Cooperation in Two-Person Games with Repeated Partner Choice
or
Why Be Helpful Even If You Are Exploited

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or

Why Be Helpful Even If You Are Exploited *

Summary

Frequently, actors face a repeated choice between several dyadic relationships in which to interact. For example, firms may enter a series of joint ventures with various partners, and employees may exchange information with a number of colleagues from other firms. This paper introduces the notion of two-person games with repeated partner choice to conceptualize such situations. Players repeatedly face two decisions, (1) with whom to interact and (2) how to interact in a chosen dyad.

A computer simulation demonstrates that in such situations a strategy of unconditional cooperation in a chosen dyad can perform as well or even better than retaliatory strategies like Tit-for-Tat — as long as the players tend to at least slightly favor those relationships in which they gain higher payoffs.

I propose that many situations resemble more the characteristics of two-person games with repeated partner choice than of a traditional two-person game viewed isolated from other relations. This might explain the puzzle of why cooperation can frequently be observed even if defection creates an advantage for the defecting player and the other players apparently do not to retaliate. In such situations, unconditional cooperation may not only be justified as morally appropriate but also as "good business."

*) I gratefully acknowledge the research assistance of Ava Kuo, who skilfully developed the simulation software as part of her Undergraduate Thesis Project at the Massachusetts Institute of Technology. I thank Lael Brainard, Dietmar Harhoff and William Riggs for their insightful comments.
Introduction

Game theoretical frameworks are frequently applied to social interactions with strategic components. The Prisoner's Dilemma framework, for example, is employed to conceptualize such diverse issues as buyer-supplier relationships (Jarillo, 1988; Johnston & Lawrence, 1988), informal information trading (von Hippel, 1987; Schrader, 1990), marketing strategies (Hauser, 1987), inter-group communication (Bornstein, Rapoport, Kerpel, & Katz, 1989), market fraud (Opp, 1986), trade policy (Yarbrough & Yarbrough, 1986), and trench warfare (Axelrod, 1984).

Retaliation for non-cooperative behavior and the threat of it constitute core elements of most game-theoretical analyses (e.g. (Axelrod, 1984; Axelrod, 1986; Schelling, 1960; Yarbrough & Yarbrough, 1986). Bhide and Stevenson, however, suggest that, at least in the business world, non-cooperative behavior seldom evokes retaliation. "Trust breakers are not only unhindered by bad reputations, they are usually spared retaliation by parties they injure" (Bhide & Stevenson, 1990, p. 125). Despite the absence of retaliation, the authors observe that most businesspeople are trustworthy, i.e. behave cooperatively. But "why be honest if honesty doesn't pay?" (Bhide & Stevenson, 1990, p. 121). The authors argue that game theory fails to explain how cooperation can persist in situations in which non-cooperative behavior creates additional payoffs and in which retaliation is not used. They interpret the dominance of cooperative behavior not with game-theoretic arguments such as provided for example by Stiglitz (1989) and Fudenberg & Tirole (1989) but as the result of moral choices. "We keep promises because we believe it is right to do so, not because it is good business" (Bhide & Stevenson, 1990, p. 128).

In this paper, I propose that the puzzle raised by Bhide and Stevenson can be explained in game-theoretical terms if one conceptualizes the underlying
interactions as two-person games with repeated partner choice. The novel concept of two-person games with repeated partner choice takes into account that players often have the choice between several dyadic relationships in which to interact. Within each chosen dyad a two-person game is played — frequently repeatedly if players select each other anew.

In a two-person game with repeated partner choice, actors face two decisions: They have to decide, first, with whom to interact and, second, how to interact in a chosen dyad. The first decision takes into account that actors are part of a multi-person environment and thus may switch interaction partners at any given point, based on their preferences. The second decision relates to the interaction of a pair of actors and can be viewed as a two-person game. Thus the designation two-person games with repeated partner choice.

Situations that follow these characteristics can be observed frequently. Take informal information trading as example (von Hippel, 1987; Schrader, 1990; Schrader, 1991a). Informally information trading refers to the exchange of valuable information between employees working for different companies. Such exchanges are common in many industries. Information trading takes place in the context of a multi-person environment. Usually, several potential information trading partners are available to a given employee. Consequently it is necessary to decide with whom to enter information trading relationships. Employees clearly prefer to cooperate with those colleagues with whom they had beneficial contacts in the past (Schrader, 1990). In addition to choosing trading partners, each employee has to decide on how to behave in a given dyad. Interestingly enough — and supporting Bhide and Stevenson's observation — retaliation within a dyad can be observed very infrequently. In most cases, employees do not retaliate directly if a colleague acts non-cooperatively in a situation in which cooperation would be expected. However,
they are now less inclined to interact with this colleague in the future (Schrader, 1990).

