Rewards and Punishments as Selective Incentives

AN APEX GAME

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Apex games place weak players in the formal equivalent of a multiperson prisoner's dilemma in which each weak player must choose between competing against the other weak players for the opportunity to coalesce with the strong player or cooperating with the other weak players to produce a jointly preferable outcome. Punishments, not rewards, are predicted to be effective for enforcing cooperation by the weak players. Fifty-four groups of four subjects each played the weak role in a five-person apex game with a confederate playing the apex (strong) role in a 3×3 design with factors of low, medium, and high levels of rewards and punishments available as incentives. As predicted, punishments but not rewards had a significant impact on increasing cooperation. Despite this effect, many groups experienced harmful effects of punishment availability that increased the risk of retaliatory spirals. It is concluded that a second-order dilemma may be seen in prisoner's dilemmas, since punishments are both necessary for enforcing cooperation and detrimental to that cooperation.

Olson (1965:51) coined the term "selective incentive" to refer to private goods given to individuals to induce them to participate in collective action to provide some public good. Subsequent critical treatments of Olson's work have shown his assertion that collective action is always irrational to be overstated (Frohlich and Oppenheimer, 1970; Frohlich et al., 1975; Chamberlin, 1974; Schofield, 1975; Bonacich et al., 1976; Smith, 1976; Oliver, 1980a), but it remains true that many collective actions are individually irrational and are made possible only

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by selective incentives. Despite the general recognition of the importance of selective incentives, their nature has not generally been fully analyzed. In particular, the differences between rewards and punishments as selective incentives generally have not been appreciated.

This article describes the results of an experiment designed to demonstrate the differential impact of rewards and punishments as selective incentives on collective action in a power-imbalanced bargaining game. The game chosen for this research is an apex game that is especially well-suited for the study of collective action. To anticipate the conclusions of this work, punishments are shown to be far more efficacious in this game (as they are predicted to be from a structural analysis of incentives), but their use invokes problems of retaliation and anger predicted from the social psychological literature on rewards and punishments. The conclusion discusses the implications of these results for problems of collective action.

POSITIVE AND NEGATIVE INCENTIVES

Olson and most others writing in the collective action tradition make no distinction between positive and negative incentives. Within the framework of rational decision-making, there is no difference between them for the recipient of the incentive. Regardless of whether it punishes noncooperation or rewards cooperation, the magnitude of the incentive must be greater than the difference between the payoff for cooperating and the payoff for not cooperating (or defecting).

But this equivalence for individual recipients does not hold for the structural problem of inducing collective action by a group (Oliver, 1980a). Because selective incentives are private goods, a greater quantity of the incentive must be expended if more people are to receive it. Positive incentives are given to cooperators: If everyone cooperates in collective action, everyone must be rewarded; if everyone defects, no one is rewarded. Negative incentives are just the opposite: If everyone

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cooperates, no one gets punished, but if everyone defects, everyone must be punished.

Thus, positive incentives are more efficient when a relatively small proportion of the total group must cooperate for the collective good to be provided, while negative incentives are more efficient when unanimity or near-unanimity is required. If only 5% of the population needs to contribute to an Arts Fund for it to be successful, they can be rewarded by having their names printed in a program: It would be silly and wasteful to try to punish the 95% who did not contribute. Conversely, strike requires near-unanimity to succeed, and it is most efficient to threaten to punish strike-breakers.

REWARDS AND PUNISHMENTS

Little prior research has examined rewards and punishments as incentives for collective action by several people, although a great deal of research has examined rewards and punishments as inducements for compliance by individuals in a wide variety of settings. A complete review of this literature is beyond the scope of this paper, but relevant patterns of findings may be highlighted.

Comparisons of rewards and punishments as reinforcers in the behaviorist tradition reveal that positive reinforcers are usually more effective than negative ones, but punishments can be effective in certain conditions, particularly in eliminating well-defined behaviors that do not have inherently positive reinforcing consequences (Bandura, 1969; Millenson, 1967). Since the game employed in this experiment has an inherent positive reinforcement for defecting, a simple application of behaviorist principles would seem to predict (contrary to the selective incentive analysis) that punishments would be ineffective.

Tedeschi (1970) stresses the communication of intentions through threats and promises; actual rewards and punishments are viewed as affecting the credibility of future promises or threats. These ideas have been expressed in subjective expected utility (SEU) terms by Tedeschi, Bonoma, and Schlenker (1972), where the SEU of complying with a communication is the product of the value of the promised reward (or threatened punishment) times the subjective probability of its presentation conditioned upon compliance. The underlying decision-theoretic approach of their work is essentially the same as the treatment of selective incentives in the present work. Their review of the relevant empirical research finds that both the value of a reward or punishment and the probability of its presentation are important predictors, but that the exact ordering of cell means is often not correctly predicted. Their model fails to treat explicitly the payoff for noncompliance (the "defection payoff" in the present work); this may contribute to their prediction failures.

There is little empirical literature relevant to the comparison of rewards and punishments as incentives, but such as exists is consistent with Oliver's (1980a) structural arguments. Comparisons of rewards and punishments as inducements for individual compliance find no difference (Kipnis, 1958; Lindskold and Tedeschi, 1971) or an advantage for rewards (Schmitt and Marwell, 1970; Hogan et al., 1974).

By contrast, experiments comparing rewards and punishments as inducements for more than one subject in collective action dilemmas usually find that punishments are more effective. Stern (1976) experimented with a wide variety of influence techniques for producing resource conservation in a simulated commons dilemma; he found that price increases—a kind of negative incentive—produced conservation while direct payoffs and rationing did not. Shaw (1977) assessed the effects of joint rewards for cooperation versus joint punishments for competition on two subjects playing a standard prisoner's dilemma game and found that punishment led to more cooperation than rewards in the control condition, even though subjects perceived themselves as more cooperative in the reward condition.

