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Constructive Intergroup Competition as a Solution to the Free Rider Problem: A Field Experiment

IDO EREV[1]

Technion, Israel Institute of Technology, Haifa, Israel

GARY BORNSTEIN

The Hebrew University of Jerusalem, Jerusalem, Israel

AND

RACHELY GALILI

Technion, Israel Institute of Technology, Haifa, Israel

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Pruitt and Kimmel (1977) regard the problem of external validity as one of the biggest problems of experimental gaming, a problem that seriously limits the relevance of this research tradition to real-life settings and to other areas of social psychology. Following Pruitt and Kimmel's dictate that "researchers try to generalize their findings," the present study attempts to generalize recent results by Bornstein, Erev, and Rosen (1990) to real-life settings. Bornstein *et al.* demonstrated that competition between groups can reduce free riding in an experimental Prisoner's Dilemma Game. The present study tested the effectiveness of intergroup competition as a solution to free riding in a lifelike orange-picking task. Groups of four subjects picked oranges under three payoff conditions: personal reward, collective reward, and intergroup competition with a reward to the most efficient team. On average, the collective reward rule resulted in a 30% loss in production compared to the personal payoff rule. The intergroup competition eliminated this loss of productivity and was more effective the more similar the competing teams

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[1] E-mail ierev01@technion.technion.ac.il.

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were with respect to overall abilities. The implications of these findings are discussed in light of a new approach to game-theoretic equilibrium solutions.

Rewarding all group members equally, regardless of their contributions to the group's success, can give rise to free riding (Kerr, 1986; Rutte, 1990; Yamagishi, 1988). Secure in the knowledge that they can share the reward once it is provided, rational and selfish group members may reduce or even eliminate their own contribution to the group's effort. As a result, the group may fail to achieve its potential level of performance. In more formal terms, a collective payoff rule creates a social dilemma (Dawes, 1980), where the dominant individual strategy (not to contribute) is associated with a suboptimal group outcome (the group fails). Numerous studies have supported the notion that groups fail to attain their optimal level of performance (Dashiell, 1935; Ingham *et al.*, 1974; Kerr & Bruun, 1983; Petty, Harkins, Williams, & Latane, 1977; Petty, Harkins, & Williams, 1980), and that most of this production loss is due to free riding or "social loafing" (Latane, Williams, & Harkins, 1979).

Intergroup Competition as a Solution to the Free Rider Problem

Bornstein, Erev, and Rosen (1990) have recently demonstrated that free riding in social dilemmas can be reduced by introducing a competition between two groups and paying a bonus to the most productive group. The dilemma in their laboratory experiment was operationalized as a "give some" game (Bonacich, 1972; Dawes, 1980), where each of three players had to decide privately whether to take 3 Israeli Shekels (IS 3; approximately $1.50) for himself/herself, or give IS 3 (from the experimenter's money) to each of the other two members of his/her group. Clearly, each player is always better off taking the money regardless of what the other group members do. However, if all players choose to take, each ends up with IS 3, whereas if all decide to give, each receives IS 6. The give some game is, thus, a social dilemma in which the choice of a dominant strategy results in a deficient group outcome. Since, when all three players decide to take, no player can benefit from unilaterally deviating from this strategy, the deficient outcome is an equilibrium point.[2]

In the control condition, each group of three subjects played an independent give some game. In the experimental condition, two groups, each engaged in a separate give some game, competed for an additional reward. The reward of IS 9 was paid to each member of a group if the number of ingroup cooperators ("givers") exceeded the number of cooperators in the outgroup. In the case of an equal number of cooperators

[2] An equilibrium is an outcome from which no member is motivated to switch unilaterally.

in both groups, the reward was divided equally among the six players and each received IS 4.5.

Bornstein *et al.* (1990) have demonstrated that the competition between the groups changes the intragroup reward structure so that defection is no longer the dominant individual strategy. Rather, a rational player should contribute (give) when his/her contribution is critical for tying or winning the game and should not contribute otherwise. When all other (ingroup and outgroup) members cooperate, Player *i* is critical for tying the game and cannot benefit from a unilateral defection. Thus, cooperation by all players is an equilibrium point. In fact, when the two groups are of equal size, this outcome is the only pure strategy equilibrium in the game (Palfrey & Rosenthal, 1983).