I propose that non-retaliatory, cooperative strategies can be as advantageous as, or may even dominate retaliatory strategies like Tit-for-Tat in two-person games with repeated partner choice if players adjust their interaction preferences for other players based on past payoffs. In this paper, I present results from a computer simulation to support this claim.

The main outcome of the computer simulation of two-person Prisoner's Dilemma games with repeated partner choice is surprisingly different to what results from the traditional analysis of two-person games (e.g. (Axelrod, 1984; Owen, 1982; Rapoport, Guyer, & Gordon, 1976; Schelling, 1960). The strategy of unconditional cooperation fares as well or even better than a retaliatory strategy like Tit-for-Tat — as long as player's preferences for specific interaction partners are at least partly updated according to the payoffs received.¹ For unconditional cooperation to be effective, players do not need to take radical measures. It is already sufficient if they are to a small degree less inclined to rechoose another player if interacting has created a disadvantage, and slightly more inclined if it has proven to be beneficial. These adjustments might be so small that at any given point they are not discernable to an outsider.

In the next section, I present briefly the arguments that are put forward in support of retaliatory strategies in two-person Prisoner's Dilemma games. I then introduce the notion of two-person games with repeated partner choice. Next, I present a computer simulation of several two-person games with repeated partner

¹ The term "unconditional cooperation" refers to the interaction behavior within a chosen dyadic relationship. The adjustment of interaction preferences might be interpreted as a form of retaliation. I will show later, however, that already small adjustments that might not be discernable for the partners suffice to reach the described results. Since a characteristic of effective retaliation is supposedly its visibility to the other players, I will not use the term retaliation (or reward) for a slight adjustment of interaction preferences based on past pay-offs.
choice. These simulations study the effectiveness of different interaction strategies depending on how sensitive players' interaction preferences are to payoffs and depending on the number of players involved. Finally, the results of this simulation are put into context. I suggest that unconditional cooperation might have some additional advantages over more sophisticated strategies like Tit-for-Tat. Retaliation by Tit-for-Tat can be misinterpreted as a tendency to be uncooperative and thereby create a negative image spillover.

The Argument for Retaliatory Strategies in Two-Person Games Without Partner Choice

In two person games, players face frequently the possibility to exploit their partners, e.g. to gain a benefit at the cost of the other.\(^1\) Repeated games provide the partners with the opportunity to retaliate such exploitation. A retaliatory strategy punishes exploitation right after it occurs — even if it creates additional costs for the exploited player (Schelling, 1960). Retaliation or sanctions and the threat of such measures can serve as means to motivate or induce other players to perform in a desirable way. (A threat is the ex-ante announcement of the willingness to retaliate in order to deter undesired actions by the other player.)

A strategy that does not retaliate exploitation will be exploited by non-cooperative strategies in the long run (Axelrod, 1984). In the context of repeated Prisoner's Dilemma games, Axelrod defines a strategy as retaliatory if it immediately defects after a defection by the other player (Axelrod, 1984, p. 44). In a Prisoner's Dilemma and related situations, retaliation serves two purposes. First, it prevents future exploitation by the other player. Second, it might induce the other player to return to a cooperative strategy, especially since the temptation benefit of

\(^1\) An extensive discussion and exhaustive list of two-by-two games can be found in Rapoport, Guyer, and Gordon (1976).
exploitation can no longer be reaped (Luce & Raiffa, 1957, p. 101; Rapoport & Guyer, 1966).

To investigate how to play a Prisoner's Dilemma game effectively, Axelrod organized a seminal computer tournament.¹ Fourteen game theory experts were invited to submit a computer program that embodied a decision rule on how to play an interactive Prisoner's Dilemma game. Tit-for-Tat, submitted by Anatol Rapoport, won the tournament, i.e. gained the highest overall payoff. Tit-for-Tat starts with a cooperative choice and thereafter mimics the other players previous action. In a second round of the tournament, 63 programs were submitted. Again, Tit-for-Tat turned out to be the overall most effective strategy.

The successful strategies identified by Axelrod's tournaments have at least three characteristics in common. First, they are "nice," i.e. they start out cooperatively. Second, they are retaliatory, i.e. they punish non-cooperative behavior. And third, they are forgiving, i.e. after having punished non-cooperative behavior, these strategies provide the possibility to return to a cooperative mode.

