LOSSES, GAINS, AND ASYMMETRY IN THE 1-SHOT PRISONER'S DILEMMA GAME

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THESIS

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Abstract

Factors affecting cooperation are rarely studied in the context of the 1-shot prisoner's dilemma (PD) game. Many real-world interactions, however, are 1-time events, so it is important to determine how well factors studied in iterated games apply to the 1-shot PD. In the present within-subject study we systematically examine the interaction between 4 factors on cooperation in the PD that have only been studied haphazardly in the literature: symmetry, the number of negative (column) payoffs, the player's relative position in asymmetric games, and social value orientation.

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Introduction

Social dilemmas arise when individuals must choose between actions that optimize their personal good or the good of the group; regardless of what others do, individuals are better off following their self-interest than acting in the collective interest (Krueger & Acevado, 2007). Formally, social dilemmas are characterized by two properties: (a) the social payoff to each individual for defecting behavior is higher than the payoff for cooperative behavior, regardless of what other society members do, yet (b) all individuals in the society receive a lower payoff if all defect than if all cooperate (Dawes, 1980).

For example, suppose you are a member of a team of students working on a project to which everyone is supposed to contribute and for which everyone will receive the same grade. If you slack off and let others do the work, you can focus on other courses, where your grade depends solely on your own effort. If everyone in the group followed the same reasoning, however, the group project would not get done and you would fail along with the others in your group. In this case, contributing is the individual's cooperative solution and free riding is the individual's defection solution.

To study the logic of social dilemmas, stripped of their real-world complexity, social scientists have invented a variety of games (Kollock, 1998). In order to control for emotions, values, and norms that human participants carry with them, experimental games often have a human decision maker (DM) unknowingly play the game with a computer (PC) with a pre-programmed strategy. These studies help researchers understand the underlying logic of the dilemmas and develop hypotheses about real-life conditions that would tip the balance toward or away from cooperation.

The most commonly studied social-dilemma games are two person games called prisoner's dilemma games (PDs). The name arises from a historical hypothetical dilemma in which each of two prisoners must choose between remaining silent and confessing. If both remain silent, both will get a short prison sentence based on other chargers. If both confess, they will both get a moderately long sentence. If only one confesses, that one will be granted immunity and gets no sentence but the partner will get a long sentence. They can neither communicate, nor learn the other's choice until both have chosen.

When played in the psychology lab, the game's stakes are changed from prison time to monetary rewards or losses. On each trial, each player can choose an action - cooperate for the common good or to defect from the common good. Neither player learns the other's choice until both have responded, and the payoff to each player depends on the combination of their two actions. The payoff matrix has the following characteristics: (a) the highest individual payoff goes to the player who defects while the other cooperates (Temptation, T); (b) the lowest individual payoff goes to the player who cooperates while the other defects (Sucker, S); (c) the highest total payoff to the two players combined occurs if both cooperate (Reward, R); and (d) the lowest total payoff occurs if they both defect (Punishment, P). These four values and their relationship are represented as a matrix in Figure 1.

The game is a social dilemma because the highest individual payoff to either player comes from defecting, but the highest total payoff to the two combined comes from cooperating. If the other player defects, one gets more for defecting than for cooperating; if the other cooperates, one still gets more for defecting than for cooperating; but if both defect, each gets less than they would have if both had cooperated.

Since a DM who always defects will necessarily win more money than one who always cooperates, logic compels both players to defect and they usually do - despite the higher payoff they would have received if they had cooperated.

The goal of the present study is to improve our understanding of the psychological processes involved in social dilemmas and situational judgments by manipulating factors that may tip the balance toward or away from cooperation. The following section reviews some of these factors.

Previous literature

In the one-trial (1-shot) version of the game, each player plays only once with another player. In the iterated PD, two players play the same game repeatedly with each other for a series of trials. In both cases the players are anonymous and cannot communicate and coordinate their choices.

Asymmetry and Relative Position

Almost all studies investigating the PD use identical payoffs for both players (symmetric payoffs), but many real-world interactions involve different outcomes for the two players, even in cases of joint cooperation and joint defection (Beckenkamp, Hennig-Shmidt, & Maier-Rigaud, 2007). For example, regardless of the players' joint choices in Figure 2's asymmetric matrix, Participant B's payoffs for each outcome (R, S, T, or P) will always be x units lower than the payoffs for the same actions for Participant A. There is little literature on asymmetric PDs, with substantial differences in the number of asymmetric payoffs, the methods by which symmetric games were transformed, and the magnitude of the transformation. When asymmetric games are studied, asymmetry is seldom treated as a factor in its own right, with direct comparisons possible between corresponding symmetric and asymmetric games. We are unaware of any within-subject studies where subjects played both a symmetric and a matching asymmetric game.

Introducing asymmetry into the PD also creates a distinction between the two players, now called the High and the Low player, with the payoffs of the High player always being greater than, or equal to, the payoffs of the Low player[1]. Cooperation rates are typically lower for the Low player, leading to overall lower cooperation in the asymmetric game than in the symmetric one.

For example, Schellenberg (1964) studied the effects of asymmetry on cooperation in prisoner dilemma games with strictly positive matrices. In Experiment 1, participants played the same game (either symmetric or asymmetric) 20 times with feedback against a live stooge with predetermined response patterns. While overall cooperation rates were the same in the symmetric (32%) and asymmetric games (33%), participants in the asymmetric game who were assigned to the higher payoff condition cooperated significantly more often (43.5%) than those assigned to the lower payoff condition (22.5%), across all conditions.

These results were not replicated in Experiment 2, where the games were played with participant-pairs rather than an experimenter stooge. There was no significant difference between cooperation rates in the symmetric and asymmetric games and no significant difference in the cooperation rate between the two players in the asymmetric game. Schellenberg attributes this discrepancy to the low cooperation rates of the chosen games in general and the low cooperation rates of the players with lower payoffs driving down the cooperation rates of those with higher payoffs.

Lave (1965) had an asymmetric treatment (DMs were exclusively human) which modified the symmetric game by multiplying the payoffs of one of the players by 2.5 in case of

[1] A non-linear transformation could produce an asymmetric matrix where payoff dominance is not so clear.

mutual cooperation. Lave found a decline of cooperation from 57.5% to 50% compared with the symmetric treatment.

Cooperation rates may have also been depressed by the lack of tangible outcomes for choices, i.e., the experiment was solely for course credit. It has been found that in the PD and other dilemma games (e.g., Gallo & McClintock, 1965; McClintock & McNeal, 1966) that participants cooperate more when real money is at stake, compared to imaginary outcomes. Radlow (1965), using a random-trial reward technique, also found that cooperation increased as the matrix values more closely approximated the actual payoffs.

Negative payoffs

Another intermittently studied factor affecting cooperation is the sign of the payoff. As many researchers study social dilemmas from a gain-loss perspective, they have focused on the comparison of all positive to all negative payoffs matrices and in a few cases on mixed matrices with two positive and two negative payoffs. The findings on the effects of sign are highly equivocal, with no consistent effects (or lack thereof). Interestingly, unbalanced matrices e.g., 3 positive / 1 negative payoff, or vice versa, are never considered.

Lave (1965) ran a prisoner's dilemma experiment with several symmetric treatments which always offered fixed positive payoffs for mutual cooperation (*R*) and fixed negative payoffs for mutual defection (*P*). The treatments varied in either 1) the severity of the negative payoff for the sucker's bet (*S*), i.e., cooperating when one's partner (sometimes a PC) defected, or 2) the temptingness (*T*) of the positive payoff should one double-cross the partner, i.e., defect when he/she cooperates. Not surprisingly, Lave found that when other factors were held constant, cooperation rates improved as the severity of *S* decreased, and declined as *T* increased.

Jones, Steele, Gahagan, and Tedeschi (1968) studied cooperation in the symmetric PD by examining two factors: the absolute magnitude of the payoff values (10s, 100s, and 1000s) and (R-P)/(T-S), the ratio of the differences among the 4 matrix payoffs (.1, .5, or .9). There is roughly a linear relationship between the (R-P)/(T-S) index and cooperation rate – people cooperate more when playing games with a higher index value. Of particular interest to the present study, was that the 10s magnitude level contained mixed positive and negative payoffs, with R and T always positive and S and T always negative (2 positive, 2 negative payoffs), while the other magnitude levels had all positive payoffs. Cooperation was significantly higher for matrices with mixed payoffs than for the all-positive matrices. It was also found that presence of negative payoffs led to more cooperative behavior as the ratio increases in value, as compared with those matrices where all the payoffs were positive. Unfortunately, the findings are hindered by the confounding of negative payoffs and magnitude.

Asymmetry, Relative Position and Sign

Only one study (Sheposh & Gallo, 1973) has compared choice behavior in the symmetric and asymmetric PD with the two other factors introduced earlier: 1) the sign of the payoffs (in their study, all positive values or 2 positive and 2 negative values), and 2) the strength of the DM's position (lower or higher potential payoff in the asymmetric game). The study used a between-subject design.

Like Schellenberg (1964, Experiment 1) and Lave (1965), Sheposh and Gallo found a main effect for asymmetry, with the asymmetric condition producing significantly less cooperation (31.11%) than the symmetric condition (39.18%). Also similar to Schellenberg's experiment with predetermined stooge responses, (a) symmetry interacted with player position, with row-players as likely to cooperate as column-players (39.76% vs. 38.6%) in the symmetric game, but low-players significantly less likely to cooperate than high-players (25.11% vs. 37.1%) in the asymmetric game. They found no interaction between symmetry and the sign of the payoff, nor any main effect of the sign of the payoff.