Although they provided no comparison with rewards, other studies have found punishments can be effective for inducing cooperation among groups of subjects. Caldwell (1976) reports that allowing subjects in a five-person prisoner's dilemma to vote to impose a fine on a defector increased cooperation above the baseline rate and above the cooperation in a period in which discussions but not fines were allowed. Oliver (1980b) reports that base players in a four-person apex game who could punish each other were much more likely to form the base coalition than were subjects in a control group. French et al. (1960) found that a "supervisor's" ability to fine a "worker" increased "production" even though it made the worker like the supervisor less. Pruitt and Gleason (1978) found that the ability to fine the other player for the mutually harmful act of putting up a gate in a mixed-motive "trucking game" increased mutual cooperation.

There are studies which find that punishment hampers cooperation, but such studies are in the threats and bargaining tradition and usually employ a threatened action that harms the person who uses the punishment as well as the target, an action such as forcing a premature closure of the game (Hartford et al., 1969; Schlenker et al., 1970; Deutsch and Krauss, 1960; Froman and Cohen, 1969).

In sum, there is empirical support for making the distinction between rewards and punishments as incentives for collective action. Punishments have been found to be more effective for producing cooperation by a group of subjects. I have found no instance in the literature in which rewards have been successfully used to induce cooperation in collective dilemmas.

Experiments on reactions to punishment reveal an important dilemma. On the one hand, punishment can effectively modify others' behavior when it is cost-effective to do so (Tedeschi et al., 1970) or when it is the only instrumental option available (Michener et al., 1978; Crott et al., 1978; Goodstadt and Kipnis, 1970). But on the other hand, there is much evidence of noninstrumental retaliatory punishment. A review by Tedeschi et al. (1972) concludes that reciprocal threats capacity can hurt cooperation because it leads to spirals of conflict and cites research indicating that subjects will retaliate to save face even if it hurts themselves. A fair amount of subsequent research has continued in this vein, finding that subjects who have been aggressed upon retaliated (Kulik and Brown, 1979), even when they could not gain materially by doing so (Felson, 1978), when doing so would not prevent future attacks (Dengerink et al., 1978), or when the punishment was justified (Oliver, 1980b); similarly, Tjosvold (1977) found that bargainers would resist influence to save face even when it meant a suboptimal outcome.

To conclude, both rewards and punishments have been found to be effective influence modes in appropriate settings, but using rewards to induce compliance seems to have no or only positive side effects, while using punishments often has the negative side effect of provoking face-saving retaliation. The few studies of the effects of incentives on groups of subjects suggest that punishments are more effective for inducing unanimous cooperation.

APEX GAMES

This experiment tests rewards and punishments as selective incentives in the particular setting of an apex game. An apex game is a power-imbalanced coalition formation game first described by von Neumann and Morgenstern (1947: 473-503) and extensively analyzed by Horowitz and Rapoport (1974). An n-person apex game has one player called an apex and n-1 players called bases; its essential feature is that the only legal winning coalitions (those with positive payoffs) must include the apex or must include all other players except the apex.

The power imbalance of apex games makes them a valuable instance for game theorists because different solution concepts yield different predictions for this class of games (Kahan and Rapoport, 1979). Many theoretical and experimental treatments of apex games have been published within the past decade with the goal of developing a general game-theoretic analysis of processes of bargaining in conflict situations.

My purpose in employing an apex game is not to contribute to game theory, but to use its results to create a collective dilemma that involves a power imbalance and to study the impact of incentives in resolving this dilemma. Two features of apex games make them well suited for such research.[1] First, apex games are strongly power-imbalanced. The apex player is in a winning coalition in from 80% to 95% of all experimental trials, while base players are in winning coalitions in an average of about 40% or less of trials with four-person apex games, and about 30% or less of trials with five-person apex games. Furthermore, when the apex forms a coalition, his share of its payoff is usually substantially greater than the share of his base partner.

Second, formation of the base coalition is a kind of "collective action" in Olson's sense and involves a dilemma that is equivalent to a multiperson prisoner's dilemma.

Oliver (1980b) demonstrates this equivalence by developing prescriptions for the rational behavior of the players in an apex game. A rational apex maximizes his or her expected payoff by offering one base an amount just greater than the base's expected share of the base coalition and by doing everything possible to assure that base that he or she (the apex) will stand by that offer. If the apex behaves this way, the chosen base will unambiguously prefer the apex-base coalition over the all-base coalition. All of the theoretical analysis and empirical data on apex games indicates that the only stable expected division of the base coalition payoff is equal: If P is the total payoff and there are m bases,

1. This summary is based on relevant treatments in Selten and Schuster (1968), Chertkoff (1971), Horowitz (1973), Horowitz and Rapoport (1974), Albers (1978), Komorita (1974), Michener et al. (1977), Murnighan et al. (1977), Rapoport et al. (1978), Ordeshook and Winer (1980), Komorita and Kravitz (1979), Kahan and Rapoport (1979), Murnighan and Roth (1980), Murnighan and Szwajkowski (1979).

the expected payoff to a base is P/m. If the apex offers the base any amount greater than this, say P/m +1, the base's probability of acceptance should be 1.0, making the expected value to the apex P – P/m –1. If the apex seeks more than this, he lowers the probability of the base's acceptance and thus of his or her expected payoff.

