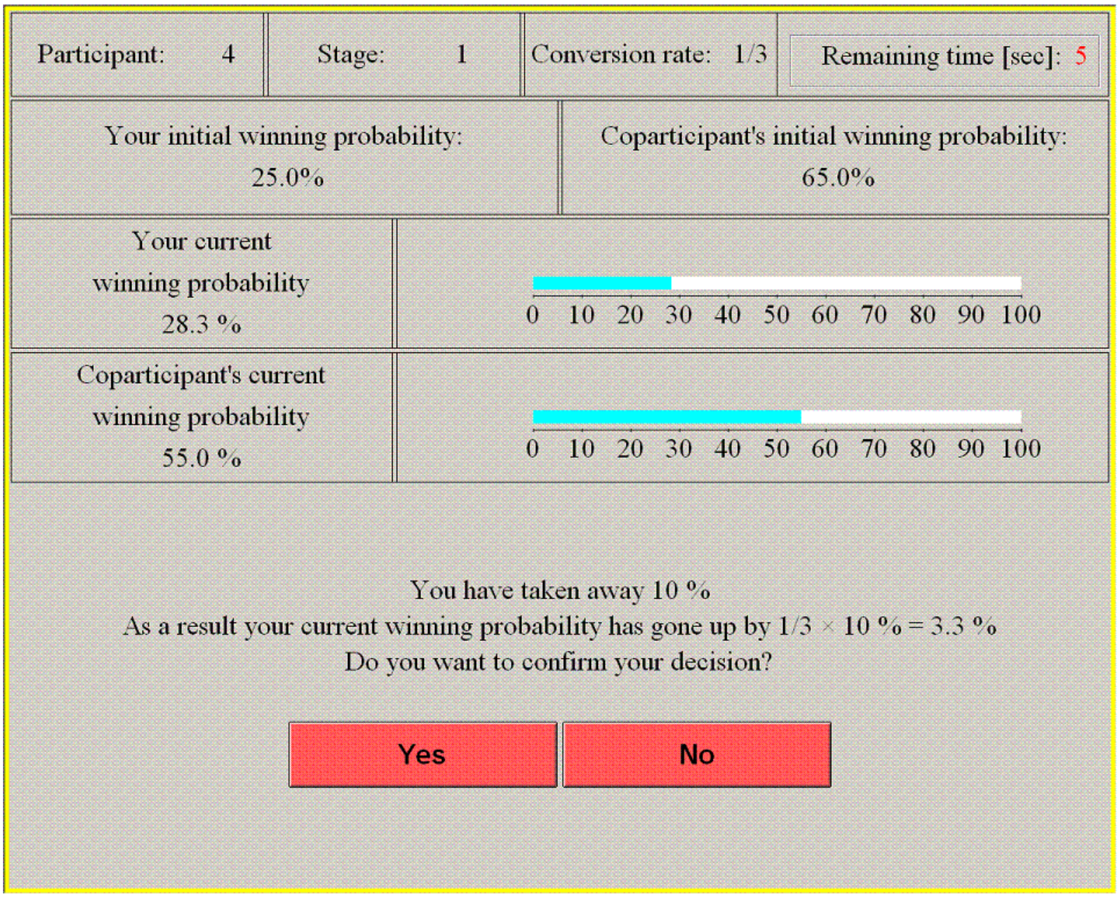