In interpreting their findings, the authors examined the DM's conditional probability of defecting given the other player's previous decisions. They found that whereas the DM was significantly less likely to defect following cooperative action than after a defection in the symmetric game, the low-player's defection rate in the asymmetric game was independent of the other player's previous choice. They tentatively inferred from this pattern that concern with relative outcomes, particularly with being surpassed by the other player, rather than maximizing one's own outcomes, was the primary motivator for low-players' low cooperation in the asymmetric game. Individual differences in weighing own- and other-outcomes would be taken up by research in social value orientation.

Social Value Orientation

Another factor which may affect cooperative behavior is social value orientation (SVO), a preference for a particular pattern of self-other outcome distributions. According to interdependence theory (Kelley & Thibaut, 1978), social motives induce a transformation of a given social dilemma into an "effective matrix" where both one's own outcome and the other's outcomes are accorded subjective weight (Ws and Wo respectively, with $-1 \leq$ Ws and Wo ≤ 1), and the weighted outcomes are summed. A three-category typology of motives has been empirically supported (Deutsch, 1960): cooperation, individualism, and competition. For those with a cooperative motive (pro-socials), the weights are equal and positive (Ws = Wo = 1); for individualists, the self is weighted positively, but the other is ignored (Ws = 1 and Wo = 0); and for competitors, the self is weighted positively and the other is weighted negatively (Ws = 1 and Wo = -1). In all cases, the individual chooses the strategy that yields the highest value by their effective matrix.

De Dreu and McCusker (1997) examined the effects of gain-loss framing (as a between-subject factor) on cooperation in the 1-shot (non-iterated) symmetric PD. A gain frame is equivalent to all-positive payoffs and a loss frame to all-negative payoffs. In experiment 1, social-value orientation was used as post-hoc blocking factor for the framing manipulation, and in experiments 2 and 3, social motive was directly manipulated via the instructions as an additional between-subjects factor. No main effect was found for gain-loss framing (there was no significant difference between the all-positive and all-negative conditions) in either experiment. However, there was a significant interaction between outcome frame and social motive - whether assessed post-hoc or directly manipulated - whereby pro-socials cooperated significantly more often in the loss frames (all-negative payoffs) than they did in gain frames (all-positive payoffs). The opposite pattern was found for individualists, who cooperated significantly less often in the loss frames than they did in gain frames. Framing had no effects on competitors (possibly due to floor effects). There was also a main effect of social motive, with pro-socials cooperating significantly more often than individualists or competitors.

De Dreu and McCusker suggest that discrepancies in the effect (or lack thereof) of the sign of the payoff may partly be explained by inadvertent manipulation of social motive in the instructions to participants. They classified 18 previous (peer-reviewed, psychology-journal) research articles according to their frames (all-positive or all-negative payoffs) and found that when frame did not affect cooperation, the instructions had been neutral; when the loss frame reduced cooperation, the instructions were primarily individualistic; and when the loss frame reduced cooperation, instructions were primarily pro-social. However, in both Sheposh's and Gallo's (1973) and Jones et al.'s (1968) studies (which they did not include), the instructions to participants were neutral and pre-play contact was minimized.

Overview of the present study

Factors affecting cooperation are rarely studied in the context of the 1-shot PD game. Instead, most studies have their subjects play a single experimental condition iterated multiple times and use the number of cooperative choices as the dependent variable. Many real-world interactions, however, are 1-time events, so it is important to determine how those factors apply to the 1-shot PD. In the present study we systematically study the interaction between 4 factors on cooperation in the PD: symmetry/asymmetry between the payers' payoffs, the number of negative payoffs of the column player, the player's relative position, and the actor's SVO.

Hypotheses

SVO. Players with a cooperative SVO should cooperate significantly more often than players with an individualist or competitive SVO. SVO will interact with (a)symmetry and relative position as detailed below.

Negative payoffs. We hypothesize that the equivocal effects shown in the literature were due to the demand characteristics of previous studies and expect to find neither a main effect of the number of negative payoffs nor any interaction with any other factor.

Symmetry and Position. We expect to find an interaction between symmetry and position: In symmetric games, there will be no consistent difference in cooperation rate when a subject plays in the row position or the column position; in asymmetric games, subject should cooperate significantly more often when playing in the higher position then when playing in the lower position.

Asymmetry and Position and SVO. Asymmetry is created by holding the row position payoffs constant and varying the payoffs of the column player. We distinguish between two types of asymmetric games: In RowPositve games the row player always receives the highest payoffs available (all positive) and in RowNegative games the row player always receives the lowest payoffs available (all negative). We expect that subjects will cooperate significantly more in the RowPositive games than in the RowNegative games when they enjoy the higher relative position, but that their cooperation rate will not differ between the RowPositive and RowNegative games when they are in the lower relative position. This interaction should be moderated by SVO, with the difference in cooperation between the RowPositive and RowNegative games being largest for those with a cooperative SVO when playing in the higher relative position but larger for those with a competitive SVO when playing in the lower relative position.

Decision Time. In addition to studying cooperation rate across conditions, we also examine decision time as a proxy for cognitive complexity. The introduction of asymmetry and negative payoffs should make games more difficult to evaluate. Particularly, decision times should increase as the number of negative payoffs increase and RowNegative asymmetric games should take longer to respond to than RowPositive or symmetric games.

Methods

Design

We examined the effects of three within-subject factors on the odds of players cooperating in the PD: symmetry/asymmetry between the players, the number of negative payoffs of the column player, and the player's relative position.

To investigate these factors we designed 13 PD games which systematically varied symmetry, the number of negative payoffs, and the player's relative position (see Table 1 for all 13 distinct combinations of the three factors). The (R-P)/(T-S) index (Rapoport & Chammah, 1965), a predictor of cooperative play in the PD based on the ratio of the differences of payoff values of all the games was 0.5. See Figures 1 and 2 for an explanation of the RSTP labels in the context of a symmetric PD and an asymmetric PD, respectively. All games were produced through linear transformations of the payoffs of the Row and / or the Column players. See Appendix A for the derivation of the game matrices and a listing of the 13 games played.

The games can be described in terms of the following factors:

(1) Symmetry had 3 levels: Symmetric, Asymmetric: RowPositive, and Asymmetric: RowNegative;

(2) The number of negative column payoffs ranged from 0 to 4, i.e., from all-positive to all-negative; the sign of row payoffs decreased systematically in Games 1-5, was always positive in Games 6-9 and was always negative in Games 10-13;

(3) Relative to the column player, the row player's payoff's were equal (Games 1-5), higher (Games 6-9) or lower (Games 10-13)

The experiment followed a within-subject design, with participants playing all 13 PDs. The games were presented in random order, and for each game subjects were randomly assigned as the row or the column player (High or Low position in asymmetric games). Participants were told that each 1-shot game was being played with another (randomly selected) participant whose identity and choices were to remain anonymous (No feedback). In fact, players were not matched - we were interested in their individual pattern of responses across the 13 matrices.

Additionally, prior to playing the PDs, participants' Social Value Orientation (SVO) was assessed by a 24-item paper-and-pencil version of Liebrand's RING measure (Liebrand & McClintock, 1988). Participants made 24 choices between two own/other outcome allocations, with each pair of outcomes sampled from the circumference of a circle in the own/other outcome plane consisting of outcomes to self on the horizontal axis, and outcomes to other on the vertical axis. Specific own/other outcomes are defined as points in this two dimensional plane, with the center of the $15.00 radius circle coinciding with the origin of the plane and denoting $.00 for self and $.00 for other.

Each pair consisted of two sampled own/other outcome allocations. For example, participants had to choose between either A: $14.50 for me, and -$3.90 for other, or B: $13.00 for me and -$7.00 for other. For each of the 24 pairs of outcomes, subjects were instructed to choose the outcome distribution they most preferred. Adding up the chosen amounts separately for self and for other provides an estimate of the weights assigned by the subject to own and other's payoffs. These weights are used to estimate the direction of the subject's value vector extending from the origin of the own/other outcome plane. All vectors with angles between 112.5 and 67.5 (North = 90; East = 0) degrees were classified as altruistic; those between 67.5 and 22.5 degrees as cooperative; those between 22.5 and 337.5 degrees as individualistic; and those between 337.5 and 292.5 degrees as competitive. See Figure 3 for a plane with these regions identified.

The length of a value vector provides a measure of the consistency of participants' choices in this linear choice model, with random choices resulting in an expected vector length of zero. The maximum vector length is twice the radius of the circle, so dividing the length by 30 gives a reliability index from 0 to 1. The observed mean reliability was .85 (*SD* = .17).

Participants

The participants were 294 (155 UIUC and 139 NWU) undergraduate students recruited via advertisements on campus bulletin boards and web sites on a first-come-first-serve basis. The UIUC sample had a mean age of 20.70 (*SD* = 2.46) and consisted of 48 males and 107 females; The NWU sample had a mean age of 19.76 (*SD* = 2.07) and consisted of 56 males and 83 females. The UIUC pool was primarily psychology majors and NWU pool was primarily business majors. Participants were compensated 5-13 dollars for their time (30-60 minutes), with the payment corresponding to their cooperation/defection decisions (in conjunction with hidden, randomly chosen responses from the PC) on a subset of the 13 matrices.