But if the apex behaves as prescribed, the bases are in a situation equivalent to a multiperson prisoners' dilemma. Each base can expect an average of P/m if the base coalition forms, but a defector can obtain more than this by forming a stable alliance with the apex. Regardless of what the other bases are doing, each base's rational choice is to negotiate with the apex: If the other bases are trying to promote the base coalition, the defector can be assured of a better payoff by bargaining with the apex, and if any other base is negotiating with the apex, a base's only choice is to enter the competition, since the base coalition requires the unanimous cooperation of the bases. Bases who seek only to form the base coalition raise other bases' expected winnings, regardless of what the others do. Or, looking at it another way, each base prefers that the other bases bargain solely with the base coalition so that he or she may obtain his share of the base coalition's payoff or obtain a favorable distribution of the payoff in bargaining with the apex without competition. The dilemma in this game is extreme, since the defection payoff increases when most bases are cooperating with the base coalition, leading the apex to offer more to attract a defector.

There are extensive debates in the prisoner's dilemma literature about whether it is more "rational"—in a evaluative sense—to defect or to cooperate (since the individually irrational cooperators achieve higher payoffs than rational defectors), but the empirical facts are clear: Prisoner's dilemmas usually but not always result in players locking into the noncooperative options, and the amount of cooperation declines rapidly as the number of players involved increases (Bixenstine et al., 1966; Hamburger et al., 1975; Kahan, 1973; Kalisch et al., 1962; Goehring and Kahan, 1976; Rapoport, 1975). Once it is understood that the bases in an apex game face the equivalent of a multiperson prisoner's dilemma, the low frequency of the base coalition is easily understood.

But if rational play by the apex places the bases in a prisoner's dilemma, then cooperation with the base coalition is an instance of collective action in Olson's sense of providing some common good. The equivalence between Olson's problem and the prisoner's dilemma was first demonstrated by Hardin (1971) and elaborated upon by Dawes (1975).

SELECTIVE INCENTIVES IN APEX GAMES

If the apex plays rationally, the bases are in a collective action dilemma that has many of the properties of a multiperson prisoner's dilemma. Olson's work suggests that the resolution of ths dilemma is the availability of selective incentives. Thus it is appropriate to consider analytically the necessary properties of selective incentives in apex games.

The magnitude of a selective incentive for any recipient has to be large enough to overcome the defection payoff. In the apex game, this payoff is the difference between a base's share of the base coalition payoff and his share of an apex-base coalition payoff. As shown above, a base's expected payoff from the base coalition in this game is P/m. For example, if the game payoff, P, is 100 and the number of bases, m, is 4, then the individual's share is $P/m = 25$. If the apex offers a 65-35 split, the defection payoff is $35 - 25 = 10$.

Suppose there are 20 points worth of incentive available. Is this enough to prevent defection? No, because if the apex offers the base any amount more than 45 points, the defection payoff will exceed the cooperation payoff; the apex will make such an offer because he prefers a smaller share of the payoff to nothing. For any incentive amount up to 74 points, the apex can reduce his share to find a bargaining partner. Thus, the minimum incentive amount to ensure that a base will prefer the base coalition in this case is 75 points; it is $P(m - 1)/m$ in the general case. Any incentive less than this minimal amount of $P(m - 1)/m$ shifts the range of bargaining but does not change the predicted coalitional outcome. Any incentive $k < P(m - 1)/m$ shifts the predicted base's share to $k + P/m$, but leaves the apex-base coalition as the predicted income.

This situation is even more complex for the bases than the analysis has suggested thus far, however, for it has considered the decision of only one base at a time. If only one base were bargaining with the apex, he or she should be able to obtain a payoff just greater than $k + P/m$ from the apex-base coalition. But if several or all bases reject the base coalition and seek to coalesce with the apex, they enter a competition and drive down the predicted base's share. They can only keep the base's share of an apex-base coalition high by credibly threatening to form the base coalition. But this threat is precisely what raises the defection payoff for each base. This is the paradox of the game: The more trustworthy others are, the greater the payoff for defection. Thus, only when the incentive is greater than $P(m - 1)/m$, completely eliminating the defection payoff, can the base coalition be enforced.

The discussion so far has ignored the question of rewards and punishments. Formation of the base coalition requires unanimous cooperation among the bases, suggesting that punishments are requisite. If positive incentives are used, each base must be rewarded with $P(m - 1)/m$ for cooperation with the base coalition, meaning that the total amount of incentives available must be $P(m - 1)$, or $m - 1$ times the value of the coalition game. An incentive of such a magnitude would dwarf the game payoff, so we may say that within the ranges of magnitudes for which "incentive" is a meaningful term, rewards are predicted to be ineffective in promoting the base coalition. By contrast, the requisite amount of punishment necessary is $P(m - 1)/m$, since only the base who coalesces with the apex needs to be punished.

This analysis applies not just to the extreme conditions of the apex game, but to any multiperson prisoner's dilemma in which the defection payoff rises with the number who cooperate rather than defect. If m is the number of persons in the dilemma, a positive incentive system must be m times greater than a negative incentive system to enforce cooperation. Of course, the specific magnitude of the necessary incentive will depend on the defection payoff.

EXPERIMENTAL DESIGN

This experiment was designed to correct potential design flaws in the work of Oliver (1980b) and to provide comparative data on the effectiveness of rewards and punishments for inducing cooperation among the bases in an apex game. It will thus be helpful to discuss the earlier experiment in some detail.

Oliver (1980b) employed a simple two-cell design. Subjects played nine rounds of a four person apex game with the characteristic function[2]

2. The characteristic function is standard game theory notation; see any standard work on game theory such as von Neumann and Morgenstern (1947), Rapoport (1970), or Davis (1970) for details on this convention and its theoretical rationale. The characteristic function shows the total payoff available to a coalition, should it form. Members of the coalition are assumed to have made some decision about how to divide this payoff among themselves in the process of forming the coalition. It is assumed that each player can be in, at most, one coalition. Thus, in Oliver's (1980b) experiment, any coalition involving the apex and one base, or the coalition involving all three bases, had a payoff of \$2.70. The remaining players (either two bases or just the apex) received nothing. In the present experiment (described below), any coalition involving the apex and one base, or the coalition involving all four bases, had a payoff of \$2; again, remaining players received nothing.

v(AB) = v(AC) = v(BCD) = \$2.70, where the payoffs of all other coalitions are zero; player A is the "apex" by definition. The apex was a confederate who behaved similarly to the description given below of the apex's role in this experiment. In this game, $P(m - 1)/m = 2(\$2.70)/3 = \$1.80$.