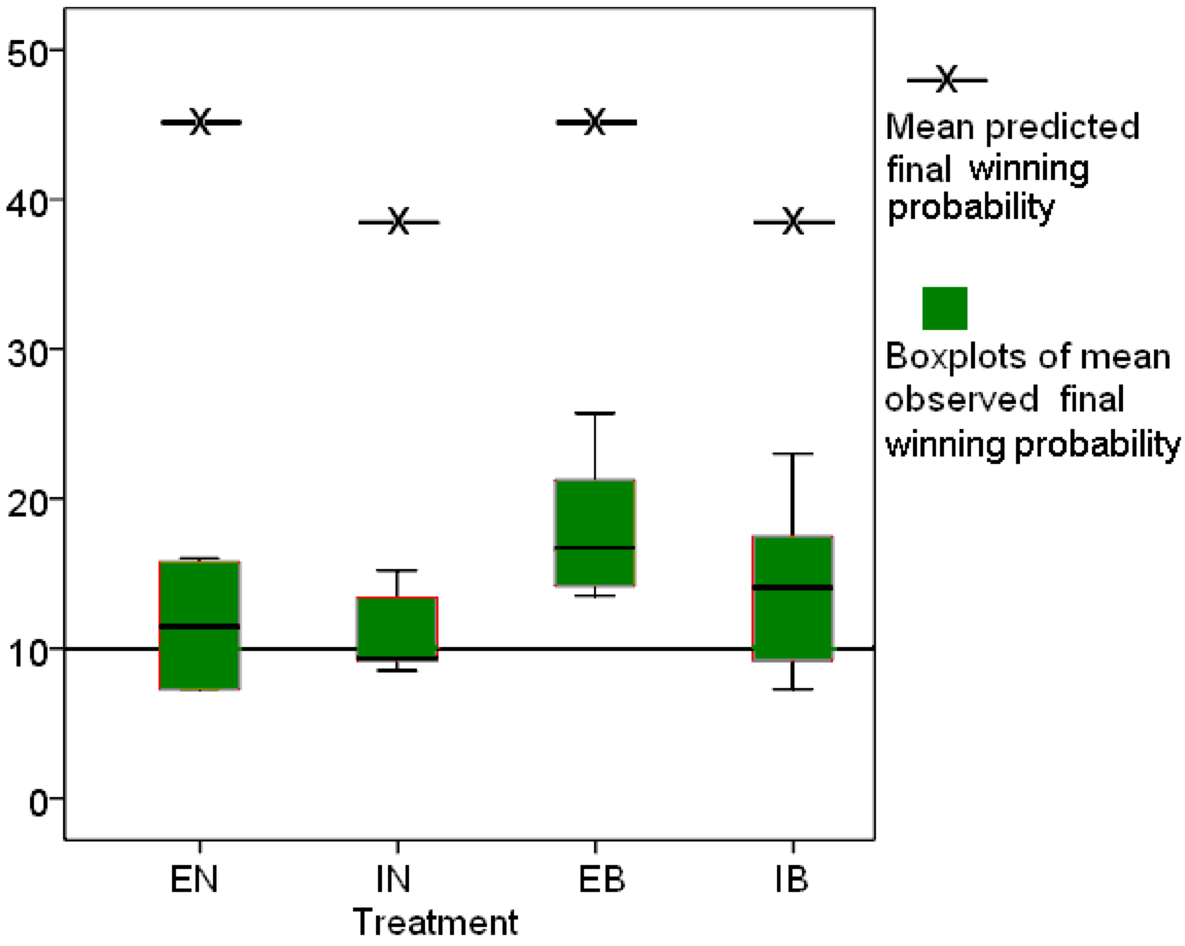