Donninger (1986) tested the generalizability of Axelrod's findings. In a similar computer tournament, he both varied the payoff matrix and the composition of strategies included. His results demonstrate that it is not always efficient to be nice. Especially if the temptation payoff (i.e. the payoff a player receives if she defects while the counterpart cooperates) is raised, non-cooperative strategies tend to perform better. Retaliation (either direct or with some time lag), however, proved to be a characteristic of all well performing strategies.

In sum, retaliation or sanctioning undesirable behavior appears to be an element of successful strategies in non-zero-sum repeated games (Hardin, 1982). Retaliation is employed to prevent exploitation and to induce the other player to act

¹ A detailed description of the tournament can be found in (Axelrod, 1984).
cooperatively. A strategy of unconditional cooperation, on the other hand, is unstable (Taylor, 1976)\(^1\) and likely to be exploited by other strategies (Rapoport et al., 1976). Although mutual cooperation can result from conditional, retaliatory strategies, "it is never rational for a player to use the unconditionally Cooperative strategy" (Taylor, 1976, p. 89).

**Two-Person Games With Repeated Partner Choice**

The traditional analysis of two-person analysis a specific relationship independent of any other relationships the players might or could be engaged in. However, many situations exist in which a specific dyadic relationship cannot be viewed isolated from other relationships. Individual frequently face numerous two-person relationships in which to potentially engage. Time and other constraints often necessitate that only a few of all potential relationships are finally actuated. For example, academicians frequently know many individuals with whom to write joint papers. Unfortunately, the number of papers an individual can write at a given time is limited. It is necessary to choose with whom to collaborate; and this choice needs to be done repeatedly. A multitude of isomorphic situations exists, such as cross licensing, joint development projects, or the exchange of birthday cards. In all these situations, an actor can or must choose between several potential relationships. Within each of the selected relationships, however, an interaction occurs that can be interpreted as a two-person game. Thus, these situations contain clearly a multi-person component. This component, however, is not addressed by the existing research on multi-person games.

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\(^1\) Taylor defines a stable equilibrium as a situation in which "no player can obtain a larger payoff by using a different strategy while the other players continue to use the same strategies" (Taylor, 1976: p. 85).
The analysis of multi-person games concentrates on different issues. Most multi-person games conceptualize situations in which several actors interact simultaneously and the action of one actor has direct consequences for the payoffs of all the other actors. The provision of public or collective goods, for example, is a central topic and issues such as the free rider problem and the emergence of behavioral norms are discussed (e.g. (Axelrod, 1986; Hardin, 1982; Olson, 1965; Taylor, 1976; Ullmann-Margalit, 1977).

The problems investigated in this article are covered neither by the traditional analysis of two-person games nor of multi-person games. The phenomenon of interest is located conceptually between two-person games and multi-person games. A player interacts with only one other player at a time. However, this specific dyadic relationship occurs in the context of many potential relationships. Such a situation is different from a two-person game in which a specific relationship is conceptualized independent of any other relationship. It is also different from n-person games that are characterized by each player simultaneously interacting with all other players.

At least two types of decisions have to be made when two-person games are played with repeated partner choice. The first decision concerns the formation of dyadic relationships. These decisions determine the pairs of interacting players. The second type of decision relates to the behavior in each dyadic relationship. The players have to decide how to act in a given dyadic. The structure of this decision is similar to a simple two-person game — although the appropriate strategy might be quite different.

Axelrod (1984, pp. 158-168) discusses a situation that resembles two-person games with repeated partner choice insofar as each player is involved in a number of dyadic relationship at the same time. He investigates strategies for Prisoner's Dilemma games in a simplistic multi-person environment. The environment is
structured so that each player has four neighbors, one to the north, one to the east, one to the south, and one to the west. The game extends over several generations. In each generation, a player interacts with all direct neighbors, i.e. plays four two-person games. After all four interactions, they players attain a success score measured by their average performance with their four neighbors. If a player faces a more successful neighbor, the player converts to this neighbor’s strategy. Axelrod finds that nice, retaliatory, and forgiving rules tend to perform well in such an environment. However, if future payoffs are discounted strongly, a community of nice strategies can be invaded by non-cooperative strategies.

In Axelrod’s game, the formation of dyadic relationships is predetermined by the location of the players. A given player always interacts with the same four players. The formation of dyadic relationships is static, i.e. unaffected by the outcomes of the interactions and unchanged in the course of the game.