Procedures

The experiment was conducted online (http://labdb6.psych.uiuc.edu/) but all subjects were run in the lab. At least four participants completed the experiment simultaneously to maintain the illusion that each game was being played with another random-selected participant rather than the PC. Following completion of the SVO questionnaire (only the last 121 participants)[2], they were logged onto privately-enclosed lab PCs and completed 4 practice matrices to familiarize themselves with the task. They then completed all 13 games (20 minutes) believing they were playing each game against another anonymous participant. Both game order and player position (row or column) within each matrix was randomly assigned.

In the second part of the experiment (not analyzed here), participants played one of the games (randomly selected) 30 times in a fixed role (row or column) against the same opponent, with feedback provided on the other player's decisions after every round. The subjects believed they were playing against another anonymous participant, but "the other" was actually the PC with a pre-programmed strategy. After completing all the games, participants answered a final short questionnaire, mostly assessing their empathy / inter-personal reactivity with the other player [in the 30 trial game] (not analyzed here). Then they were debriefed, paid, and dismissed.

[2] The data were collected in two waves, with 94 UIUC and 79 NWU subjects participating in the first wave, and 61 UIUC and 60 NWU in the second. Only those who participated in the second wave completed the SVO questionnaire.

Results

Descriptive Statistics

Table 2 provides the cooperation rate (proportion of subjects choosing the cooperative action) by game. Games are categorized by their symmetry and the number of negative column payoffs. For symmetric games, cooperation rates are given separately for when participants played in the row and column positions. Row and Column payoffs are always matched and both decrease equally as the number of negative payoffs increase. In the asymmetric games, cooperation rates are given separately for when players had the higher relative payoff (High) and when they had the lower relative payoff (Low). Asymmetric games are further subdivided into RowPositive, where the row player's payoffs were always the maximum available (and all positive), and RowNegative, where the row player's payoffs were always the minimum (and all negative); only the column payoffs decrease as the number of negative payoffs increase. The dashes in the asymmetric blocks denote invalid combinations – conditions where the games would be symmetric instead of asymmetric. The final column in Table 2, Joint, gives the probability that players in both positions will cooperate in a given game.

Of the 121 participants administered the SVO, 37 were Cooperative, 64 were Individualist, and 19 were Competitive. There were no altruists and 1 'sadist' (ignore own payoffs, harm others). The distribution of SVO did not differ by sex, χ^2 (2) = .13, p = .94, but did differ by school, χ^2 (2) = 68.77, p < .001 (see Table 3).

Inferential Statistics

Cooperation rate and decision times were examined (a) across all games, (b) for symmetric games only, and (c) for asymmetric games only. Analyzing the data across all conditions allowed for finer distinctions within factors such as 3 levels of symmetry

(RowPositive, Symmetric, and RowNegative) and 3 levels of position (High, Matched, and Low), but made interactions more difficult to interpret given the unbalanced experimental design. By reanalyzing the data using only symmetric games, we could focus on the interaction between the number of negative payoffs and SVO in a comparable manner to previous research. In turn, by reanalyzing the data using only asymmetric games, we were better able to disentangle the interaction between Asymmetry, Position, and SVO. See Figure 4 for the cumulative distributions of the number of cooperative decisions (0-5 for symmetric games, 0-8 for asymmetric games, and 0-13 for all games).

In addition to partitioning the games in three different ways, the analysis of cooperation rate and decision time was conducted for four different methods of sub-setting the sample:

1) Include all subjects ($N = 294$);

2) Include only subjects with measured SVO ($N = 120$);

3) Include only subjects who did not defect (or cooperate) across all 13 games ($N = 194$);

4) Include only subjects with measured SVO who did not defect (or cooperate) across all 13 games ($N = 83$).

SVO was only measured in the second wave of data collection, so the full sample could not be used when analyzing its main effect or interactions. The data were reanalyzed without persistent cooperators or defectors because subjects who responded the same way across all conditions may not have seriously attended to any of the experimental factors, masking differences across conditions.

Table 4 summarizes the results (s / ns / na) across factors and analyses.

All Games

Full Sample

Cooperation rate. Given the binary outcome variable (cooperate or defect) and the unbalanced repeated measures design, the data were analyzed with SAS's GENMOD function (SAS 9.1.3) with a logit linking function and an exchangeable covariance structure, $r = .34$ (an unstructured approach did not improve fit). In addition to the three factors manipulated (symmetry, position, negative payoffs), the participants' sex and school (UIUC psychology and NWU business) were included as blocking variables, and age as a covariate. For the 2- and 3-way models, the interaction between symmetry (Symmetric, RowPositive, RowNegative) and position (High, Neutral, Low) was analyzed via an indicator variable containing the 5 valid combinations: Symmetric & Neutral ($M = .26$); RowPositive & High ($M = .31$); RowPositive & Low ($M = .21$); RowNegative & High ($M = .24$); RowNegative & Low ($M = .19$). The 2-way model's deviance (4135) did not differ dramatically from that of the 3-way (4125), so only the symmetry by position interaction was included.

Table 5 contains the score χ^2 tests of the model effects on cooperation rate: Both the blocking variable School (χ^2 (1) = 17.25) and the interaction between Symmetry and Position (χ^2 (4) = 14.70) were significant, $p < .0001$. Table 6 examines the parameter estimates and odds-ratios for each effect: Students at UIUC (predominantly psychology majors) were 2.17 times more likely than students at NWU (predominantly business majors) to cooperate in the PD games; compared to when playing in RowNegative & Low games, participants were 1.95 times more likely to cooperate when they played in RowPositive & High games ($p < .001$), 1.51 in Symmetric & Neutral games($p < .001$), 1.35 in RowNegative & High games ($p = .04$), and 1.08 in RowPositive & Low games (not significant, $p = .61$). The interaction is primarily explained by participants cooperating significantly more often in the RowPositve & High games than in any of the others, χ^2 (1) = 16.1, p < .0001. There was a main effect of symmetry, with participants cooperating significantly more often when playing in RowPositve (χ^2 (1) = 4.95, p = .03) and Symmetric (χ^2 (1) = 9.31, p = .002) games than when playing in RowNegative games. There was also a main effect of position, with participants cooperating significantly more often when playing in the High (χ^2 (1) = 14.57, p = .0001) and Neutral (χ^2 (1) = 14.75, p = .0001) positions than when playing in the Low position.

Decision Time. Decision times were treated as normally distributed and also analyzed in Genmod with an exchangeable covariance structure (r = .44); fit was neither improved by treating decision times as gamma distributed with an inverse linking function nor by treating covariance as unstructured. The 2-way model's deviance (3818) did not differ from that of the 3-way, so only the symmetry by position interaction was included.

Table 7 contains the score χ^2 tests of the model effects on decision times: Both the blocking variable Sex (χ^2(1) = 8.53), the factor Negative Payoffs (χ^2 = 23.09) and the interaction between Symmetry and Position (χ^2 (4) = 14.70) were significant, p < .0001. In turn, Table 8 examines the parameter estimates and mean decision times for each effect: Males took significantly longer to respond than females (M = 18.98 sec. vs. 15.54 sec.); decision times were significantly faster when players had 0 (M = 15.95 sec.) or 1 (M = 16.14) negative payoffs than when they had 2 (M = 17.68), 3 (M = 17.94) or 4 (M = 18.60) negative payoffs (the contrast between 1 and 2 was significant, χ^2 (1) = 13.49, p = .0002, so the others were as well). For the symmetry by position interaction, decision time were significantly slower in RowNegative & Low games than in any of the other games, χ^2 = 22.83, p < .0001. There was a main effect for symmetry, with decision times significantly slower in RowNegative games (M = 17.76) than in RowPositive (M = 16.09, χ^2 (1) = 30.29) or Symmetric games (M = 16.30, χ^2 (1) = 18.03), $p <$ .0001. There was also a main effect of position, with decision times significantly slower when playing in the Low position than when playing in the Neutral position (M = 17.03 sec. vs. 16.30 sec.), χ^2 (1) = 5.08, p = .02.

SVO Added as a Within-subjects Factor

Cooperation rate. The analyses were repeated (N reduced from 294 to 120) with SVO included as a within-subjects factor and the measure of the SVO's reliability included as a covariate. The deviance for the model with a 2-way interaction between symmetry and position (1616) was not significantly worse than the model with a 3-way interaction between symmetry, position, and SVO (1596), χ^2 (16) = 20, p = .22, so SVO was only included as a main effect.

Once again, only School (χ^2 (1) = 9.02, p = .003) and the Symmetry by Position interaction (χ^2 (4) = 15.07, p = .003) were significant, with SVO (χ^2 (2) = 4. 21) at p = .12. In terms of the odds, those with a cooperative SVO were 2.16 times more likely to cooperate than those with a competitive SVO (p = .08) and 1.74 times more likely to cooperate than those with an individualist SVO (p = .06), but neither comparison was significant at $p < .05$.

Decision time. SVO was again not a significant predictor, χ^2 (2) = 4.70, p = .10; mean decision time for those with a cooperative SVO (M = 19.21) was significantly (p = .03) slower than those with a competitive SVO (M = 14.99) but did not differ significantly (p = .08) from those with an individualist SVO (M = 16.40).

Persistent Cooperators and Defectors Excluded

Cooperation rate. The analyses of cooperation rate and decision time were also rerun excluding those subjects who had defected across all 13 games ($n = 98$) and those who had cooperated across all 13 games ($n = 2$), leaving 194 subjects. The 2-way model still provided the best fit. For cooperation rate, the symmetry by position interaction remained significant (χ^2 (4) = 24.09, $p < .0001$); removing persistent defectors, however, eliminated the effect of the blocking variable School on cooperation rate, χ^2 (1)= .76, $p = .38$. Of the 98 persistent defectors, 65 were from NWU, i.e., the "business major" sample; thus, 65/139 = .47 of the NWU sample were persistent defectors (as were 33/155 = .21 of the UIUC sample).