FIGURE 3. MEAN FINAL WINNING PROBABILITIES BY SESSION




*Notes*: the mean predicted final winning probability is 38 1/3% for each session. The boxplots provide information on mean observed final winning probabilities by session (*n* = 6 in each treatment). The median value is the middle bar, the edges of the box represent the 25th and 75th percentile and whiskers include all remaining observations.

FIGURE 4. SAMPLE GAME OUTCOMES

(a) *EN treatment (conversion rate 2/3)*

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **61.7** | | | | | | | | | | | | | | | | | | | |
| **58.3** | | | | | | | | | | | | | | | | | | | |
| **55** | | | | | | | | | | | | | | | | | | | |
| **51.7** | | | | | | | | | | | | | | | | | | | |
| **48.3** | | | | | | | | | | | | | | | | | | | |
| **45** | | | | | | | | | | | | | | **9** | | | | | |
| **41.7** | | | | | | | | | | | | | | | | | | | |
| **38.3** | | | | | | | | | | | | 1 | | | | | | | |
| **35** | | | | | | | | | | | 1 | | | | | | | | |
| **31.7** | | | | | | | | | | | | | | | | | | | |
| **28.3** | | | | | | | | | 2 | | | | | 1 | | | | | |
| **25** | | | | | | | | | | | | | | | | | | 1 | |
| **21.7** | | | | | | | | | | | | | | | | | | | |
| **18.3** | | | | | | | | | | | | | | | | | | | |
| **15** | | | | | 2 | | | | | 1 | | | | | | | | | |
| **11.7** | | | | 3 | | | | | | | | | | | | | | | |
| **8.3** | | | 26 | | | | | | | | | | | | | | | | |
| **5** | | | | | | | | | | | | 1 | | | | | | | |
| **1.7** | | | | | | | | | | | | | | | | | | | |
| | **1.7** | **5** | **8.3** | **11.7** | **15** | **18.3** | **21.7** | **25** | **28.3** | **31.7** | **35** | **38.3** | **41.7** | **45** | **48.3** | **51.7** | **55** | **58.3** | **61.7** |

(b) *EB treatment (conversion rate 2/3)*

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.7** | | | | | | | | | | | | | | | | | | | |
| **58.3** | | | | | | | | | | | | | | | | | | | |
| **55** | | | | | | | | | | | | | | | | | | | |
| **51.7** | | | | | | | | | | | | | | | | | | | |
| **48.3** | | | | | | | | | | | | | | | | | | | |
| **45** | | | | | | | | | | | | | | **5** | | | | | |
| **41.7** | | | | | | | | | | | | | 1 | | | | | | |
| **38.3** | | | | | | | | | | | | | | | | | | | |
| **35** | | | | | | | | | | | | | | | | | | | |
| **31.7** | | | | | | | | | | | | | | | | | | | |
| **28.3** | | | | | | | | | | | | | | | | | | | |
| **25** | | | | | | | | | | | | | | | | | | | |
| **21.7** | | | | | | | | | | | | | | | | | | | |
| **18.3** | | | | | | | | | | | | | | | | | | | |
| **15** | | | | | 1 | | | | | | | | | | | | | | |
| **11.7** | | | | | | | | | | | | | | | | | | | |
| **8.3** | | | 40 | | | | | | | | | | | | | | | | |
| **5** | | | | | | | | | | | | | | | | | | | |
| **1.7** | | | | | | | | | | | 1 | | | | | | | | |
| | **1.7** | **5** | **8.3** | **11.7** | **15** | **18.3** | **21.7** | **25** | **28.3** | **31.7** | **35** | **38.3** | **41.7** | **45** | **48.3** | **51.7** | **55** | **58.3** | **61.7** |

*Notes*: Numbers on each grid represent the number of times (out of 48 cases) a final winning probability pair (x%, y%) was obtained (where, for unequal final outcomes, x%, on the horizontal axis, is the final value for the more successful agent and y%, on the vertical axis, that for the less successful one). 0.3 (0.7) decimals are one decimal approximation of 1/3 (2/3). For example, in the EB treatment (conversion rate 2/3) in 40 cases both players ended up with 8 1/3. Only shaded cells can be reached from the initial point (45, 45).