In the experimental condition, each round of the Apex game was followed by a round of the "ding game" in which the base players could each take up to 90¢ away from other bases, meaning that any two players controlled the necessary \$1.80 of incentive if all of it was used. In this simple experiment, the base coalition formed in only 20% of the control trials (no punishment) but in 62% of the trials in which bases could punish each other (F 1, 17 = 17.784, $p < 001$, $R = .53$).

This simple experiment yielded strong results, but had questionable internal validity. First, the presence and absence of the incentive was confounded with procedural differences involved in administering the "ding game." Second, the results could be due either to a simple reinforcement process or to a simple tendency for people to attend to the implicit evaluations of others. Although it may not be possible to provide careful specifications or tests of alternate theories, an experimental design should rule out coarse versions of alternate explanations as causes of methodological artifacts.

PREDICTIONS

The following a priori hypotheses are subjected to test:

(1) The Available Rewards and Punishments Will Be Used as Selective Incentives. That is, they will be used to punish cooperation with the apex and to reward cooperation with the base coalition or noncooperation with the apex, and not otherwise. If subjects do not use the rewards and punishments available to them in the predicted fashion, the rationale for the experiment is clearly in error. Subjects should punish any base who coalesces with the apex and reward each other when the base coalition forms. Additionally, when one base coalesces with the apex, each base should reward all bases who did not coalesce with the apex as such noncoalescence is beneficial to all other bases.

(2) The Base Coalition Will Form Much More Often for Those Conditions in Which the Incentive Is Large Enough to Offset the Defection Payoff Than for Those When It Is Not. This hypothesis

concerns the maximum incentive size as it exists and the maximum defection payoff, and predicts that the maximum incentive must exceed the maximum defection payoff for cooperation to be affected. The maximum defection payoff is always 70 points; this is the maximum base share of an apex-base coalition (95 points) minus the base's expected share of a base coalition (25 points). The maximum negative incentive available to punish a base who coalesces with the apex is three times the negative incentive controlled by each individual; the maximum average positive incentive available in the base coalition is the total available (amount controlled by each individual times four) divided equally among the four bases. Table 1 shows the combined maximum negative and positive incentives for each cell of the design. The cells for which the incentive exceeds the defection payofff are marked.

(3) The Level of Punishment Available Will Have a Strong effect on the Amount of Cooperation with the Base Coalition While the Amount of Reward Available Will Not. This prediction is not statistically independent of the previous one, but it is desirable to test it to verify that plausible alternate explanations do not account for the observed results. It was argued above that rewards available in the same magnitudes as punishments should be ineffective given the structure of this game. If rewards are effective, the theoretical basis for this experiment would be seriously questioned.

It should be emphasized that the reason a system of rewards is predicted to be ineffective as a selective incentive in this experiment is because it is not possible for such an incentive system to provide an adequate incentive for individuals. Thus, this experiment does not test the difference between rewards and punishments of comparable magnitudes as individual incentives; rather, it tests for differences between systems of rewards and punishments with comparable magnitudes on collective action by a group.

The logic of this test is the "failure to falsify" model. Confirming the prediction cannot prove the theoretical assumptions, since there are other possible explanations of such a result. But disconfirming the prediction would be strongly damaging to the theoretical analysis; thus, failing to disconfirm provides support for the analysis.

METHODS AND PROCEDURES

The present experiment was designed to address the threats to internal validity in Oliver's (1980b) experiment and to meet the

TABLE 1
Maximum Incentive (Negative Plus Positive) Available in Each Condition of Experiment

	Level of Punishment Available[a]		
Level of Reward Available[b]	*Low (5)*	*Medium (20)*	*High (35)*
Low (5)	20	65	110[c]
Medium (20	35	80[c]	125[c]
High (35)	50	95[c]	140[c]

a. Maximum negative incentive available is three times the individual number.
b. Maximum expected positive incentive available is the individual amount , that is, the total amount available to four players divided by the four possible recipients.
c. Exceeds the maximum possible defection payoff of 70 points.

additional goal of providing further information about the effect of selective incentives on collective action. These goals were met by the use of a 3 × 3 factorial design crossing the levels of available punishment with three levels of available rewards. The independent variables were manipulated by the number of pink (punishment) and blue (reward) index cards subjects were given to allocate to the other players, a procedure that allowed all cells of the design to be identical in all respects except for the manipulated variables. The lowest levels of both punishment and reward were nonzero, so that all subjects had both rewards and punishments to administer to others. The manipulation of levels of incentive isolated the amount of available rewards and punishments as the only operative variable distinguishing the conditions.

Subjects were 216 college undergraduates enrolled in classes in a wide variety of academic disciplines (excluding psychology and advanced sociology courses), who voluntarily completed availability schedules after hearing the experimenter or an assistant truthfully describe the general nature of the experiment and the range of possible earnings. Subjects were assigned to groups solely on the basis of availability. Groups of subjects were randomly assigned to treatment conditions.

Each group of subjects played the 4 base positions in 10 rounds of an apex game with characteristic function v(AB) = v(AC) = v(AD) = v(AE) = (BCDE) = 100 points = $2.00. Subjects were not told how many rounds they would play. All bargaining, rewarding, and punishing were limited to multiples of 5 points (equivalent to multiples of 10¢). The basic unit of exchange was a green 3 × 5 index card that was worth 5 points or 10¢.