Many situations exist, however, in which the formation of dyadic relationships depends on past payoffs. Consider informal information trading. Persons tend to prefer those relationships that have proven to be beneficial (Schrader, 1991b). They are less inclined to continue relationships that have been disadvantages. Frequently, it can be observed that individuals try to avoid to get in contact with those who have taken advantage of them. They might, for example, not return a phone call. In this case, the two players do not interact at all. Yet, if a contact cannot be avoided, the individual might be as helpful as ever. Bhide and Stevenson (1990) have observed this tendency of not adjusting one’s interaction strategy (i.e. the strategy used for interaction in a chosen dyad) and to remain cooperative even if the partner’s is known to take advantage of this — as long as the players interact at all.

In the following, results of a computer simulation that takes into account that players might update their preferences for specific interaction partners based on past
payoffs are presented. It will be seen that a strategy of unconditional cooperation might actually be more advantageous than it appears on first sight.

**Simulation of Two-Person Games With Repeated Partner Choice**

Computer simulation is used here to study the effectiveness of different interaction strategies for two person games with repeated partner choice. Computer simulation is frequently used to investigate games with complex strategic interactions (e.g., Axelrod, 1984; Axelrod, 1986; Behr, 1981; Donninger, 1986; Fader & Hauser, 1987; Schüßler, 1986). Simulation allows to probe into situations that do not lend themselves to formal analysis, including many games with multiple players using different, sometimes varying strategies with random elements.

**The Structure of the Simulation Game**

The computer simulation investigates a situation in which several players have a recurrent choice of which dyadic relationship to enter. In each dyadic relationship, the same two-person game is played. Once the players have interacted, they choose anew an interaction partner from the set of possible partners for the next round. Their preferences for specific relationships, however, is influenced by past payoffs (Figure 1). In other words, if a relationship has proven to be beneficial for a player, he is more inclined to choose this relationship again. On the other hand, if a player was exploited by another player, he is less inclined to choose the same player. Instead he will lean more towards choosing another interaction partner.
In each dyadic relationship, the players face a Prisoner's Dilemma. In the computer simulation, the payoffs remain constant.\footnote{An interesting extension of the model would be to use dynamic pay-offs. As Granovetter's work suggests, the expected benefit of each interaction within a specific relationship frequently decreases over time (Granovetter, 1973). New, "weak" ties often provide greater benefits per interaction than old, strong ties.} The classical Prisoner's Dilemma payoff matrix (Ullmann-Margalit, 1977, p. 31) is used (Figure 2). This matrix fulfills both conditions for a Prisoner's Dilemma as defined by Axelrod (Axelrod, 1984: 10). The first condition refers to the ordering of payoffs. The best a player can do is to defect while the other player cooperates, and the worst a player can do is to cooperate while the other player defects. The reward for mutual cooperation is higher than the payoff for mutual defection. The second condition states that an even chance of exploitation and being exploited results in a worse outcome than mutual cooperation.\footnote{Rapoport and Guyer's definition of a Prisoner's Dilemma encompasses the first condition only (Rapoport & Guyer, 1966: 211).}
FIGURE 2. Prisoner's Dilemma Pay-Off Matrix

Four strategies are included in the simulation. All of them are simple. They are at the core of most other strategies suggested for playing a Prisoner's Dilemma. The first strategy is Tit-for-Tat. Tit-for-Tat starts out cooperatively and thereafter mimics the previous choice of the other player. (With previous choice of the other player we refer to the last choice which the player with whom Tit-for-Tat is interacting currently has made in the same dyadic relationship.) It is a conditional strategy, i.e. Tit-for-Tat's choice depends on the other player's behavior (Taylor, 1976). The second strategy is Defect. Defect is an unconditional strategy. Independent of the other player's behavior, defection is chosen. The third strategy, Cooperate, is similar to Defect with the difference that cooperation is chosen all the time. Random is the last strategy. It is an unconditional strategy as well and chooses arbitrarily between cooperate and defect.

Choosing Interaction Partners

A player may choose any of the other players as desired interaction partner. For the simulation it is assumed that an interaction occurs only if two players choose each other simultaneously, i.e. Player A selects Player B and Player B picks Player A in the same round. Without such a double coincidence no interaction occurs.

Players choose interaction partners based on individual preferences. These preferences are expressed in a probability matrix. The probability matrix reflects the
likelihood that one player chooses another player as the desired interaction partner. These probabilities can be interpreted as a function of the expectations regarding the usefulness of future interactions with a given partner. In the beginning of the simulation, no prior biases towards specific interaction partners exist, i.e. the preference matrix is uniform.¹ In other words, each player has the same chance to be picked by another player as the preferred interaction partner for that round.