FIGURE 5. MEAN FINAL WINNING PROBABILITY OVER TIME

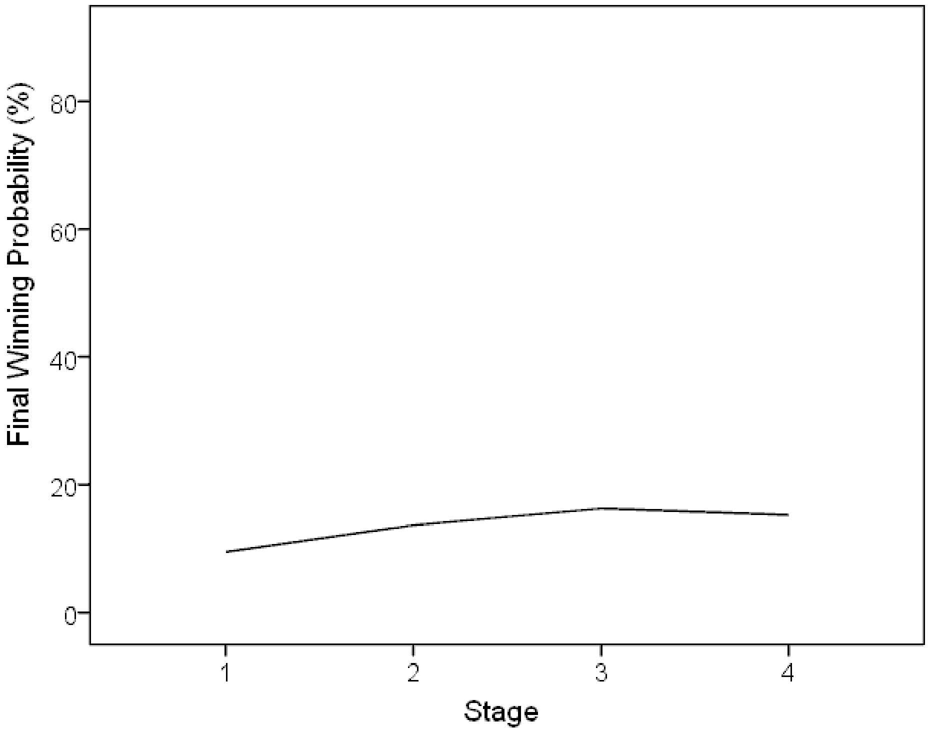
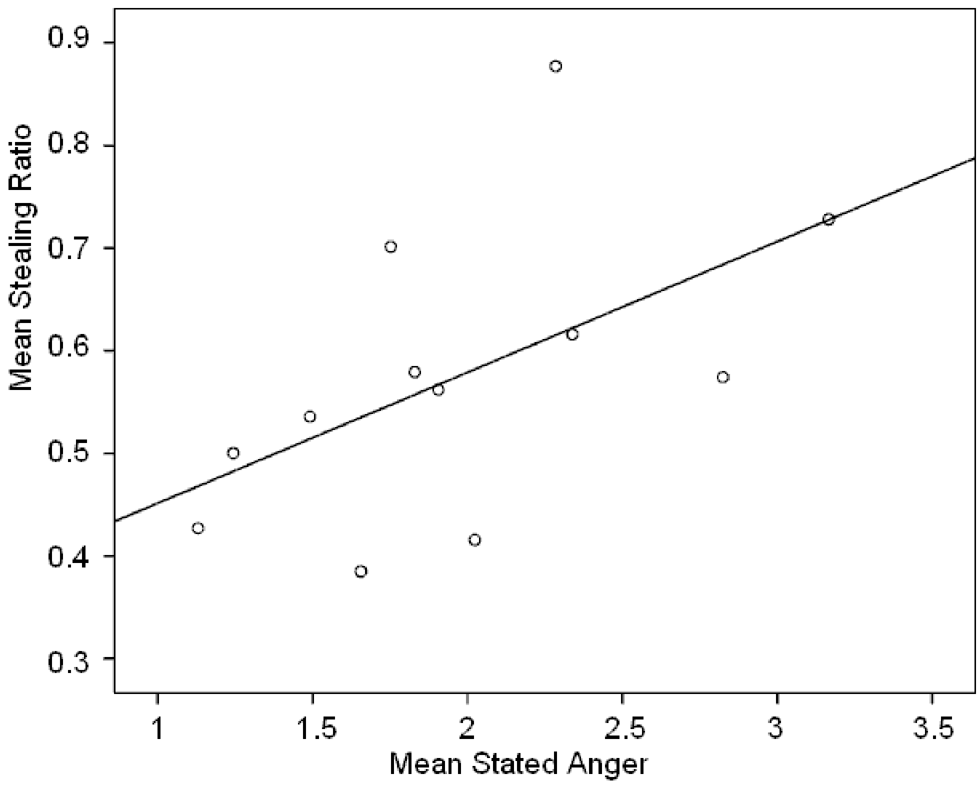