The rules and procedures for the bargaining phase of the game were developed as a manually administered version of those created by Kahan for his program COALITIONS (1970), which has been used extensively in gaming research (e.g. Horowitz and Rapoport, 1974; Kahan and Rapoport, 1979). Members of a coalition had to maintain agreement with a particular payoff division for 3 complete bargaining cycles (so that each player had 3 opportunities to make or consider alternative proposals) before they could ratify it. The members of ratified coalitions received their agreed upon payoffs in green index cards at the end of each round. These cards could be lost or others gained in the reward/punishment sessions that followed each round of bargaining. At the end of 10 rounds, subjects were paid 10¢ for each green card plus an additional $1 promised as payment for "showing up and listening to the instructions."

Subjects were asked to meet the experimenter in different places and were conducted one at a time into the laboratory and seated in cubicles that allowed them to see the experimenter but not each other. They were asked not to talk. A 15-minute instruction period described the rules and procedures of the game in neutral terms, avoiding all references to power, collective action, imbalance, or the like. Each player was referred to by letter and masculine pronouns, and no special differentiation of Player A (the apex) was made beyond that inherent in the rules and a statement that player A had received "additional instructions." Subjects bargained by holding up cards that represented their various options. The experimenter reproduced all bargaining on charts on the front wall so all players had full information about the bargaining process. The part of the apex was played by a confederate according to a detailed set of instructions developed through extensive pretesting that made the apex's behavior appear "natural" in all conditions while confronting each group of subjects with the same stimulus. To ensure that the bases were in a symmetric prisoner's dilemma, the apex sought a 50-50 split with a base (but would accept other divisions), never abandoned a coalition once a base had accepted it, took a smaller share of the payoff if necessary to ensure a coalition, and ensured that each base had an equal number of opportunities to be "favored" for an apex-base coalition across all the rounds of game.[3] This behavior of the apex

3. The complete protocol for the apex was six single-spaced pages long; interested readers may write to the author for a copy. It was constructed through elaborate pretesting to make the apex's behavior appear "natural" in all circumstances despite being

generated a true dilemma for the bases: They would all genuinely earn more money if they cooperated with the base coalition, but they could count on a reasonable payoff if they coalesced with the apex.

The independent variables were manipulated as follows. Each round of bargaining and coalition formation was followed by a "reward/punishment session." Each of the base players (B, C, D, and E) controlled a designated amount of points of reward and punishment that he could give to any other base player. These were represented by blue and pink cards (worth 5 points or 10¢ each) that subjects placed in envelopes to indicate what they wanted to do with them. Each player had separate envelopes for each other player and an envelope marked "not used." Blue and pink cards were worth nothing to the player who controlled them, could not be saved from round to round, and could not be exchanged for anything. On each round a player could give as many of his available cards as he wanted to any player and was free not to use any or all of them. There was no direct cost for giving out rewards and punishments, and no direct cost for not doing so. All rewards and punishments were given anonymously; everybody knew how many points of reward and punishment each player received, but not who gave what to whom. Negative totals did not accumulate from round to round; a player who lost more than he had earned on a particular round was just credited with zero. The rules for the system of rewards and punishments

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completely controlled. The apex never had the first play of the experiment; a random draw determined which subject played first in the first round. After that, play rotated in alphabetical order within a round, as did the chance to play first in each subsequent round.

The protocol that was developed meets the criteria for a "rational" apex described in the text above, with two exceptions. The 50-50 split is the kernel solution, which is one extreme of the bargaining set; it assumes that persons within a coalition bargain about the payoff division while others wait passively, rather than making competitive counteroffers (Kahan and Rapoport, 1979). Horowitz and Rapoport's (1974) competitive bargaining set and von Neumann and Morgenstern's (1947) main simple solution would be the 75-25 split; as argued in the text, the maximizing apex would prefer a 70-30 split, to move the base away from indifference in this game where the minimum units are 5 points. The kernel was chosen rather than the maximizing solution to increase the defection payoff to 25 points rather than 5 points; as game theorists argue, it is one psychologically meaningful solution point.

The other departure from rationality is more substantial, but was essential for this experiment. As is argued in the text above, a perfectly rational apex would not only be trustworthy within rounds, but would form a stable alliance with one base across rounds. The apex's rational strategy here would have put only one base in the dilemma; given the larger goals of the experiment, it was decided to rotate among the bases so that they would all be in the equivalent position of a symmetric dilemma.

were invented to fulfill the theoretically specified criteria for a potential selective incentive and to keep the direct cost of using the incentive the same for both rewards and punishments.[4] The low level was 1 card = 5 points = 10¢; medium was 4 cards = 20 points = 40¢; and high was 7 cards = 35 points = 70¢. These amounts were available to each subject in each round.

Random assignment of groups to design cells was accomplished by drawing a slip of paper late in the instruction period, just before the last section of reward/punishment instructions were read. All that varied in the instructions according to condition were references to the number of reward and punishment cards. Thus the experimenter did not know which cell of the design subjects would fall into at the time of scheduling them, meeting them, or explaining the rules and procedures of the games. There was no practical way for the experimenter to be blind to the treatment condition.

Data were actually collected in a randomized block design, with each replication of the nine-cell design comprising a time block. This was done because the data were collected over a nine-month period. Minor changes in the instructions were made between blocks 3 and 4.

RESULTS

Analysis of block parameters revealed no significant or consistent block effects for either the comparison among all six blocks or the contrast between the first three and the last three blocks. Therefore, the reported results omit them.