Players update their preferences based on past payoffs. Once a player has experienced that interacting with a specific partner is beneficial he will prefer to interact more with this partner and less with the other players. Similarly, if a player is exploited by another player he will be less inclined to choose that player again as an interaction partner and will be more inclined to choose another player. This assumption coincides with empirical research on the formation of exchange networks that stipulates that those ties get reinforced that create benefit for the network members (Schrader, 1991b). Thereby it is assumed that an expectation-supporting behavior changes preferences less than behavior that contradicts existing expectations.

A sensitivity parameter s is used to characterize how strongly a player's preference for a specific interaction partner (not the player's interaction strategy) is influenced by past payoffs. A large sensitivity parameter indicates that a player's interaction preferences are strongly influenced by past payoffs, a small sensitivity parameter indicates that a player considers past payoffs only slightly when choosing interaction partners. The following procedure was used to update the probability matrix. In the case that A and B interact and A receives a negative payoff, A will reduce the probability to choose B as an interaction partner by the negative payoff multiplied with the sensitivity parameter and increase the other probabilities

¹ Such biases could be caused for example by physical or any other type of proximity.
accordingly. (The sensitivity parameter is restricted so that no meaningless probabilities result.) If A receives a positive payoff, A will decrease the probability to choose somebody other than B by the positive payoff multiplied with the sensitivity parameter and increase the probability to choose B accordingly. Through this procedure, events that contradict existing expectations receive a stronger weight than events that are expectation supporting.\textsuperscript{1}

The following two tables exemplify the updating procedure. Table 1a depicts a probability matrix at the beginning of an unspecified round t. Table 1b contains the updated probability matrix after A and B have interacted in round t. For this example it has been assumed that A cooperates and B defects. Thus A has received a negative payoff of -2 and B a positive payoff of 2. The sensitivity parameter is assumed to be 0.05, i.e. a negative payoff of -2 leads to a reduction of the probability to interact by 10 percent. B reduces by the same percentage the probability of interacting with anybody other than A and increases accordingly the probability to choose A again in the future.

\textsuperscript{1} The formulas to update the interaction probabilities are as follows for an interaction between players A and B if A receives a negative pay-off in round t-1.

\begin{align}
(1) \quad P_t(A,B) &= P_{t-1}(A-B) \times (1 + s^*\pi) \\
(2) \quad P_t(A,K) &= P_{t-1}(A-K) - (s^*\pi) \frac{P_{t-1}(A,B)}{1-P_{t-1}(A,B)} P_{t-1}(A,K)
\end{align}

If A receives a positive pay-off in round t-1, the probabilities are updated as follows.

\begin{align}
(3) \quad P_t(A,B) &= P_{t-1}(A,B) + (s^*\pi)(1-P_{t-1}(A,B)) \\
(4) \quad P_t(A,K) &= P_{t-1}(A,K) \times (1 - s^*\pi),
\end{align}

with

A, B = The interacting players A and B.
K = Another player but A and B.
\pi = pay-off to player A.
P_t(A,K) = Probability that player A will choose player B in round t as desired interaction partner (Interaction probability).
s = Sensitivity parameter, indicating how strongly players consider past pay-offs when adjusting the interaction probabilities.
TABLE 1a

Assumed Distribution of Interaction Probabilities Before Interaction Between A and B in Round t

<table>
<thead>
<tr>
<th>Choosing Player</th>
<th>Chosen Interaction Partner</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>0.0</td>
<td>0.3</td>
<td>0.2</td>
<td>0.5</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>0.6</td>
<td>0.0</td>
<td>0.1</td>
<td>0.3</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>0.6</td>
<td>0.2</td>
<td>0.0</td>
<td>0.2</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td>0.3</td>
<td>0.3</td>
<td>0.4</td>
<td>0.0</td>
</tr>
</tbody>
</table>

TABLE 1b

Distribution of Interaction Probabilities After Interaction Between A and B in Round t

<table>
<thead>
<tr>
<th>Choosing Player</th>
<th>Chosen Interaction Partner</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td>0.000</td>
<td>0.270</td>
<td>0.209</td>
<td>0.521</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>0.640</td>
<td>0.000</td>
<td>0.090</td>
<td>0.270</td>
</tr>
<tr>
<td>C</td>
<td></td>
<td>0.600</td>
<td>0.200</td>
<td>0.000</td>
<td>0.200</td>
</tr>
<tr>
<td>D</td>
<td></td>
<td>0.300</td>
<td>0.300</td>
<td>0.400</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Parameters used for updating the probabilities:
- A cooperates, B defects.
  A's payoff = -2
  B's payoff = 2
- Sensitivity parameter s = 0.05