Decision time. In predicting decision times with persistent defectors removed, both the blocking variable Sex (χ^2 (1) = 6.34, $p = .01$), the factor Negative Payoffs (χ^2 (4) = 22.15, $p = .0002$) and the interaction between Symmetry and Position (χ^2 (4) = 21.56, $p = .0002$) remained significant. Males took significantly longer to respond (M = 19.78 sec.) than females (M = 15.96). Decision times were significantly faster in games with 0 (M = 16.65 sec.) or 1 (M = 16.59) negative payoffs than in games with 2 (M = 18.08), 3 (M = 18.45), or 4 (M = 19.59), χ^2 (1) = 19.95, $p < .0001$. Decision times were significantly faster in the Symmetric & Neutral (*M* = 17.32 sec.), RowPositive & High (*M* = 17.07) and RowPositive & Low (*M* = 16.57) games than in the RowNegative & High (*M* = 18.45); RowNegative & Low (*M* = 19.95) games, χ^2 (1) = 18.59, $p < .0001$.

SVO Added and Persistent Cooperators/Defectors Excluded

Cooperation rate. With SVO included as a within-subjects factor, its reliability included as a covariate, and the persistent cooperators and defectors excluded, the sample size was reduced to 83. As always, the symmetry by position interaction was a significant predictor of cooperation, χ^2 (4) = 15.40, $p = .004$, with players 2.11 times more likely to cooperate when playing Symmetric & Neutral games (p = .0009) and 2.74 times more likely to cooperate when playing RowPositive & High games (p = .0007) than when playing in the Low position of either RowPositive or RowNegative games. SVO did not significantly predict cooperation (χ^2 (2) = 5.50, p = .06). In terms of the odds, cooperators were 1.97 times more likely to cooperate than competitors (p = .08) and 1.88 times more likely to cooperate than individualists (p = .02), but only the cooperative vs. individualist comparison was significant at $p < .05$.

Decision time. In predicting decision time, only the number of negative payoffs was significant, χ^2 (4) = 13.90, p = .008. Mean decision time was significantly faster with 0 (M = 16.51 sec.) or 1 (M = 16.23) negative payoffs than with 2 (M = 17.84), 3 (M = 18.48), or 4 (M = 20.28) negative payoffs, χ^2 (1) = 9.95, p = .002.

Symmetric Games Only

Full Sample

Cooperation rate. In examining only the symmetric games (N = 294), the effects tested were the blocking variables school and sex, the covariate age, and the factor the number of negative payoffs to the column player. Under this model, school (χ^2 (1) = 10.41, p = .001), sex (χ^2 (1) = 3.90, p = .05), and negative payoffs (χ^2 (4) = 9.55, p = .05) were significant predictors of cooperation. UIUC students were 1.96 times more likely to cooperate than NWU students and males were 1.52 times more likely to cooperate than females. Players were more 1.33 times more likely to cooperate in games where all payoffs were positive (0 negative payoffs) than in games with 1 negative payoff (p = .05) and 1.52 more likely than in games with 3 negative payoffs (p = .003). See Figure 6 for cooperation rate across negative payoffs.

Decision time. Both the covariate Sex (χ^2 (1) = 9.25, p = .002) and the factor Number of

Negative Payoffs (χ^2 (4) = 41.63, p < .0001) were significant predictors of decision time. Males took significantly longer to respond than females, M = 18.87 vs. 14.82 sec. Mean decision time was significantly faster with 0 (M = 14.80 sec.) or 1 (M = 15.04) negative payoffs than with 2 (M = 18.13), 3 (M = 17.80), or 4 (M = 18.46) negative payoffs, χ^2 (1) = 41.45, p < .0001.

SVO added as a within-subjects factor

Cooperation rate. Table 9 and Figure 5 give the cooperation rate when the number of negative payoffs is crossed with SVO (N = 120). Neither the interaction between the number of negative payoffs and SVO (χ^2 (8) = 7.30, p = .50) nor the effects of negative payoffs (χ^2 (4) = 1.63, p = .80) or SVO (χ^2 (2) = 5.90, p = .06) were significant. School was significant (χ^2 (1) = 4.28, p = .04), with UIUC students 1.96 times more likely to cooperate than NWU students.

Decision time. In predicting decision time, only the number of negative payoffs was significant, χ^2 (4) = 20.72, p = .0004. Mean decision time was significantly faster with 0 (M = 14.30 sec.) or 1 (M = 14.11) negative payoffs than with 2 (M = 17.73), 3 (M = 17.75), or 4 (M = 18.95) negative payoffs, χ^2 (1) = 19.44, p = .0001.

Persistent Cooperators and Defectors excluded

Cooperation rate. With persistent cooperators and defectors excluded (N = 194), only the number of negative payoffs remained significant, χ^2 (4) = 9.55, p = .05. Players likelihood to cooperate with 3 negative payoffs was .60 that of their likelihood to cooperate with 2 (p = .05) and .57 that of their likelihood to cooperate with 4 (p = .03) negative payoffs.

Decision time. Only the number of negative payoffs was significant, χ^2 (4) = 15.01, p = .005. Mean decision time was significantly faster with 0 (M = 15.68 sec.), 1 (M = 16.39) or 2 (M = 17.75) negative payoffs than with 3 (M = 19.17) or 4 (M = 19.96) negative payoffs, χ^2 (1) =

13.68, p = .0002.

SVO Added and Persistent Cooperators/Defectors Excluded

Cooperation rate. With SVO included as a within-subjects factor, its reliability included as a covariate, and the persistent cooperators and defectors excluded (N = 83), no effects were significant at $p < .05$.

Decision time. Both SVO (χ^2 (2) = 6.93, p = .03) and the number of negative payoffs (χ^2 (4) = 10.87, p = .03 were significant. For SVO, cooperators (M = 23.84 sec.) took significantly longer to respond than either competitors (M = 13.44, p = .002) or individualists (M = 17.48, p = .04). For negative payoffs, mean decision time was significantly faster with 0 (M = 15.57 sec.), 1 (M = 15.49) or 2 (M = 17.96) negative payoffs than with 3 (M = 20.71) or 4 (M = 21.55), χ^2 (1) = 10.56, p = .001.

Asymmetric Games Only

Full Sample

Cooperation rate. Cooperation rate in the asymmetric games was examined by testing for an interaction between the type of asymmetric game and the player's relative position (see Table 10 for the cooperation rates by condition). Besides the interaction, the main effects of asymmetry and position were also included in the model, along with the blocking variables school and sex, the covariate age, and the factor the number of negative payoffs (and its interactions with the other factors). The asymmetry by position interaction was significant, χ^2 (1)= 3.99, p = .05, with the odds for cooperating in RowPositive versus RowNegative games being 1.6 times larger when playing in the High position than when playing in the Low position (p = .04). In other words, participants cooperated significantly more often in the RowPositve games, but only when they were in the higher relative position (see Figure 7). Position was also significant, χ^2 (1) = 11.65, p = .0006, but its effect is explained by the interaction. As usual the effect of school was significant, χ^2 (1) = 23.05, p = .0006, with UIUC students 2.44 times more likely to cooperate than NWU students.

Decision time. Sex was significant, χ^2 (1) = 6.89, p = .009, with males taking longer to respond than females (M = 18.87 vs. 15.84 sec.) Asymmetry was significant, χ^2 (1) = 22.67, p < .0001, with participants taking longer to respond in RowNegative games than in RowPositive games (M = 18.36 vs. 16.35 sec.)

SVO added as a within-subjects factor

Cooperation rate. The analysis for only asymmetric games was repeated with SVO included as a factor and its reliability as a covariate (N = 120). Table 11 contains the score χ^2 tests of the model effects on cooperation rates in the asymmetric games. The 3-way interaction between asymmetry, position, and SVO (see Table 12 for cooperation rates by condition), was not significant at p < .05, with χ^2 (2) = 5.49, p = .06. In RowPositve games, the odds for cooperating when playing in the High position compared to when playing in the Low position were 7.52 times larger for those with a cooperative SVO than those with an individualist SVO (see Figure 8). The 2-way interaction between asymmetry and SVO was significant, χ^2 (2) = 7.33, p = .03, with the odds for cooperating in the RowPositve games compared to the RowNegative games being 7.37 times larger for those with an individualist SVO than those with a cooperative SVO. The 3-way interaction between, negative payoffs, position and SVO (see Table 13 and Figure 9) was significant, χ^2 (8) = 17.35, p = .03, but none of the odds contrasts were.

Decision time. Only Asymmetry was significant, with χ^2 (1) = 8.45, $p < .004$, with participants taking longer to respond in RowNegative games than in RowPositive games (M = 17.81 vs. 15.96 sec.)

Persistent Cooperators and Defectors excluded

Cooperation rate. Removing persistent defectors eliminated the school effect (χ^2 = 2.87, p = .09) and strengthened the odds in the asymmetry by position interaction to 1.77.

Decision time. Sex was significant, χ^2 (1) = 5.00, p = .03, with males taking longer to respond than females (M = 19.61 vs. 16.32 sec.) Asymmetry was significant, χ^2 (1) = 13.96, $p <$ .0002, with participants taking longer to respond in RowNegative games than in RowPositive games (M = 18.98 vs. 16.96 sec.)