Based on the game-theoretic solution, Bornstein *et al.* (1990) hypothesized that the opportunity to win an additional reward for outperforming the rival group will increase the rate of cooperation among individual group members. Indeed, they reported that 78% of their subjects cooperated in the intergroup competition condition, compared to a cooperation rate of only 47% in the give some game. Having confirmed their prediction, Bornstein *et al.* argued that the increased cooperation in the intergroup competition condition can be explained by the situation's incentive structure without having to assume that individuals contribute for reasons other than self-interest.

Whereas this structural explanation is indeed the most parsimonious, its validity may be limited to the artificial laboratory setting. Experimental games are very useful in facilitating a precise definition of how subjects are dependent on each other. However, they place subjects in an unfamiliar strategic environment where well-rehearsed habits are not readily available and where factors that normally affect behavior such as social norms, attitudes, and social motives have relatively little impact. Generalizing from this artificial environment to natural settings is therefore problematic.

Indeed, Pruitt and Kimmel (1977) regard the problem of external validity as "one of the biggest problems of this [research] tradition." In reviewing the first 20 years of gaming research, Pruitt and Kimmel write: "most researchers who use games simply report their results with no attempt to speculate about the real-life implications" and, as a result, "questions have been raised about the relevance [of gaming research] to real-life settings and to other parts of the field of social psychology" (p. 367).

Following Pruitt and Kimmel's dictate that "researchers try to generalize their findings," the present study attempts to generalize the Bornstein *et al.* (1990) results to a real-life setting. There are two major difficulties in such an attempt. The first problem is to identify the critical factors, or "background conditions" (cf., Pruitt & Kimmel, 1977) that distinguish

TABLE 1

A HYPOTHETICAL ORANGE GROVE DILEMMA: WORKER i'S PAYOFFS PER HOUR WORK AS A FUNCTION OF HIS/HER EFFORT INVESTMENT AND THE NUMBER OF OTHER HIGH-EFFORT INVESTORS ON HIS/HER TEAM

Worker i's investment	Number of high-effort investors among the other three workers			
	0	1	2	3
High	2.25	3.50	4.75	6.00
Low	4.00	5.25	6.50	7.75

Note. The values in the table were calculated using the equation:

$$V_i = \begin{cases} .25[(N_H)(1000) + (3 - N_H)(500)] + (.25 - .2)(500) & \text{if } i \text{ chooses Low} \\ .25[(N_H)(1000) + (3 - N_H)(500)] + (.25 - .4)(1000) & \text{if } i \text{ chooses High} \end{cases}$$

where V_i is worker i's profit and N_H is the number of workers (excluding i) that choose High. This payoff rule is implied by the verbal description of the game in the text.

between the laboratory setting and the natural situation of interest. The second difficulty is to provide a theoretical basis for predicting the conditions that may limit generality.

In the following section we discuss the major factors that distinguish the simple experimental paradigms used by Bornstein *et al.* (1990) from a typical work environment. Using game-theoretic tools we then analyze the structural implications of these factors in the context of a hypothetical "orange grove" dilemma. Finally, we report an experiment which tested some of the theoretical implications in an actual orange grove setting.

INTERGROUP COMPETITION IN THE WORKPLACE

Consider an hypothetical workplace in which a team of four orange pickers is paid 1 cent for each orange picked. The payment is divided equally among the four workers such that each gets .25 cent per orange. Assume that the cost of picking oranges (i.e., in terms of energy loss and risk of injuries) is an increasing function of work speed. The cost is .2 cent per orange given a low work speed (500 oranges per hour) and .4 cent per orange given a high speed (1000 oranges per hour). Assume, for simplicity, that each worker makes a binary choice between working slowly (investing minimum effort) and working quickly (investing maximum effort).

Table 1 presents worker (player) i's payoffs per hour work as a function of his/her effort investment and the number of other high-effort investors on his/her team. The table shows that an individual group member is always better off investing minimum effort. By taking a free ride, a worker can increase his/her earnings by \$1.75, regardless of what the others do.

However, if all group members invest minimum effort, the group's total payoff is $16 ($4 for each member), whereas if all invest maximum effort, the total team payoff is $24 ($6 for each team member). Thus, the payoff structure in our hypothetical orange grove dilemma has the two defining properties of an n-person Prisoner's Dilemma Game (PDG) or a social dilemma (Dawes, 1980).