The Base Case: No Adjustment of Interaction Preferences

Two questions are at the core of this paper. First, which interaction strategies are preferable if players adjust their preferences for a specific interaction partner
based on past payoffs? Here the extent of the preference adjustment will be at the center of our interest. And second, how does the number of players in the environment effects the usefulness of different strategies? It will be investigated whether the common notion can be confirmed that cooperation is less likely to evolve the greater the number of players that interact.

To generate a common point of reference for the subsequent discussion, a game in which players do not update their interaction preferences is used as base case. This base case assumes that every player picks randomly one of the remaining players as desired interaction partner without preferring one player over another. Twelve players participate in this simulation. The four generic strategies (Cooperate, Defect, Tit-for-Tat, and Random) are represented with equal number of players.

The game runs for 1,000 rounds. On first sight, this appears to be a large number of rounds. However, since an interaction occurs only if two player choose each other simultaneously, only approximately 1.09 dyadic interactions occur per round. Thus after 1,000 rounds, circa 1090 interactions have occurred. Consider that each of the 12 players can interact with 11 other players. Consequently 66 unique dyads can be formed. Thus, in the base case, the members of a specific dyad have interacted approximately 16.5 times with each other after 1,000 rounds.

The expected payoffs and the expected number of interactions can be determined easily. Table 2 reports the expected payoffs for the first and all subsequent rounds.
<table>
<thead>
<tr>
<th>Strategy</th>
<th>Expected payoff first round*</th>
<th>Expected payoff subsequent rounds</th>
<th>Expected number of interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperate</td>
<td>-0.021</td>
<td>-0.021</td>
<td>0.091</td>
</tr>
<tr>
<td>Defect</td>
<td>0.095</td>
<td>0.021</td>
<td>0.091</td>
</tr>
<tr>
<td>Tit-for-Tat</td>
<td>-0.021</td>
<td>0.017</td>
<td>0.091</td>
</tr>
<tr>
<td>Random</td>
<td>0.037</td>
<td>0.000</td>
<td>0.091</td>
</tr>
</tbody>
</table>

* The expected payoff equals the sum of the probabilities that the player forms a specific dyad multiplied with the payoff he is expected to receive in this dyad.

Table 2: The Base Case: Expected Pay-Offs and Expected Number of Interactions per Round per Player

The outcome of the base case supports the above discussion on advantages of retaliation and conforms with the results of Donninger's (1986) simulation. Cooperate gains the lowest average payoff, primarily because it is exploited by Defect and to some degree by Random. Tit-for-Tat does nearly as well as Defect. It avoids being exploited by Defect and gains the cooperation benefit from interacting with itself and with Cooperate. In this specific environment Defect outperforms Tit-for-Tat slightly. This is primarily due to the great benefits it gets from interacting with Cooperate. A purely cooperative strategy is an obviously inefficient strategy in an environment in which other strategies try to exploit a players' cooperativeness and in which the players do not adjust their interaction preferences based on past payoffs.

Adjustment of Interaction Likelihood

In the following simulations, the assumption that players choose interaction partners independent of the outcome of past interactions is removed. Instead, players now adjust their interaction preferences based on past payoffs. However, it is
not necessarily assumed that players outright refuse to interact with another player that has exploited them. They rather may adjust their interaction preferences only slightly. Such a small adjustment would coincide with the observation by Bhide and Stevenson (1990) that most people do not retaliate in any obvious way once they have been exploited.

The first simulation reflects the case that players sparingly adjust their interaction preferences at any given time. Previous payoffs change to only a relatively small extent the players' inclination for choosing other interaction partners. The sensitivity parameter \( s \) equals 0.05. That means, if a player cooperates and the partner defects, the player reduces the probability to again choose the same partner by 10 percent of the original probability. E.g., if the probability to choose the other partner was 30 percent before the interaction it will be 27 percent afterwards.