SVO Added and Persistent Cooperators/Defectors Excluded

Cooperation rate. The 3-way interaction between, negative payoffs, position and SVO remained significant, χ^2 (8) = 17.65, p = .02. Instead of a 3-way interaction between asymmetry, position, and SVO (χ^2 (2) = 4.38, p = .11), there was now a 2-way interaction between asymmetry and SVO (χ^2 (2) = 8.40 p = .02) and a main effect for position (χ^2 (1) = 6.21 p = .01).

Decision time. Nothing predicted decision time at $p < .05$.

Discussion

Factors affecting cooperation are rarely studied in the context of the 1-shot PD game. Many real-world interactions, however, are 1-time events, so it is important to determine how well factors studied in iterated games apply to the 1-shot PD. In the present within-subject study we systematically examine the interaction between 4 factors on cooperation in the PD that have only been studied haphazardly in the literature: symmetry, the number of negative (column) payoffs, the player's relative position in asymmetric games, and SVO.

When asymmetry has been investigated in the literature (always in iterated games), experiments have lacked symmetric benchmarks, have used too few observations, or have involved pre-programmed strategies. Moreover, studies have usually been limited to investigating a single form of asymmetry, whereas asymmetry can take many forms.

When studying the sign of the payoff (usually in the context of a gain-loss frame), previous research has often been limited to comparing games with all positive and games with all negative payoffs or, occasionally, comparing games with positive payoffs to those with 2 negative payoffs. We are unaware of studies including 1 or 3 negative payoffs.

While players' relative position has been studied in asymmetric games, we study it more thoroughly by distinguishing between two types of asymmetric games: RowPositive games where the row player always receives the highest payoffs available (all are positive) and RowNegative games where the row player always receives the lowest payoffs available (all are negative). With row position payoffs held constant in one of those two ways, column position payoffs are free to vary, creating eight different asymmetric games.

We are unaware of research where SVO was studied with asymmetric games, so it was included in our experiment as a potential predictor of cooperation.

Across all conditions in our grand experiment we found an interaction between symmetry and position, with cooperation rates lower in asymmetric games due to increased defection among players in the Low position. This is consistent with Sheposh and Gallo's (1973) findings. We also found a main effect for symmetry, with subjects cooperating significantly more often when playing RowPositive games than when either playing Symmetric or RowNegative games. This leads to another interpretation of the interactions, with players cooperating significantly more often when playing in the High position of the RowPositive games than in any of the other games. This is not necessarily inconsistent with Sheposh and Gallo's findings – they only use one type of asymmetry and the closest game they have to a RowPositive matrix is one in which both players share a 0 for the *S* payoff, preventing complete dominance by the High player.

A main effect was found for the convenience sample, with those at NWU (business majors) cooperating significantly less often than those at UIUC (psychology majors). This effect disappeared when the analysis was rerun without persistent defectors (those who defected on all 13 games) since the NWU sample had more persistent defectors than the UIUC sample. Neither the number of negative payoffs, SVO nor their interactions with any other factors was useful in predicting cooperation. The blocking variable sex and the covariate age did not contribute much to the models either.

Given difficulties arising from the unbalanced experimental design, it was helpful to analyze the symmetric games and the asymmetric games separately.

For the symmetric games there was a main effect of the number of negative payoffs, but no effect for SVO, nor an interaction between number of negative payoffs and SVO. The negative payoff effect was exclusively driven by subjects cooperating less often when playing with 3 negative payoffs (M = .22, *SE* = .02). Nevertheless, while significant, the difference in cooperation rate was not particularly large, with the most cooperation occurring when playing with 0 negative payoffs (M = .30, *SE* = .03).

Our findings are in stark contrast to those of Experiment 1 of de Dreu and McCusker (1997) which examined cooperation as a function of SVO and Frame (gain or loss, equivalent to 0 or 4 negative payoffs) in symmetric games and found an interaction between SVO and frame, a main effect for SVO and no main effect for frame. Reanalyzing our data with just two levels of negative payoffs, we find neither an interaction nor any main effects. Moreover, whereas they found individualists cooperate more with a gain frame than a loss frame (.39 vs. .14) and cooperatives cooperate less with gain frame than a loss frame (.53 vs. .75), we found the opposite (but non-significant) pattern: Individualist .23 vs. .27 (*SE* = .06); Cooperative .41 vs. .38. (*SE* = .08).

We do not have a specific explanation for this discrepancy with de Dreu and McCusker, but will note some possibilities: 1) They use a much cruder assessment of SVO, Kuhlman and Marshello's (1975) "triple dominance games" in which subjects are presented a game with three self-other outcome options, each corresponding to the cooperative, competitive, or individualist SVO (the less common SVOs are not available). Subjects are classified as the SVO corresponding to the option they endorse for least 6 of the 9 games (7 of their 81 initial subjects were dropped for failing to meet this criterion). 2) They note that a large (but undeclared) portion of their subjects were drawn from medical students (possibly explaining the unusually large number of competitive SVOs in their sample) with the others drawn from the social sciences / humanities, but they fail to include this discipline factor in their analyses. 3) Their study involves a specific manipulation of the frame: In the gain frame, subjects begin with 0 points and can gain points by making decisions; in the loss frame, subjects start with 22 points and can lose points (up to the 22) by making decisions. By contrast, the current study used a more sensitive measure of SVO, Liebrand's (1988) RING, included a proxy of discipline as a blocking variable, a reliability variable as a covariate, and did not make use of a frame when distinguishing between positive and negative payoffs.

By conducting further analyses focused solely on the asymmetric games, we were better able to disentangle the interaction between Asymmetry, Position, and SVO. Much like in the analysis across all games, we found an asymmetry by position interaction driven primarily by greater cooperation when subjects played RowPositive games in the High position (M = .31 vs. overall M = .24) and we found a main effect of position, with subjects cooperating more often in the High position than in the Low position (M = .27 vs. .20). These differences in cooperation rate increased in magnitude when SVO was added to the asymmetry by position interaction: While the overall cooperate rate in the RowPositve & High position condition was .33, it was .45 for cooperatives, .34 for individualists, and .23 for competitors.

Overall, both the number of negative payoffs and sex did predict decision times, with males taking longer than women (M = 15.54 vs. 18.98 secs.) and a mostly linear increase in decision times as the number of negative payoffs increased (M = 15.95 to 18.60 secs). These differences tended to erode with greater partitioning of the games and subjects and we are uncertain of their utility.

Caveats

Our subjects played 13 PD games in which they were randomly assigned as a Row or

Column position player in the symmetric games and as a High or Low position player in the asymmetric; this yielded an unbalanced repeated measures design, with subjects only playing 13 of the 26 possible position configurations. Standard ANOVA and GLM procedures cannot handle unbalanced repeated measures designs, so instead we employed Generalized Linear Models with GEE (SAS's Proc GenMod)[3], a procedure not normally found in the PD literature. Similarly, the within–subject design, large number of factors investigated and 1-shot nature of the games led to the analyses being conducted in terms of odds of cooperating, i.e., logistic regression, rather than testing for differences in mean cooperation rates. We consider logistic regression an excellent way to study manipulations in (1-shot) PD games, but again it is not how iterated PD games are usually studied.[4] Finally, our SVO measures were only added *in media res*, leading to some complicated sample sub-setting (see Table 4) and additional analyses[5].

Conclusions

We study the effects and interactions of four factors (symmetry, the number of negative (column) payoffs, the player's relative position, and SVO) far more systematically than they have preciously been studied in the PD literature. We also study many of these factors for the first time in 1-shot PD games and offer useful suggestions on the means by which 1-shot games may be analyzed.

[3] HLM procedures could have been used instead, but SAS 9.1's Proc GenMod was used for reasons of software availability and ease of use: SPSS 17's HLM procedure (Proc Mixed) cannot accommodate non-linear models; HLM6's free student version could not accommodate the number of variables needed per level; SAS 9.1's non-linear model HLM procedure (Proc NLMixed) was difficult to use and its successor (Proc Glimmix) was not fully functional until SAS 9.2.

[4] Before settling on GenMod with binary outcome variables, we attempted to analyses our data via the McNemar, a non-parametric test of correlated proportions, but then the results would have had to have been discussed via differences in games, rather than main effects and interactions of the factors manipulated.

[5] The number of subjects (N = 120) used for the second wave of data collection followed from a power calculation based on results from McNemar tests on the the first wave of data (N = 174).

Figures

		Participant A	
		Cooperate	Defect
Participant B	Cooperate	R R	T S
	Defect	S T	P P

Figure 1. Matrix payoffs for the four possible outcomes of a trial and the relation between payoffs. The right-justified value above the diagonal in each cell is Participant A’s payoff. The matrix values are subject to the following conditions: (a) $2R > T+S > 2P$; (b) $T > R$; (c) $T > S$; (d) $P > S$.

		Participant A	
		Cooperate	Defect
Participant B	Cooperate	R R ± x	T S ± x
	Defect	S T ± x	P P ± x

Figure 2. Matrix payoffs for an asymmetric game where each of Participant B's four possible outcomes (left justified) are always x increments lower than the same outcomes for Participant A.