FIGURE 6. MEAN STATED ANGER AND MEAN STEALING RATIO BY SESSION




*Note*: each dot on the scatterplot corresponds to a session with between rounds emotion elicitation, and therefore where an estimate of mean stated anger can be computed from between rounds emotion elicitations.

TABLE 1. EXPERIMENTAL STRUCTURE

| | | Initial winning probabilities | |
|---|---|---|---|
| | | Equality | Inequality |
| BREE | No | Equality, no BREE (EN)<br>6 sessions | Inequality, no BREE (IN)<br>6 sessions |
| | Yes | Equality, BREE (EB)<br>6 sessions | Inequality, BREE (IB)<br>6 sessions |

*Notes*: BREE stands for between rounds emotion elicitation. In each of the four treatments 3 sessions had a conversion rate of 1/3 in the first two stages and 2/3 in the last two stages, and the remaining three had the reverse order.

TABLE 2. MEAN FINAL WINNING PROBABILITY, STEALING RATIO AND TERMINAL STATE

Final winning probability

| | Treatment | | | | |
|---|---|---|---|---|---|
| Stage | EN | IN | EB | IB | Overall |
| 1 | 10.417 | 8.264 | 9.792 | 9.236 | 9.427 |
| 2 | 11.25 | 9.792 | 17.083 | 16.458 | 13.646 |
| 3 | 10.972 | 11.25 | 24.097 | 18.819 | 16.285 |
| 4 | 13.611 | 14.097 | 21.111 | 12.222 | 15.26 |
| Overall | 11.563 | 10.851 | 18.021 | 14.184 | 13.655 |

Stealing ratio

| | Treatment | | | | |
|---|---|---|---|---|---|
| Stage | EN | IN | EB | IB | Overall |
| 1 | 0.742 | 0.769 | 0.683 | 0.773 | 0.742 |
| 2 | 0.697 | 0.727 | 0.5 | 0.6 | 0.631 |
| 3 | 0.714 | 0.741 | 0.383 | 0.545 | 0.596 |
| 4 | 0.64 | 0.621 | 0.431 | 0.604 | 0.574 |
| Overall | 0.698 | 0.715 | 0.499 | 0.631 | 0.636 |

Terminal state

| | Treatment | | | | |
|---|---|---|---|---|---|
| Stage | EN | IN | EB | IB | Overall |
| 1 | 0.833 | 0.792 | 0.833 | 0.792 | 0.813 |
| 2 | 0.875 | 0.833 | 0.542 | 0.583 | 0.709 |
| 3 | 0.875 | 0.75 | 0.417 | 0.542 | 0.646 |
| 4 | 0.792 | 0.708 | 0.542 | 0.625 | 0.667 |
| Overall | 0.844 | 0.771 | 0.583 | 0.635 | 0.708 |

*Notes*: the final winning probability values refer to the winning probability at the end of each stage; the terminal state values refer to the proportion of games in each stage which end up in a terminal state, that is with both final winning probabilities being less than 10%; stealing ratio values refer to the mean proportion of the coplayer's winning probability that was stolen during each stage.