According to Bornstein *et al.*'s (1990) formulation, the orange grove dilemma can be solved by dividing the four workers into two competing dyads and paying a bonus to the more productive dyad. If the individual bonus for tying or winning the competition exceeds the cost of contribution, the motivation to take a free ride is eliminated. For example, if a bonus of $4 is paid to each member of the winning dyad (and $2 for a tie), cooperation becomes the rational individual choice. Since, if all workers invest maximum effort, no individual worker can benefit from investing less, cooperation by all players is the only equilibrium solution of the game.

There are at least three factors that seem especially relevant when discussing the generalizability of this simple intergroup competition game. First, contribution in most realistic settings is continuous rather than binary. Second, most work environments involve long-term relations and therefore constitute repeated, rather than one-shot, games. Finally, dilemmas outside the laboratory are rarely symmetrical in the sense that all players have the same ability to contribute. More often than not, individual players differ with respect to their contribution ability. The following sections examine the effects that these factors might have on individual choice behavior.

Continuous vs Binary Contributions

Assume that, rather than making a binary decision between high and low levels of contribution, each worker may choose any level of performance between 500 to 1000 oranges per hour. As in the original problem, the cost per orange is a linear increasing function of work speed (cost = speed/2500). The possibility of continuous contribution does not change the strategic properties of the game. The continuous game remains a social dilemma since investing minimal effort (500 oranges per hour) is still the dominant individual strategy, whereas investing maximal effort (1000 oranges per hour) is collectively optimal.

Similarly, allowing continuous contribution does not change the effect of the intergroup competition. Competition between the dyads over a bonus of $4 changes the equilibrium solution of the game from minimum investment to maximum investment. If all workers pick 1000 oranges per hour, no one can improve his/her payoff by slowing down.

One-Shot Game vs Repeated Game

The principal difference between one-shot and iterated games (often referred to as "supergames") involves the possibility of conditional cooperation. In a repeated game, players can modify their behavior during the course of the interaction. They affect the other players and are affected by them. Axelrod (1984) argued that, while defection is collectively stable in the one-shot Prisoner's Dilemma game, contingent cooperation (tit-for-tat) may be stable in the PDG supergame. Taylor (1987) presented a similar argument with regard to the n-person PDG.

However, for the tit-for-tat strategy to be collectively stable, the game must be played for an unknown number of rounds, and the probability on round t to play round $t + 1$ must be sufficiently high. As pointed out by Luce and Raiffa (1957), when the number of iterations is finite and known in advance, tit-for-tat is no longer an equilibrium strategy. This is so because rational players have no incentive to cooperate in the last round. Knowing that, there is obviously no reason for them to cooperate in the round before last. Similarly, there is no reason to cooperate in the round before that, and so on and so forth. This backwards induction renders defection a rational choice in all rounds.

To illustrate this point assume that each worker in the orange grove dilemma is making 10 binary decisions per hour rather than just 1. That is, the workers play 10 repetitions of Game 1 (with the original payoffs divided by 10). Obviously, a rational player should not cooperate on round 10 and, consequently, has no reason to cooperate on any of the previous rounds. In other words, the game has only one equilibrium outcome, namely defection in all 10 rounds of the game.

The backwards induction leads to a totally different conclusion when applied to the intergroup competition game. Assume that a bonus of 40 cents is paid to each member of the dyad whose overall production level over the 10 rounds is higher than that of the other dyad. (In the case of a tie, each worker gest 20 cents.) This bonus is sufficient to ensure contribution by rational players on round 10 given that the game has been tied at the conclusion of round 9 (the likelihood of a tie depends on the symmetry among the players as we discuss below). As a result, a version of the tit-for-tat strategy that states "contribute if and only if the game is tied" is in equilibrium. Thus, a small bonus for winning the competition, a bonus just large enough to change the intragroup reward structure in the last constituent game, renders cooperation to be the rational individual choice in all rounds of the repeated game.[3]

[3] When the competition is destructive (e.g., the Intergroup Public Good game studied by Rapoport and Bornstein, 1987) and the game is to be played an unknown number of rounds, a tit-for-tat strategy can support a stable and efficient outcome in which no player invests in the competition. In the present setting, however, such an outcome is neither an

Symmetrical vs Asymmetrical Players

Consider a variant of the orange grove dilemma in which one or more players can work faster than the others (all the other workers can choose between low- and high-speed performance, but these particular players can also work at a "super" speed). This exceptional ability should not affect the players' decision in any way. Investing minimal effort is still their dominant strategy, and the game retains its social dilemma properties.