USE OF INCENTIVES

As predicted, the available rewards and punishments were generally used to induce formation of the base coalition. High proportions of

4. It was essential that the costs for the two types of incentives be the same. There were insufficient resources to multiply design cells to bring incentive cost into the design as an independent variable. Setting the constant cost to some level other than zero would have required additional procedures and complications in the game to provide a way to "bill" subjects for their incentive use, so the decision was made to make the incentives cost-free in this experiment.

available incentives[5] were used to promote the base coalition or hinder the apex-base coalition: 64% for punishing the player who coalesced with the apex, 71% for rewarding other bases in the base coalition, and 60% for rewarding players who did not coalesce with the apex when someone else did. By contrast, very low proportions were used in ways that hindered the base coalition or promoted the apex-base coalition: 4% for rewarding a player who coalesced with the apex, 20% for punishing other base players in the base coalition, and 8% for punishing players who did not coalesce with the apex. Even though it is much lower than the 71% of rewards used in the base coalition, the use of 20% of the punishments in this condition is high enough to suggest the possibility of negative side effects and will be pursued below.

The effect of experience in the game on rewarding and punishing was checked in analyses that are not shown but may be obtained from the author. There are only two statistically significant trends over time: (1) punishment for coalescing with the apex increased 36% from the first five to the last five rounds and (2) the player who coalesced with the apex showed a 29% increase in punishment and a 23% decrease in rewards from the first five to the last five rounds. Analyses of these differences by condition show that the trend of increasing punishment for the base who coalesces with the apex is strong and significant at all incentive levels. The second trend appears at all incentive levels but is significant only for the lowest levels of negative incentive.

Analyses of incentive use by cell of the design found no significant or consistent differences across cells in the proportion of available incentives used in various ways, except that subjects used proportionately fewer of their punishments to punish the defector when they had more to use. This proportionate decline does not equalize punishment across conditions. In the low negative conditions, the average punishment to the defector was 11 points (out of 15 available, or 73%). In the medium

5. These data have been standardized to allow direct comparisons among the kinds of incentive use. The number of rewards (punishments) used in each way was divided by the number of rewards (punishment) available in that condition, the number of players who could use the incentive that way in any round, and the number of rounds in which the appropriate coalition structure had been formed. Each figure thus represents the proportion of the incentive that was actually used of that which could have been used. Most are mutually independent. The exception is for players left out when the others coalesced with the apex: They can punish or reward either the player who coalesced with the apex or the others. Since 28% of all rewards and 32% of all punishments were not used in this situation, these choices did not completely interfere with each other. Computed proportions for rewards and punishments in the base coalition exclude 10 groups that never formed this coalition. Players who had coalesced, themselves, with the apex gave 52% of their available rewards and 41% of their available punishments to the other players.

negative condition it was 37 points (out of 60, or 62%); in the high negative conditions, it as 55 points (out of 105, or 52%).

Reasons given for rewarding and punishing in a postexperimental survey confirmed these behavioral measures. Clear leaders in reported and prescribed usage are those reasons that promote the base coalition. This is especially true for punishments where reported punishment of anyone who ratified a proposal with A exceeded any other use by a full point on a four-point scale.

To summarize, despite the greater potency of punishments due to the structural constraints of this situation, subjects used both rewards and punishments at fairly high and roughly equal levels in the manner predicted (i.e., to reward cooperation with the base coalition and to punish defection to the apex-base coalition). There appears to be no preference in use for rewards over punishment or vice versa.

AVAILABILITY OF INCENTIVES AND COOPERATION

Hypothesis 2 predicted that cooperation with the base coalition will be higher when available incentives exceed the defection payoff than when they do not. The results may be seen in Figure 1, which plots the proportion of all rounds in which the base coalition formed within each condition. An analysis of variance of all 10 rounds contrasting the lower 4 cells with the higher 5 cells is significant at the .001 level; the R^2 for this contrast is .327.

As the figure indicates, when the incentive is smaller than the defection payoff, the proportion of base coalitions for all 10 rounds vacillates within the .1 to .2 range, which has been found to be typical for apex game experiments employing no incentives. When the incentive is greater than the defection payoff, the proportion for base coalitions appears to rise with incentive magnitude, at least until the highest levels are reached.

In sum, the magnitude of the available incentive has a clear impact on the amount of cooperation with the base coalition.

EFFECTIVENESS OF PUNISHMENTS VERSUS REWARDS

Hypothesis 3 was that punishments but not rewards would be effective incentives in the apex game. The test of this hypothesis is not statistically independent from the previous test but provides another way of viewing the results that allows rejection of certain alternate