TABLE 3. TOBIT REGRESSIONS ON STEALING RATIO, ALL TREATMENTS

| | Model 1 | | | Model 1' | | |
|---|---|---|---|---|---|---|
| | β | *t* | *P* | β | *t* | *P* |
| BREE | 0.103 | 0.4 | 0.689 | 0.066 | 0.4 | 0.689 |
| Inequality | 0.009 | 0.07 | 0.943 | 0.004 | 0.07 | 0.943 |
| ConversionRate | -0.019 | -0.15 | 0.884 | 0.093 | -0.15 | 0.884 |
| FirstMover | 0.019 | 0.41 | 0.684 | 0.024 | 0.41 | 0.684 |
| Disadvantaged | -0.128 | -1.1 | 0.273 | -0.104 | -1.1 | 0.273 |
| Stage | 0.058 | 0.38 | 0.702 | 0.026 | 0.38 | 0.702 |
| StageSquared | -0.022 | -0.74 | 0.459 | -0.016 | -0.74 | 0.459 |
| LStolen | 1.475 | 22.39 | 0 | 1.549 | 22.39 | 0 |
| BREE x Stage | -0.45 | -2.12 | 0.034 | -0.395 | -2.12 | 0.034 |
| BREE x StageSquared | 0.087 | 2.09 | 0.036 | 0.078 | 2.09 | 0.036 |
| BREE x Inequality | 0.175 | 1.05 | 0.292 | 0.198 | 1.05 | 0.292 |
| Constant | 0.231 | 1.13 | 0.257 | 0.13 | 1.13 | 0.257 |
| Log Likelihood | -2046.872 | | | -2154.157 | | |

*Notes*: $n$ = 2572 (of which 529 censored at 0, 1329 censored at 1). Model 1 controls for subject level non independence, and model 1' for session level non independence of observations.

Table 4 – Tobit Regressions on Stealing Ratios Employing Emotion Responses

| | Model 2 | | | Model 2' | | | Model 3 | | | Model 3' | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | β | *t* | *P* | β | *t* | *P* | β | *t* | *P* | β | *t* | *P* |
| Inequality | 0.466 | 2.41 | 0.016 | 0.445 | 1.87 | 0.061 | 0.246 | 1.73 | 0.084 | 0.246 | 1.89 | 0.059 |
| ConversionRate | -0.111 | -0.53 | 0.595 | 0.012 | 0.05 | 0.959 | -0.029 | -0.15 | 0.877 | 0.057 | 0.29 | 0.775 |
| FirstMover | 0.068 | 0.92 | 0.359 | 0.081 | 1.14 | 0.254 | 0.008 | 0.12 | 0.902 | -0.025 | -0.4 | 0.693 |
| Disadvantaged | -0.385 | -1.74 | 0.082 | -0.213 | -2.09 | 0.036 | -0.175 | -1.07 | 0.283 | -0.089 | -0.98 | 0.328 |
| Stage | -0.802 | -4.72 | 0 | -0.796 | -4.37 | 0 | -0.429 | -2.78 | 0.005 | -0.416 | -2.57 | 0.01 |
| StageSquared | 0.124 | 3.75 | 0 | 0.121 | 3.43 | 0.001 | 0.069 | 2.28 | 0.023 | 0.067 | 2.12 | 0.034 |
| LHappiness | -0.217 | -9.25 | 0 | -0.205 | -9.73 | 0 | -0.094 | -4.45 | 0 | -0.093 | -4.93 | 0 |
| LAnger | 0.065 | 3.1 | 0.002 | 0.033 | 1.75 | 0.081 | -0.007 | -0.39 | 0.7 | -0.036 | -2.08 | 0.037 |
| LSurprise | -0.003 | -0.18 | 0.853 | 0.027 | 1.53 | 0.126 | 0.005 | 0.32 | 0.751 | 0.023 | 1.46 | 0.145 |
| LStolen | | | | | | | 1.319 | 12.49 | 0 | 1.419 | 12.89 | 0 |
| Constant | 2.137 | 8.03 | 0 | 1.999 | 6.57 | 0 | 0.701 | 2.87 | 0.004 | 0.595 | 2.35 | 0.019 |
| Log Likelihood | -1235.37 | | | -1298.439 | | | -1077.16 | | | -1119.464 | | |