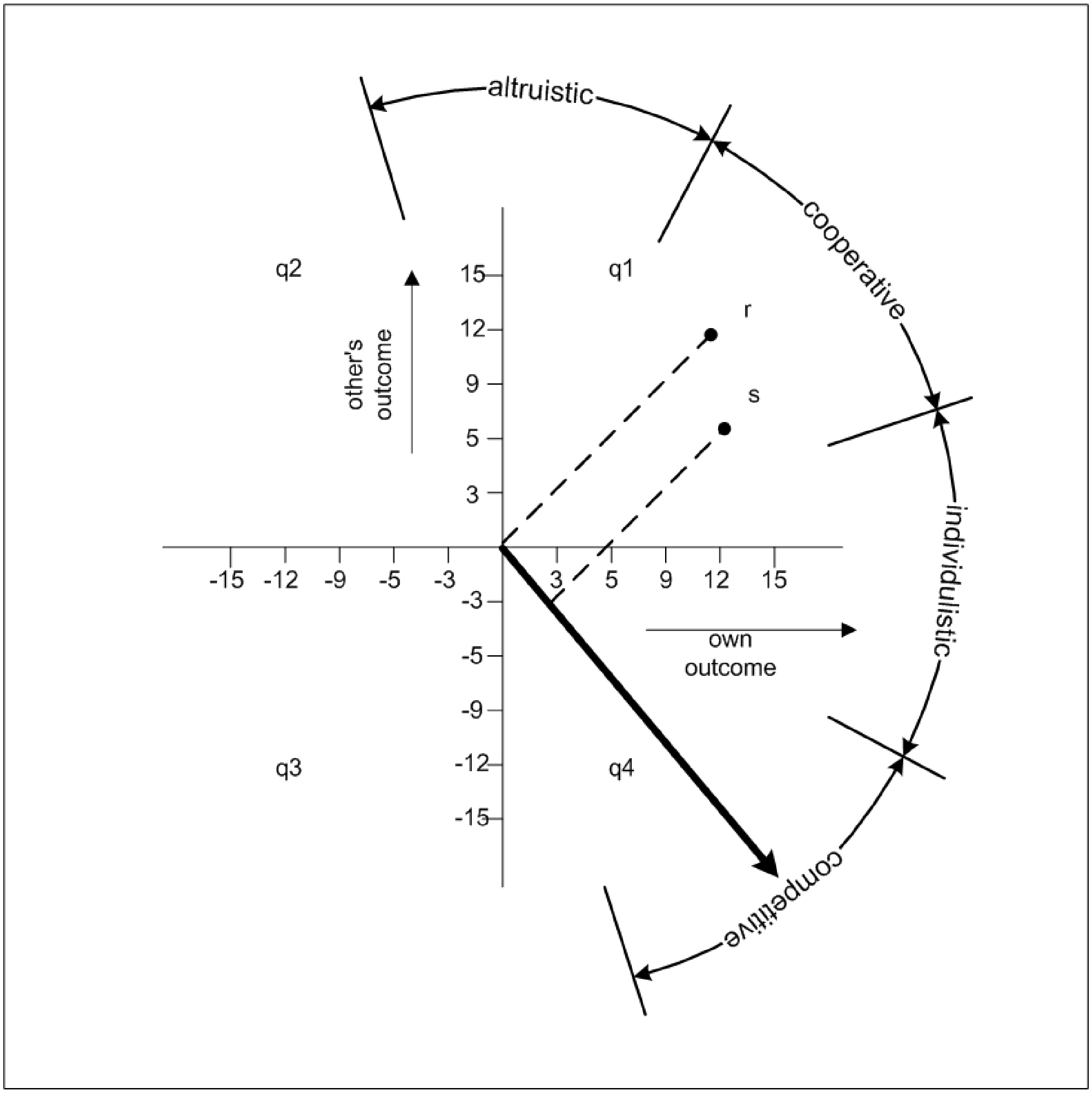

Figure 3. Own/Other outcome plane and four classes of social values orientations. Adapted from Liebrand and McClintock (1988).

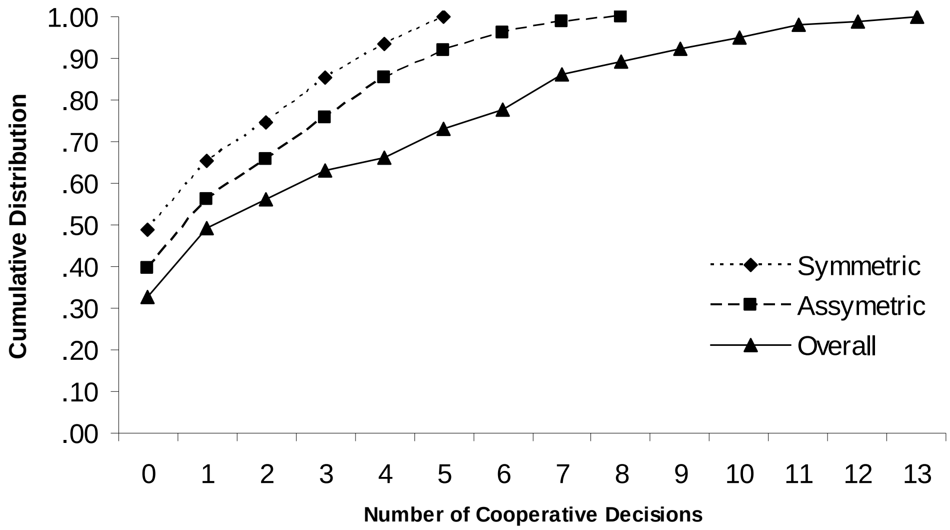

Figure 4. Cumulative distribution of cooperative decisions for symmetric, asymmetric and all games.

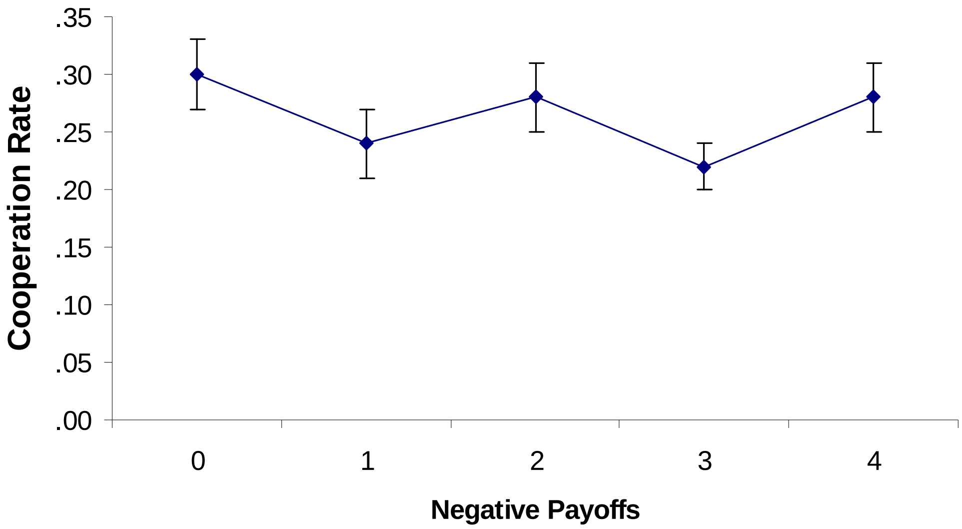

Figure 5. Cooperation Rate (± *SE*) in symmetric games across negative payoffs.

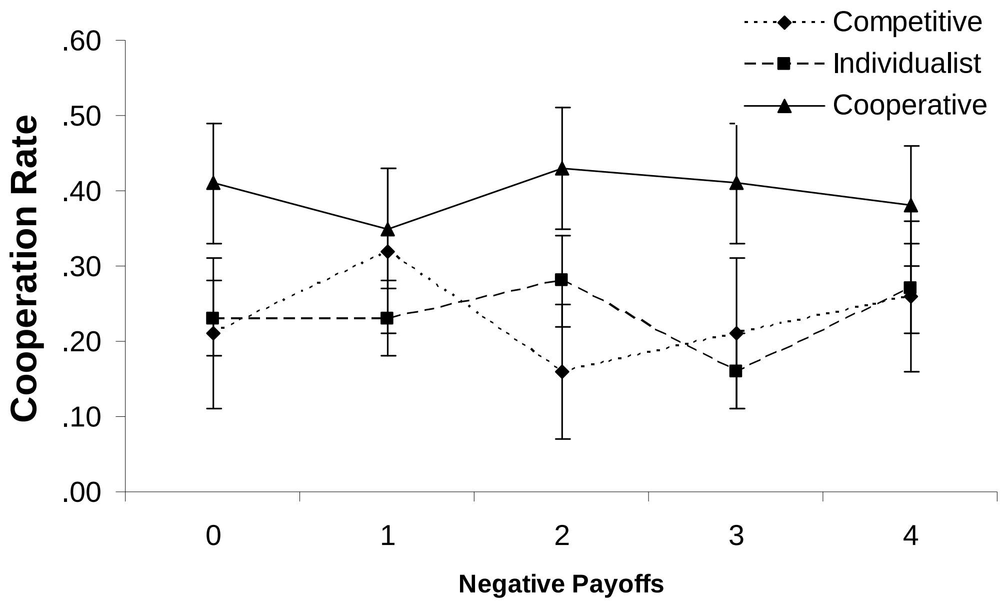

Figure 6. Cooperation Rate (± *SE*) in symmetric games for each SVO across negative payoffs.