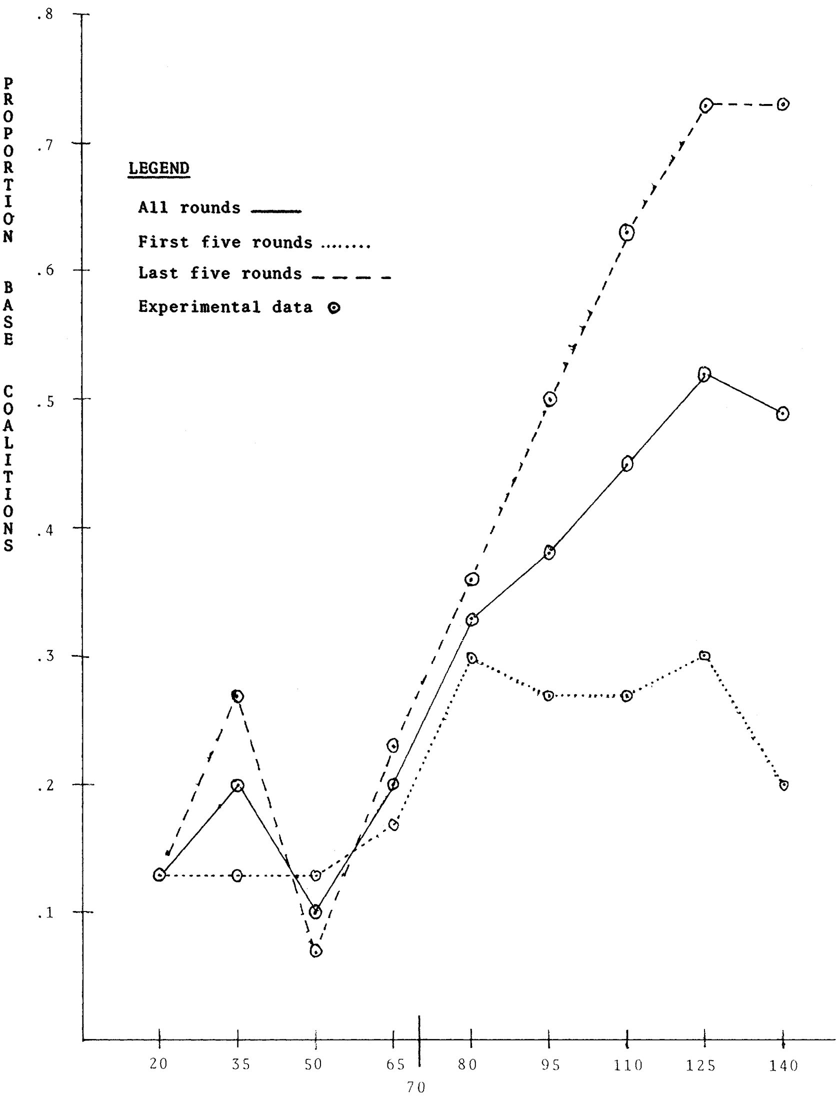

Figure 1: Proportion of Base Coalitions by Total Amount of Incentive Available

explanations of the results, as described above. A standard two-way analysis of variance shows that punishments are significant at the .001 level, while neither rewards nor the interaction term has any significant effect (with probabilities equal to .4 and .7, respectively). This suggests that the actual magnitude of the effective incentive and not the simple fact or symbolic interpretation of rewarding or punishing is operative.

INCENTIVE MAGNITUDE AND LEARNING EFFECTS

Another check on the plausibility of the theoretical account of the results may be obtained by examining changes in subjects' behavior through the course of the experiment. Subjects in this experiment faced a complex situation with many parameters. The assumption underlying the theoretical analysis is that people understand their choices and their likely consequences, and make instrumental decisions on the basis of this understanding. People may take a while to learn what they need to know about a situation and this might produce mistakes, but the mistakes should diminish and people's behavior should become more in accord with the predictions over time. If this pattern does not hold, the fundamental assumptions of the theory may be in error.

A simple check of this prediction may be made by dividing the data in half, analyzing the first five and the last five rounds separately. In Figure 1, it may be seen that the proportions for the cells where the incentive is below the defection payoff are in the same general range for the first five and last five rounds. However, when the incentive is greater than the defection payoff, the proportions of base coalitions rise sharply with incentive magnitude in the last five rounds, while the rise is quite small in the first five rounds. Separate analyses of variance for the first five and last five rounds indicate that the effect of the incentive on cooperation rates is statistically significant only for the last five rounds. The fact that subjects' behavior becomes more in accord with the theory over time increases the plausibility of the account offered of their behavior.

PATTERNS OF INCENTIVE USE AND COOPERATION

The results have shown that the availability of incentives has a strong impact on rates of cooperation with the union of weak players in an apex game. It might be wondered whether the way these incentives are actually used affects this impact. It is difficult to provide a definitive answer to this question, as there is an extremely high correlation ($r = .93$) between the amount of punishment available and the amount of punishment the defector receives. The bivariate correlation between the number of base coalitions and the amount of incentive available is .57, while the correlation for the amount of punishment given to a defector is .54. In short, there is little evidence that using all rather than most of the available punishments is any more effective in promoting the base coalition.

However, when incentive availability is controlled (R^2 = .33), not using the punishments to punish nondefectors when someone else defected adds another .23 to the explained variance. Rewards given by the defector adds only another .03; no other form of incentive use adds more than .01 to the explained variance. It is especially noteworthy that rewards and punishments given in the base coalition have no significant effect on cooperation.

Achieving the cooperative solution of the base coalition required recognition of it as the rational outcome. Punishment of the defector was important but was not a good predictor when incentive availability was controlled, because there was relatively little variation in how much punishment was used against defectors within availability conditions. By contrast, punishing nondefectors showed much greater variability: Although 30% of the groups never punished nondefectors and for 56% the proportion was less than .10, for 40% it was between .1 and .2, and 2 groups had very high proportions of .3 and .5. This variable had a negative effect in all conditions, but its effect was stronger in the conditions with more negative incentives. Not punishing nondefectors was strongly predictive of forming base coalitions, although it is not clear whether this is because punishing nondefectors disrupted the base coalition or because it is evidence of a failure to understand the structure of the situation, a failure manifested both in this deviant use of the incentives and in not forming the base coalition. In sum, the base coalition was enforced by punishing defectors, not by rewards and punishments given within it.

RECIPROCATION AND RETALIATION

Punishing a defector promoted the base coalition. But the use of 20% of the available punishments within the base coalition raises the specter of retaliation. Such punishment was explored by computing the full matrix of correlations among all types of incentive use in the first 5 and the last 5 rounds. The correlation between the first 5 and the last 5 rounds for punishing the defector was .28, while for rewarding the defector it was .21. Correlations between punishing the defector and punishing within the base coalition range from − .11 to + .30.