| | Model 4 | | | Model 4' | | | Model 5 | | | Model 5' | | | Model 6 | | | Model 6' | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | β | *t* | *P* | β | *t* | *P* | β | *t* | *P* | β | *t* | *P* | β | *t* | *P* | β | *t* | *P* |
| Inequality | 0.228 | 1.63 | 0.103 | 0.225 | 1.76 | 0.078 | 0.229 | 1.63 | 0.103 | 0.223 | 1.72 | 0.085 | 0.239 | 1.66 | 0.096 | 0.239 | 1.84 | 0.066 |
| ConversionRate | -0.007 | -0.04 | 0.971 | 0.076 | 0.38 | 0.706 | -0.049 | -0.26 | 0.796 | 0.025 | 0.12 | 0.903 | -0.056 | -0.3 | 0.768 | 0.041 | 0.21 | 0.837 |
| FirstMover | -0.001 | -0.02 | 0.986 | -0.042 | -0.67 | 0.506 | 0.008 | 0.12 | 0.901 | -0.02 | -0.33 | 0.745 | 0.008 | 0.12 | 0.906 | -0.021 | -0.34 | 0.737 |
| Disadvantaged | -0.149 | -0.93 | 0.352 | -0.361 | -2.23 | 0.026 | -0.16 | -0.99 | 0.32 | -0.384 | -2.38 | 0.018 | -0.183 | -1.12 | 0.265 | -0.418 | -2.58 | 0.01 |
| Stage | -0.392 | -2.52 | 0.012 | 0.058 | 1.83 | 0.067 | -0.407 | -2.63 | 0.009 | 0.061 | 1.92 | 0.055 | -0.428 | -2.78 | 0.005 | 0.067 | 2.13 | 0.033 |
| StageSquared | 0.063 | 2.07 | 0.038 | -0.151 | -5.79 | 0 | 0.065 | 2.14 | 0.032 | -0.086 | -4.55 | 0 | 0.068 | 2.27 | 0.023 | -0.096 | -5.05 | 0 |
| LHappiness | -0.13 | -4.78 | 0 | -0.03 | -1.77 | 0.077 | -0.088 | -4.13 | 0 | 0.063 | 1.8 | 0.071 | -0.099 | -4.65 | 0 | -0.032 | -1.86 | 0.063 |
| LAnger | -0.005 | -0.26 | 0.793 | 0.026 | 1.68 | 0.093 | 0.055 | 1.54 | 0.124 | 0.025 | 1.63 | 0.102 | 0 | 0.01 | 0.988 | 0.057 | 2.21 | 0.027 |
| LSurprise | 0.009 | 0.54 | 0.592 | -0.059 | -0.64 | 0.519 | 0.008 | 0.5 | 0.618 | -0.067 | -0.74 | 0.46 | 0.055 | 2.14 | 0.032 | -0.091 | -1 | 0.319 |
| LStolen | 1.127 | 8.35 | 0 | 1.104 | 7.95 | 0 | 1.455 | 11.47 | 0 | 1.622 | 12.43 | 0 | 1.511 | 11.3 | 0 | 1.554 | 11.17 | 0 |
| LStolen x LHappiness | 0.089 | 2.16 | 0.031 | 0.136 | 3.36 | 0.001 | | | | | | | | | | | | |
| LStolen x LAnger | | | | | | | -0.085 | -2.06 | 0.04 | -0.134 | -3.23 | 0.001 | | | | | | |
| LStolen x LSurprise | | | | | | | | | | | | | -0.087 | -2.5 | 0.012 | -0.059 | -1.67 | 0.094 |
| Constant | 0.744 | 3.04 | 0.002 | 0.691 | 2.72 | 0.006 | 0.598 | 2.4 | 0.016 | 0.454 | 1.77 | 0.077 | 0.611 | 2.48 | 0.013 | 0.531 | 2.08 | 0.038 |
| Log Likelihood | -1074.802 | | | -1113.656 | | | -1075.031 | | | -1114.186 | | | -1074.007 | | | -1118.062 | | |

*Notes*: Models 2 and 2': $n$ = 1361 (of which 370 censored at 0, 604 censored at 1); other models (including lagged stealing ratios, and therefore dropping first stealing decision): $n$ = 1298 (of which 345 censored at 0, 576 censored at 1). For each model pair ($x$, $x$'), Model $x$ controls for subject level and Model $x$' for session level non independence of observations.