Let us now examine the effect of asymmetrical abilities on the intergroup competition game. If Group A is more capable and this information is common knowledge, the motivation to contribute is expected to diminish in both groups. Each member of Group A may be tempted to take a free ride hoping that the contribution of his/her teammate will be sufficient to win the competition. Similarly, members of Group B, the weaker group, may be reluctant to contribute, suspecting that their group will lose the game anyway. In short, when the game is asymmetrical the full cooperation outcome is no longer an equilibrium point, and consequently individual contributions are not critical in the sense described above (Rapoport & Bornstein, 1987). The same is true in the repeated intergroup competition game. A visible advantage to one of the groups is expected to eliminate the structural effect of the competition and, consequently, its effectiveness as a solution to the intragroup dilemma.

But what if information about differential abilities is not common knowledge? Clearly, the more able team should not reveal its true ability early in the competition. (Assuming that the other players use the strategy "contribute if and only if the game is tied," the members of the stronger team maximize payoff by keeping the game tied as long as possible and revealing their real ability and winning the game in the last decisive round. This "decisive finish" strategy promises maximum gain from the weaker team's contribution in addition to the reward.) Thus, when information concerning objective abilities is incomplete, asymmetrical abilities are expected to somewhat impair the effectiveness of the intergroup competition (as the true potential of the high capability team is not realized) but not to eliminate it altogether.

THE EXPERIMENT

To test some of the above ideas we conducted an experiment in a real orange grove. The experiment employed a within-subject design in which groups of four subjects participated in an orange-picking task. Each group worked under three payoff conditions (the order of which was, of course,

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equilibrium of the noncooperative game, nor a likely solution of a bargaining process (since it is not socially desirable).

balanced across groups). In the *Personal* payoff condition, each subject was paid according to the quantity of oranges he/she picked. In the *Team* payoff condition, the group was paid based on its overall production and each worker received one quarter of the total group payoff. Finally, in the *Competition* condition the group was divided into two dyads, and a bonus was paid to each member of the more productive dyad.

Hypotheses

The analysis of the hypothetical orange-grove dilemma above was used to derive three hypotheses:

Hypothesis 1: Free riding. Subjects will be less productive in the Team condition than in the Personal condition.

Hypothesis 2: Constructive competition. Subjects will be more productive in the Competition condition than in the Team condition.

Hypothesis 3: Differential abilities. A difference between the abilities of the two competing dyads will impair the effectiveness of the competition. Hence, a negative linear relation between the ability difference and the competition's effectiveness is predicted.

METHOD

Subjects. Forty-eight male high school students from an Israeli suburban town participated in the experiment. The subjects were recruited by advertisements promising monetary rewards for 3 h work in a nearby orange grove. (It is customary in Israel for high school students to work in the groves during the orange-picking season after school hours or during holidays.) Subjects were divided into 12 groups of four members. The allocation of subjects to groups was made randomly, but effort was made to prevent close friends from joining the same group. The subjects' payoff was contingent on the productivity (the amount of oranges they picked), as well as the productivity of the other members of their group; it varied between IS 17 and IS 29.

Design. Three payoff conditions were compared in a within-subject (within-group) design. Each condition lasted 40 min, and their order was balanced across groups (two groups participated in each of the six possible order conditions). In all three payoff conditions the subjects' task was to pick oranges (fill containers). The group's total payoff in each condition was based on a fixed fee of IS 8, and a piecework pay of IS 24 per container (which is the usual fee per container). Thus, for each condition the four group members were paid a total of IS $8 + 24P$, where P is the portion of the container filled by the group.

The three conditions differed in the way the two components of the group's payoff were allocated to the four subjects: In the Personal condition, the container was divided into four equal sections and each subject was asked to fill up his personal section. The individual payoff in this condition consisted of (a) a flat payment of IS 2, and (b) a fee of $6Q$, where Q is the portion of the personal section filled by the subject. For example, if a subject filled 3/4 of his section of the container (3/16 of the whole container) he received a total fee of IS 2 + IS 6(3/4) = IS 2 + IS 24(3/16) = IS 6.5.

The container used in the Team condition was not divided. Each worker received a payment of IS 2 bonus plus 1/4 of the group's piecework pay. That is, if the group filled 3/4 of the container each worker received IS 2 + IS 24(3/4)/4 = IS 6.5.