Such a small adjustment of interaction preferences already changes the outcome dramatically in comparison to the base case. Defect, the strategy that performed best in the base game, turns out to be the least efficient strategy if the interaction preferences are adjusted slightly — except during the very first rounds (Figure 3). The two winning strategies are Tit-for-Tat and Cooperate. Their average payoffs per player per round are nearly the same. Tit-for-Tat outperforms Cooperate in the first one hundred rounds to a small extent and Cooperate performs somewhat better thereafter.
Sensitivity Parameter $s = .05$
12 players
Values are based on average of 100 simulations

FIGURE 3. Average Pay-Offs Per Player Per Round, Small Adjustment of Interaction Preferences

Does this pattern change if the players' interaction preferences are more strongly influenced by past payoffs? To address this question the sensitivity parameter was increased to 0.25. This means, a cooperative player who was exploited by another player decreases the probability to interact again with this exploiting player by 50 percent.

Under such conditions, the results are comparable to the ones found for the small adjustment of interaction preferences (Figure 4). However, two main differences can be observed. First, the development towards a stable pattern of
interaction is faster. Second, Cooperate outperforms Tit-for-Tat in a more significant way during the later stages of the game.

![Graph showing the average pay-off over rounds for different strategies: Coop, Tit-for-Tat, Defect, and Random.]

Sensitivity Parameter \( s = .25 \)

12 players

Values are based on average of 100 simulations

FIGURE 4. Average Pay-Offs Per Player Per Round, Large Adjustment of Interaction Preferences

The reason for Cooperate's slight advantage over Tit-for-Tat after the first rounds is that Cooperate more decisively recognizes non-beneficial partners than Tit-for-Tat. Cooperate clearly loses, for example, when interacting with Random. The expected payoff for each interaction with Random is \(-.5\). Consequently, Cooperate has both a negative motivation for not choosing Random in the future and a positive motivation for choosing other cooperative strategies. The negative
motivation results from the losses Cooperate experiences when interacting with Random. The positive motivation is due to the gains that result from interacting with other cooperative strategies. Tit-for-Tat, on the other hand, limits potential losses when interacting with Random. Thus, it does not experience a negative motivation for not interacting with Random. Or to say it in simplifying words, Tit-for-Tat "hopes" to turn the relationship with Random into a cooperative one — which naturally cannot be achieved. Thus it does not learn as quickly as Cooperate that it is not beneficial to interact with Random.

**Small Versus Large Number of Actors**

Is the finding that unconditional cooperation performs well in two person-games with repeated partner choice sensitive to the number of participating players? The traditional theory of collective action argues that cooperation is less likely to emerge in large groups than in small ones (Hardin, 1982; Olson, 1965).

To investigate the effect of group size, the number of players is increased from 12 to 20. It is assumed that players adjust their interaction preferences sparingly, i.e. s=0.05. The resulting distribution of payoffs is similar to the one for 12 players, with the difference that more time is needed to reach a stable pattern (Figure 5). Similarly to the 12-player case, Tit-for-Tat outperforms Cooperate slightly; Tit-for-Tat's average payoff for the first 1000 rounds is 5.6 percent higher than Cooperate's. After 3000 rounds, however, both strategies gain the same payoffs.
In sum, the strategy of unconditional cooperation performs in the investigated environments approximately as effective as the conditional, retaliatory strategy Tit-for-Tat as long as the players' interaction preferences are at least partly shaped by past payoffs. The greater the extent to which past payoffs influence the adjustment of interaction preferences, the more beneficial is the strategy Cooperate. Under some circumstances, it even outperforms Tit-for-Tat. A large adjustment of interaction preferences, however, may be interpreted as another form of retaliation.
The surprising result of the simulations is that Cooperate performs nearly as well as Tit-for-Tat even if the preferences are adjusted only to such a small degree that outsiders are likely to be unable to detect this adjustment. Under such circumstances, the adjustment does not constitute retaliation. Retaliation appears to not always be necessary for cooperation to emerge as a stable behavioral pattern.

**Conclusion: Unconditional Cooperation Because it Pays**

This paper has introduced a new class of games: Two person games with repeated partner choice. These games show characteristics of both two-person games and multi-person games. Players interact in dyadic relationships. At any point, however, they can choose between several dyads in which to interact.

Although one might have expected that a series of two-person games with repeated partner choice is similar to a collection of two-person games played nearly simultaneously, the possibility to choose between different interaction partners has a profound impact on the efficiency of interaction strategies.