TABLE 5 – TOBIT REGRESSIONS ON STEALING RATIOS EMPLOYING EMOTION INDEX

| | Model 7 | | | Model 7' | | | Model 8 | | | Model 8' | | | Model 9 | | | Model 9' | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | β | *t* | *P* | β | *t* | *P* | β | *t* | *P* | β | *t* | *P* | β | *t* | *P* | β | *t* | *P* |
| Inequality | 0.404 | 2.08 | 0.038 | 0.385 | 1.63 | 0.102 | 0.201 | 1.4 | 0.163 | 0.193 | 1.51 | 0.132 | 0.192 | 1.38 | 0.169 | 0.189 | 1.48 | 0.14 |
| ConversionRate | -0.093 | -0.45 | 0.656 | 0.048 | 0.21 | 0.831 | -0.023 | -0.12 | 0.904 | 0.079 | 0.39 | 0.695 | -0.034 | -0.18 | 0.855 | 0.039 | 0.2 | 0.844 |
| FirstMover | 0.068 | 0.92 | 0.359 | 0.105 | 1.48 | 0.14 | 0.008 | 0.12 | 0.904 | -0.007 | -0.1 | 0.917 | 0 | -0.01 | 0.995 | -0.022 | -0.36 | 0.722 |
| Disadvantaged | -0.388 | -1.73 | 0.084 | -0.216 | -2.11 | 0.035 | -0.172 | -1.03 | 0.301 | -0.084 | -0.92 | 0.36 | -0.138 | -0.86 | 0.389 | -0.045 | -0.5 | 0.618 |
| Stage | -0.762 | -4.48 | 0 | -0.746 | -4.08 | 0 | -0.394 | -2.56 | 0.01 | -0.372 | -2.3 | 0.022 | -0.355 | -2.3 | 0.021 | -0.322 | -2 | 0.046 |
| StageSquared | 0.119 | 3.59 | 0 | 0.116 | 3.25 | 0.001 | 0.064 | 2.12 | 0.034 | 0.061 | 1.94 | 0.053 | 0.057 | 1.88 | 0.061 | 0.051 | 1.64 | 0.102 |
| Emotion Index | 0.274 | 12.35 | 0 | 0.234 | 10.92 | 0 | 0.08 | 3.67 | 0 | 0.05 | 2.43 | 0.015 | 0.173 | 4.91 | 0 | 0.192 | 5.44 | 0 |
| LStolen | | | | | | | 1.343 | 12.69 | 0 | 1.453 | 13.08 | 0 | 1.285 | 12.14 | 0 | 1.339 | 12.14 | 0 |
| Emotion Index x LStolen | | | | | | | | | | | | | -0.164 | -3.44 | 0.001 | -0.239 | -5.05 | 0 |
| Constant | 1.754 | 7.1 | 0 | 1.617 | 5.6 | 0 | 0.444 | 1.97 | 0.049 | 0.291 | 1.23 | 0.22 | 0.507 | 2.25 | 0.025 | 0.42 | 1.77 | 0.076 |
| Log Likelihood | -1244.674 | | | -1312.034 | | | -1081.898 | | | -1129.2022 | | | -1075.844 | | | -1115.8272 | | |

*Notes*: Models 7 and 7': $n$ = 1361 (of which 370 censored at 0, 604 censored at 1); other models (including lagged stealing ratios, and therefore dropping first stealing decision): $n$ = 1298 (of which 345 censored at 0, 576 censored at 1). For each model pair ($x$, $x$'), Model $x$ controls for subject level and Model $x$' for session level non independence of observations.