By contrast, the correlations were significantly higher (in the range of .5) for rewarding and punishing in the base coalition between the first five and last five rounds, and for rewards and punishments given to nondefectors. Punishments given by the defector also has higher correlations with punishing nondefectors and punishing within the base coalition. These higher correlations suggest that reciprocation and retaliation operated when the incentives were used noninstrumentally, that is, in ways other than to promote the base coalition.

Thus, it appears that unjustified punishment was especially likely to provoke retaliation. The danger of punishment seems not so much that its use to punish defectors hurts cooperation, but rather that its sheer existence tempts subjects to use it in other ways, provoking retaliation that then escalates.

INCENTIVES AND BARGAINING OUTCOMES

The focus of this research has been on which coalition forms, not on the division of the payoff within the coalition. Analysis has been based on the expected long-run division of payoffs within the apex-base and base coalitions. Of course, individual groups deviated from these long-range expectations. Statistical analysis indicates that these deviations were not correlated with the major variables in the experiment.

The apex sought a 50-50 split of the payoff. An effective threat of the base coalition might tilt this split toward the base. Control of the apex's bargaining tended to prevent the base's share from being less than 50, but some bases "insisted" upon taking less, presumably in an attempt to establish a long-range relationship with the apex. The mean base's share within condition ranges from 47 to 59; analysis of variance indicates that these differences are not significant. The lowest mean occurs in the cell with the smallest amount of available incentive; the largest means occur in the cells just below and above the point where the incentive magnitude equals the defection payoff. The other means are all about equal to each other. Thus there is some evidence that moderate amounts of incentive, too small to ensure the formation of the base coalition, are large enough to improve the bases' bargaining position with the apex. But, to reiterate, this difference is small and nonsignificant.

Base coalition divisions are harder to describe. The long-range expectation is an equal division of the payoff. Of all base coalitions formed in all trials, 55% divided the payoff equally. Unequal divisions most commonly arose when one player offered to give himself less as a strategy for promoting the others' cooperation, often consciously in an attempt to attract rewards from the others. Some inequalities arose in attempts to lure a defector back into the base coalition, but this player was often subsequently punished, so that this pattern was not often repeated. The highest proportion of equal divisions (88%) occurred in the cell with the lowest available incentive; the next lowest cell had 75% equal divisions. (Very few base coalitions formed in these conditions, of course.) The lowest proportion of equal divisions (36%) occurred in the cell with the highest available incentives. The proportions in the other cells ranged from 48% to 68%, in haphazard order. Analysis of variance indicates that these differences are not significant.

CONCLUSIONS

The apex game provides an interesting arena for studying the dilemmas of cooperation in power-imbalanced situations. From the perspective of the bases, the game is mathematically equivalent to a multivalued prisoner's dilemma game; the difference is that another person benefits from their failure to cooperate rather than the money being lost to the environment (or to the experimenter). In real-life dilemmas, people face exactly this sort of problem in defining the situation: Should a worker define his problem as one of cooperating with other workers to improve their collective outcomes or as one of cooperating with the boss? The experiment captures a primitive analog of the problem of class consciousness.

Understanding the use of rewards and punishments to enforce compliance in collective action situations is essential for a complete understanding of collective action. One of the most important elements of such understanding is to distinguish necessary properties of the systems of incentives for motivating collective action from the properties of individual incentives for individual behavior. Situations requiring unanimous collective action and entailing a high payoff for anyone who defects when everyone else cooperates are an extreme instance of this general principle. In these cases, only punishments can provide an effective system of incentives to prevent defection, for a system of rewards would have to be so large as to make the original collective action insignificant for the actor's payoffs.

The results of this experiment indicate that a system of negative incentives can be an effective tool for raising the amount of cooperation in a game requiring unanimous collective action in the face of high defection payoff. There is clear-cut evidence that when the incentives exceeded the defection payoff, the amount of cooperation was much higher than when they did not.

But the experiment also points to problems and complications that arise in motivating collective action. The first is that punishments, while effective, have harmful side effects. Partly it is that persons who are justly punished retaliate to save face, but the more serious risk is that unjustified use of punishments can open up costly retaliatory spirals. Some of this seems to be an artifact of a laboratory experiment: Once cooperation with the base coalition was established, some subjects became oriented toward winning the game (being the top point getter) rather than toward maximizing their earnings as emphasized in the instructions, and thus started punishing others. But the bulk of the problem is that, one unjustly punished, subjects are unwilling to accept their losses; instead, they punish back. Since punishments in this experiment were given anonymously, retaliation could not be focused on the appropriate target. Thus, retaliation almost always hurt "innocent bystanders," who then retaliated for their unjust punishment, and so forth. Although the specific dynamics of those spirals are shaped by the particular gaming setting, the bulk of experimental and anecdotal evidence available suggests that the problem of face-saving retaliation permeates the use of punishment.

The results of this experiment emphasize that theories of incentives for collective action cannot rely solely on research data on individual compliance. Individuals' decisions to use incentives and their reactions to being the recipients of them are only part of the picture. The structural properties of the collective action situation itself must be taken into account. Situations involving unanimous cooperation and high defection payoffs require punishments as incentives. By contrast, it is predicted that when one person must be induced to make a sacrifice for the benefit of a larger group, punishments will be ineffective, and only rewards will be sufficient to produce the collective benefit.

At the same time, however, research on the reactions of individuals to rewards and punishments is important, for it suggests that situations whose structures require negative incentives will be more prone to the harmful side effects of the incentives than will situations requiring positive incentives. This suggestion from the literature proved true in this experiment, for even though noninstrumental use of punishments was much lower than instrumental use, it was high enough to seriously damage subjects' payoffs. We may in general expect to find that unanimous collective action, when there are high defection payoffs, will be riddled with paradoxes and contradictions as coercion simultaneously ensures and disrupts cooperation.

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