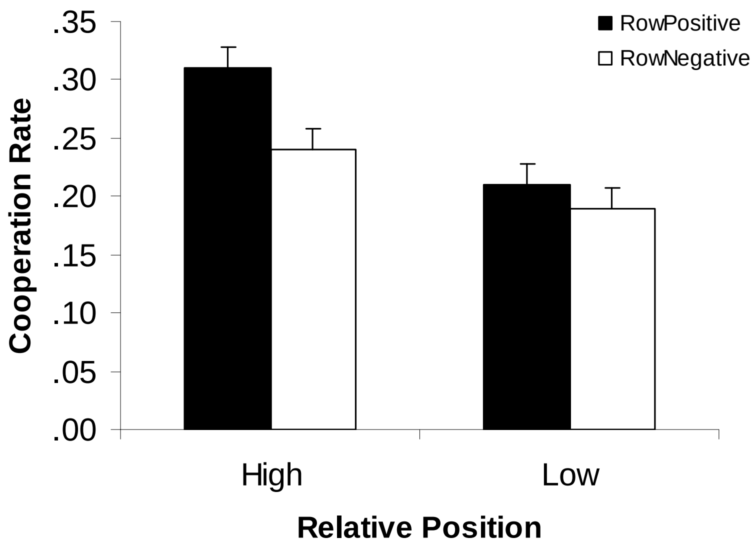

Figure 7. Cooperation Rate (± *SE*) for High and Low Position in Asymmetric Conditions

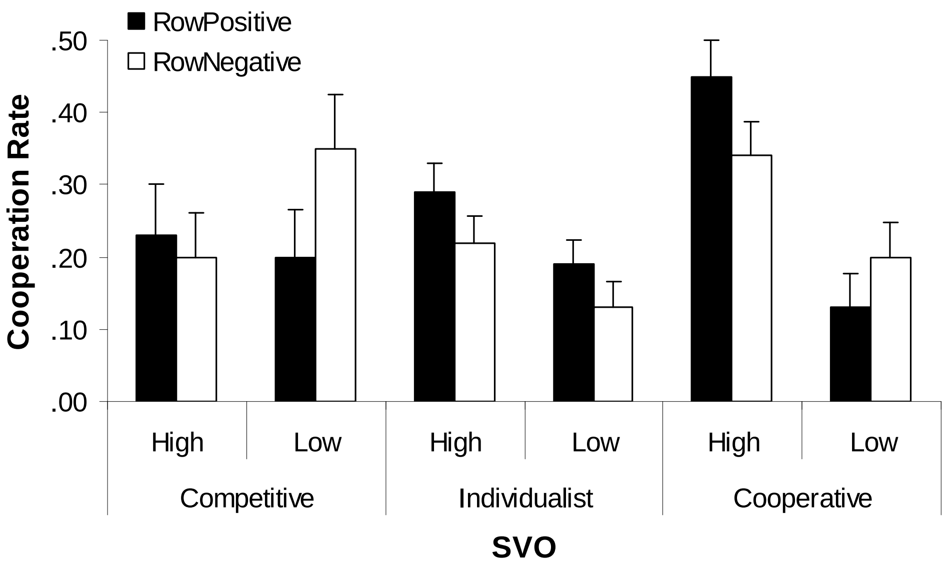

Figure 8. Cooperation rate (± *SE*) in asymmetric games for players in high and low position by SVO

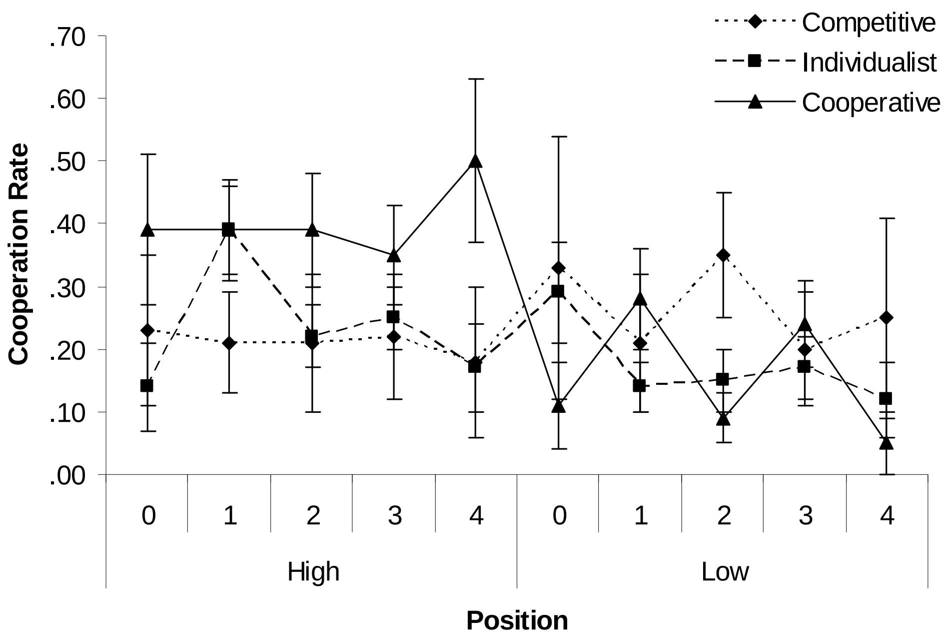

Figure 9. Cooperation rate (± *SE*) in asymmetric games as a function of the negative payoffs, for players in high and low position by SVO

Tables

Table 1

Experimental Design (Valid Combinations)

Game	Symmetry	Negative Payoffs	Row Position
1	S	0	E
2	S	1	E
3	S	2	E
4	S	3	E
5	S	4	E
6	A	4	H
7	A	3	H
8	A	2	H
9	A	1	H
10	A	0	L
11	A	1	L
12	A	2	L
13	A	3	L

Symmetry: S = Symmetric, A = Asymmetic

Row Position: E= Equal, H = Higher, L = Lower

Table 2
Cooperation Rate by Game

		Negative Payoffs	Cooperation Rate: Row	Cooperation Rate: Column	Cooperation Rate: Joint
Symmetric Games					
	1	0	.32	.28	.09
	2	1	.22	.27	.06
	3	2	.27	.28	.08
	4	3	.24	.20	.05
	5	4	.32	.24	.08
Asymmetric: RowPositive			High	Low	Joint
	-	0	-	-	-
	9	1	.33	.22	.07
	8	2	.33	.20	.06
	7	3	.31	.16	.05
	6	4	.26	.25	.07
Asymmetric: RowNegative			High	Low	Joint
	10	0	.25	.17	.04
	11	1	.25	.22	.05
	12	2	.26	.18	.05
	13	3	.23	.19	.04
	-	4	-	-	-

Note. *n* - Total: 294, Row: 129-159, Column: 135-165

Table 3

SVO Distribution by School

	School		
SVO	NW	UIUC	Total
Competitive	5	14	19
Individualist	36	28	64
Cooperative	19	18	37
Total	60	60	120

Table 4

Significance of Cooperation Rate and Decision Time Across all Subsets and Subsamples

Factor	Cooperation Rate				Decision Time			
	Full	SVO	NoPersistent	SVO & NoPersistent	Full	SVO	NoPersistent	SVO & NoPersistent
				All Games				
School	**S**	**S**	N	N	N	N	N	N
Sex	N	N	N	N	**S**	**S**	**S**	N
Age	N	N	N	N	N	N	N	N
Symmetry (S)	**S**	**S**	**S**	**S**	**S**	**S**	**S**	N
Position (P)	**S**	**S**	**S**	**S**	**S**	**S**	**S**	N
Negative Payoffs (N)	N	N	N	N	**S**	**S**	**S**	**S**
SVO	-	N	-	N	-	N	-	N
S x P	**S**	**S**	**S**	**S**	**S**	**S**	**S**	N
S x N	N	N	N	N	N	N	N	N
S x SVO	-	N	-	N	-	N	-	N
P x N	N	N	N	N	N	N	N	N
P x SVO	-	N	-	N	-	N	-	N
N x SVO	-	N	-	N	-	N	-	N
S x P x N	N	N	N	N	N	N	N	N
S x P x SVO	-	N	-	N	-	N	-	N
S x N x SVO	-	N	-	N	-	N	-	N
P x N x SVO	-	N	-	N	-	N	-	N
S x P x N x SVO	-	N	-	N	-	N	-	N
				Symmetric Games				
School	**S**	**S**	N	N	N	N	N	N
Sex	**S**	N	N	N	**S**	N	N	N
Age	N	N	N	N	N	N	N	N
Symmetry (S)	-	-	-	-	-	N	-	N
Position (P)	-	-	-	-	-	N	-	N
Negative Payoffs (N)	**S**	N	**S**	N	**S**	**S**	**S**	**S**
SVO	-	N	-	N	-	N	-	**S**
S x P	-	-	-	-	-	-	-	-
S x N	-	-	-	-	-	-	-	-
S x SVO	-	-	-	-	-	-	-	-
P x N	-	-	-	-	-	-	-	-
P x SVO	-	-	-	-	-	-	-	-
N x SVO	-	N	-	N	-	N	-	N
S x P x N	-	-	-	-	-	-	-	-
S x P x SVO	-	-	-	-	-	-	-	-
S x N x SVO	-	-	-	-	-	-	-	-
P x N x SVO	-	-	-	-	-	-	-	-
S x P x N x SVO	-	-	-	-	-	-	-	-
				Asymmetric Games				
School	**S**	**S**	N	N	N	N	N	N
Sex	N	N	N	N	**S**	N	N	N
Age	N	N	N	N	N	N	N	N
Symmetry (S)	N	N	N	N	**S**	**S**	N	N
Position (P)	**S**	**S**	**S**	**S**	N	N	**S**	N
Negative Payoffs (N)	N	N	N	N	N	N	N	N
SVO	-	N	-	N	-	N	-	N
S x P	**S**	N	**S**	N	N	N	**S**	N
S x N	N	N	N	N	N	N	N	N
S x SVO	-	**S**	-	**S**	-	N	-	N
P x N	N	N	N	N	N	N	N	N
P x SVO	-	N	-	N	-	N	-	N
N x SVO	-	N	-	N	-	N	-	N
S x P x N	N	N	N	N	N	N	N	N
S x P x SVO	-	N	-	N	-	N	-	N
S x N x SVO	-	N	-	N	-	N	-	N
P x N x SVO	-	N	-	**S**	-	N	-	N
S x P x N x SVO	-	N	-	N	-	N	-	N

Note. S = Significant at $p < .05$, N = Non-significant, - = Non-applicable

Full: All subjects ($N = 294$);

SVO: only subjects with measured SVO ($N = 120$);

NoPersistent: only subjects who did not defect (or cooperate) across all 13 games (N = 194);

SVO & NoPersistent: only subjects with measured SVO who did not defect (or cooperate) across all 13 games (N = 83).