Unconditional cooperation proves to be a surprisingly effective strategy — as long as the players adjust their preferences for interacting with other players at least to a small extent based on past payoffs. This adjustment of interaction preferences could be interpreted as indirect retaliation. Effective retaliation, however, requires that the punished player recognizes the punishment (Bayard & Elliott, 1991). Yet, the computer simulations have demonstrated that even very small adjustments are sufficient to protect Cooperate from being overly exploited by other strategies. No drastic measures are necessary. Exploitation does not need to result in an outright cancellation of the relationship. Rather, it is sufficient to only slightly reduce the chance of again choosing the exploiting player as interaction partner. These adjustments can be so small that other players might be unable to perceive them as
retaliation. This would help explain why Bhide and Stevenson's (1990) believe that frequently untrustworthy behavior remains unpunished.

If interaction preferences are updated, both Tit-for-Tat and Cooperate perform approximately equally well. Under some conditions Tit-for-Tat slightly outperforms Cooperate, under other conditions Cooperate outperforms Tit-for-Tat. Both strategies isolate non-cooperative players. Tit-for-Tat, in addition, punishes non-cooperation. This punishment generates short term advantages over the strategy of unconditional cooperation. It does not, however, create a significant benefit in the long run.

One major difference between Tit-for-Tat and the strategy of unconditional cooperation is not captured in the presented simulation model. In a multi-person environment, unconditional cooperation is a less risky strategy than Tit-for-Tat, as long as reputation spillover can occur. Assume that two players, A and B, interact and B defects on A. In addition, assume that A plays Tit-for-Tat and punishes B's defection once they meet again. Outsiders might only observe this punishment and might not know the history of the relationship. They might wrongly deduce that A is a non-cooperative player with whom better not to interact. Consequently, punishment bears the danger of creating a negative external image spillover for the punishing party. This danger does not exist for the strategy of unconditional cooperation.

The strength of unconditional cooperation in the context of two-person games with repeated partner choice is even more astonishing if one considers that Cooperate is a very unsophisticated strategy. No strategic game plan is used. Only the preferences of Cooperate for interacting with other players change slightly based on the past payoffs received.

The distinction between choosing interaction partners based on past payoffs and the strategies used within a given dyadic relationship is of great empirical
importance. Take informal trading of technical information for an example (von Hippel, 1987; Schrader, 1991a; Schrader, 1991b). If some employee demonstrates uncooperativeness by providing unreliable information, other employees do not tend to counter by providing false information themselves. Instead, they are inclined to decrease the likelihood of interacting with this uncooperative employee again. Sometimes, such behavior is even codified, as is the case in the oil-exploration industry, where exploration firms delegate to some employees, the so-called oil-scouts, the task of exchanging valuable proprietary information informally (Schrader & von Hippel, forthcoming). These oil-scouts are organized in professional societies and meet at regular intervals, usually once a week. The societies enforce an elaborate set of rules of conduct such as "no member (...) shall intentionally report false information" (By-Laws of the Houston Oil Scouts Association). If members violate these rules, the only punishment is that they may be expelled from one or several future association meetings. By expelling non-cooperative members from the meetings, their chance to interact with other members is greatly reduced. If, however, they do interact with other members outside the meeting, those members have to follow the rules of the association. In sum, defection does not induce counter-defection, but does lead to a reduction of the interaction probability.

It is frequently proposed that general behavioral norms like telling the truth emerge out of dyadic relationships (i.e. two-person games) in which conditional cooperation is a stable strategy (Hardin, 1982; Ullmann-Margalit, 1977). Unconditional cooperation, however, is argued not to be a stable strategy in two-person games. To be unconditionally cooperative is non-rational in the context of nearly all specifications of traditional two-person games (Taylor, 1976, p. 89). This paper, however, has shown that the strategy of unconditional cooperation can be effective in some situations that are easily misinterpreted as two-person games:
situations in which a player has a repeated choice between different dyads in which to interact. In such situations, which I have labeled as two person games with repeated partner choice, unconditional cooperation can perform as well as other retaliatory strategies, as long as the players tend to at least slightly favor those relationships in which they gain higher payoffs.

Several authors view retaliation of non-cooperative behavior as a prerequisite for cooperation to evolve and stabilize. Frequently, however, retaliation is costly to the one who retaliates. This led Axelrod (1986) to introduce a meta norm that punishes non-punishment. The results presented in this paper, however, suggest that at least for some two-person games with repeated partner choice retaliation is not necessary. Even small behavioral adjustment that are in the individual's self-interest and that may not be detectable by an outsider may be sufficient to stabilize cooperation.

I would argue that many situations resemble more the characteristics of a two-person game with repeated partner choice than of a traditional two-person game. This might explain the puzzle of why cooperation can frequently be observed even though defection creates an advantage and players apparently do not to retaliate. In such situations, unconditional cooperation may not only be justified as morally appropriate but also as "good business."
References