Table 5

Tests of Model Effects on Cooperation

Source	Score χ^2	*df*	*p*
Between subjects			
School	17.25	1	.00
Sex	2.18	1	.14
Age	.01	1	.91
Within subjects			
Negative Payoffs	5.91	4	.21
Symmetry x Position	14.70	4	.00

Table 6

Parameter Estimates and Cooperation Odds

Parameter		Estimate	*SE*	95% *CI*		*Z*	*p*	Odds	95% *CI* for Odds	
Intercept		-1.06	.83	-2.70	.57	-1.27	.20	.35	.07	1.77
School	NW	-.78	.19	-1.14	-.41	-4.15	.00	.46	.32	.66
	UIUC	0								
Sex	Male	.28	.18	-.08	.63	1.51	.13	1.32	.92	1.88
	Female	0								
Age		.00	.04	-.08	.07	-.11	.91	1.00	.92	1.08
Negative Payoffs	0	.02	.11	-.20	.24	.18	.86	1.02	.82	1.27
	1	-.04	.11	-.24	.17	-.34	.73	.96	.78	1.19
	2	-.03	.11	-.24	.19	-.23	.81	.97	.79	1.21
	3	-.19	.11	-.41	.02	-1.79	.07	.82	.67	1.02
	4	0								
Symmetry x Position	Symmetric & Neutral	.41	.12	.18	.64	3.45	.00	1.51	1.19	1.90
	RowPositive & High	.67	.15	.37	.96	4.44	.00	1.95	1.45	2.62
	RowPositive & Low	.08	.15	-.22	.37	.51	.61	1.08	.81	1.45
	RowNegative & High	.30	.15	.01	.60	2.02	.04	1.35	1.01	1.81
	RowNegative & Low	0								

Table 7

Tests of Model Effects on Decision Time

Source	Score χ^2	*df*	*p*
	Between subjects		
School	3.31	1	.07
Sex	8.53	1	.00
Age	1.63	1	.20
	Within subjects		
Negative Payoffs	31.97	4	.00
Symmetry x Position	33.47	4	.00

Table 8

Parameter Estimates and Mean Decision Times

Parameter		Estimate	*SE*	95% *CI*		*Z*	*p*	Means	*SE*
Intercept		24.83	3.98	17.03	32.63	6.24	<.0001		
School	NW	-1.86	1.01	-3.84	0.11	-1.85	.06	16.33	.73
	UIUC	0						18.19	.78
Sex	Male	3.43	1.15	1.18	5.68	2.99	.00	18.98	.99
	Female	0						15.54	.56
Age		-0.25	0.19	-0.62	0.11	-1.36	.17		
Negative Payoffs	0	-2.65	0.60	-3.82	-1.48	-4.44	<.0001	15.95	.63
	1	-2.46	0.55	-3.54	-1.38	-4.47	<.0001	16.14	.55
	2	-0.92	0.50	-1.90	0.06	-1.84	.07	17.68	.65
	3	-0.66	0.57	-1.77	0.46	-1.16	.25	17.94	.63
	4	0						18.60	.75
Symmetry x Position	Symmetric & Neutral	-2.40	0.51	-3.41	-1.40	-4.68	<.0001	16.75	.61
	RowPositive & High	-2.75	0.56	-3.85	-1.66	-4.93	<.0001	16.40	.58
	RowPositive & Low	-3.13	0.57	-4.24	-2.02	-5.52	<.0001	16.02	.60
	RowNegative & High	-1.17	0.60	-2.34	0.00	-1.96	.05	17.98	.72
	RowNegative & Low	0						19.15	.72

Table 9

Cooperation Rate in Symmetric Games by Negative Payoffs and SVO

	SVO			
Negative Payoffs	Competitive	Individualist	Cooperative	Overall
0	.21	.23	.41	.28
1	.32	.23	.35	.28
2	.16	.28	.43	.31
3	.21	.16	.41	.24
4	.26	.27	.38	.30
Overall	.23	.23	.39	.28

Table 10

Cooperation Rate for High and Low Position in Asymmetric Conditions

	Relative Position		
Asymmetry	High	Low	Overall
RowPositive	.31	.21	.26
RowNegative	.24	.19	.22
Overall	.27	.20	.24

Table 11
Asymmetric Games: Tests of Model Effects on Cooperation

Source	Score χ^2	*df*	*p*
	Between subjects		
School	11.85	1	.00
Sex	0.68	1	.41
Age	0.10	1	.75
SVO	0.71	2	.70
SVO Reliability	5.27	1	.02
	Within subjects		
Asymmetry (A)	0.77	1	.38
Negative Payoffs (N)	3.52	4	.47
Position (P)	5.95	1	.01
A x P	1.15	1	.28
N x P	1.08	4	.90
P x SVO	4.39	2	.11
A x SVO	7.33	2	.03
N x SVO	7.77	8	.46
A x P x SVO	5.49	2	.06
N x P x SVO	17.35	8	.03

Table 12

Cooperation Rate in Asymmetric Conditions by Position and SVO

		Asymmetry		
SVO	Player Position	RowPositive	RowNegative	Overall
Competitive	High	.23	.20	.21
	Low	.20	.35	.27
Individualist	High	.29	.22	.25
	Low	.19	.13	.17
Cooperative	High	.45	.34	.39
	Low	.13	.20	.16
Overall		.24	.22	.23

Table 13

Cooperation Rate in Asymmetric Games across Negative Payoffs, Position and SVO

		SVO			
Player Position	Negative Payoffs	Competitive	Individualist	Cooperative	Overall
High	0	.23	.14	.39	.23
	1	.21	.39	.39	.35
	2	.21	.22	.39	.27
	3	.22	.25	.35	.28
	4	.18	.17	.50	.26
Low	0	.33	.29	.11	.23
	1	.21	.14	.28	.19
	2	.35	.15	.09	.17
	3	.20	.17	.24	.19
	4	.25	.12	.05	.11
Overall		.24	.21	.27	.23

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Appendix A

The 13 games can be subdivided into 3 categories, each with five matrices (2 matrices overlap conditions): Symmetric, Asymmetric: RowPositive, and Asymmetric: RowNegative.

Symmetric. Row and Column payoffs are all positive (4+/0-) initially, and both are reduced in 40 point increments, increasing the number of negative payoffs by one on every subsequent matrix.

Asymmetric: RowPositive. Row payoffs always remain positive, but Column payoffs are reduced in 40 point decrements, increasing the number of negative column payoffs by one on every subsequent matrix.

Asymmetric: RowNegative. Row payoffs are always negative, but Column payoffs are increased in 40 point increments, increasing the number of positive column payoffs by one on every subsequent matrix.

See Figure A1 for the matrices sorted by symmetry category and the number of negative payoffs. In each matrix, the row player must choose between the upper (U) and lower (D) rows and the column player must choose between the left (L) and right (R) columns. Within each quadrant, the row player's payoffs are indicated in the lower left and the column player's in the upper right.

Negative Payoffs	Symmetric	Asymmetric: RowPositive	Asymmtric: RowNegative

0

Game 1	L	R
U	110 / 110	150 / 30
D	30 / 150	50 / 50

Game 1	L	R
U	110 / 110	150 / 30
D	30 / 150	50 / 50

Game 10	L	R
U	110 / -50	150 / -130
D	30 / -10	50 / -110

1

Game 2	L	R
U	70 / 70	110 / -10
D	-10 / 110	10 / 10

Game 9	L	R
U	70 / 110	110 / 30
D	-10 / 150	10 / 50

Game 11	L	R
U	70 / -50	110 / -130
D	-10 / -10	10 / -110

2

Game 3	L	R
U	30 / 30	70 / -50
D	-50 / 70	-30 / -30

Game 8	L	R
U	30 / 110	70 / 30
D	-50 / 150	-30 / 50

Game 12	L	R
U	30 / -50	70 / -130
D	-50 / -10	-30 / -110

3

Game 4	L	R
U	-10 / -10	30 / -90
D	-90 / 30	-70 / -70

Game 7	L	R
U	-10 / 110	30 / 30
D	-90 / 150	-70 / 50

Game 13	L	R
U	-10 / -50	30 / -130
D	-90 / -10	-70 / -110

4

Game 5	L	R
U	-50 / -50	-10 / -130
D	-130 / -10	-110 / -110

Game 6	L	R
U	-50 / 110	-10 / 30
D	-130 / 150	-110 / 50

Game 5	L	R
U	-50 / -50	-10 / -130
D	-130 / -10	-110 / -110

Figure A1. Games sorted by symmetry and number of negative payoffs. Note that in symmetric games both Row and Column payoffs are systematically reduced by 40 point increments as the number of negative payoffs increases; in asymmetric games only Column payoffs are reduced. Grayed-out games are redundant placeholders.