In the Competition condition the container was divided into two equal parts. Each group of four subjects was randomly divided into two dyads, and each dyad was assigned one section of the divided container. At the end of the competition, the quantities of oranges in the two sections were compared and each member of the more-productive dyad earned a bonus of IS 4. Members of the less-productive dyad received no bonus. In the case of equally productive dyads, a bonus of IS 2 was paid to each subject.[4] After the outcome of the competition was determined, the divider was removed and subjects received a piecework payoff identical to that in the Team condition (that is, $24P/4$). For example, if the two members in Dyad A filled up their section of the container, whereas the members of Dyad B filled only half of their section, each member in A received IS 4 + IS 24(3/4)/4 = IS 8.5, whereas each member in B received only IS 24(3/4)/4 = IS 4.5.

Procedure. Prior to the arrival of the subjects, tree lines with approximately uniform orange distribution were selected. As in a typical orange-picking task, the workers received general instructions and equipment (picking baskets and ladders). The general instructions included explanation of the picking technique, the criteria for moving from one tree to the next, and safety instructions. The subjects were instructed about the payoff rules of the first experimental condition and started working. After 40 min, the subjects stopped for a 10-min break, after which the instructions for the second condition were provided. Following another period of 40 min work and 10 min rest, subjects were instructed about the third and final condition. Note that since subjects were able to modify their behavior and affect as well as be affected by others, the experimental games had characteristics of repeated game.[5]

The dependent variable was the quantity of oranges picked. This quantity was measured twice (to detect a possible time effect) within each payoff condition. The first measurement was taken after 20 min of work and the second was taken after 40 min. The quantity was measured by volume (proportion of container filled) which was later converted into weight in kilograms (kg). The average net weight of a full container is about 400 kg.

RESULTS

Free Riding and Constructive Competition

Figure 1 presents the average performance in the three conditions as measured after 20 and 40 min of work. As can be seen in this figure, a strong payoff condition by time interaction was observed ($F[2, 10] = 30.4$, $p < .0001$ using the group as a unit of analysis). In the first 20 min, the average group picked 190 kg of oranges in the Personal condition compared to an average of only 160 kg in the Team condition. The difference increased in the last 20 min where 186 kg were picked in the Personal condition compared to only 120 kg in the Team condition. Both differences are significant ($F[1, 11] = 6.84$, $p < .015$ in the first 20 min, and $F[1, 11] = 30.8$, $p < .0002$ in the last 20 min). Overall, the average group picked 376 kg of oranges in the Personal condition compared to an average of only 280 kg in the Team condition. This difference in production is highly significant, $F[1, 11] = 46.2$, $p < .0001$. As predicted by Hypothesis

[4] Note that in this case the payoff rule in the Competition condition coincides with the payoff rule in the Team condition.

[5] The average subject emptied his basket about 15 times in each condition and was then able to see the amount of oranges in the container. In the Competition condition subjects could have pretty accurate assessment of the difference between the two groups.

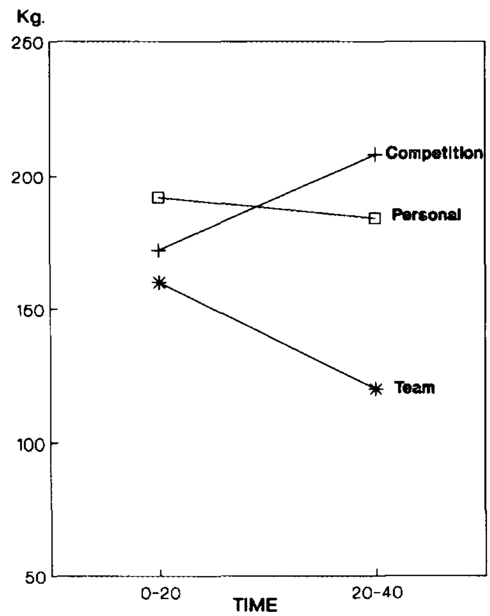

FIG. 1. The average performance in the three conditions as measured after 20 and 40 min of work.

1, the equal payoff rule resulted in a substantial production loss. Indeed, lower productivity in the Team condition was observed in all 12 groups.

The difference between the Competition and the Team conditions was insignificant in the first 20 min of work. However, in the last 20 min the average group picked 208 kg in the Competition condition which is significantly more and, indeed, almost double the 120 kg that was picked in the Team condition, ($F[1, 11] = 69.3$, $p < .0001$). Overall, the average group picked 380 kg in the Competition condition which is significantly more than the 280 kg picked in the Team condition ($F[1, 11] = 39.7$, $p < .0001$). Competition increased production in 11 of the 12 groups (the remaining group achieved equal performance levels in the two conditions). This effect of intergroup competition supports Hypothesis 2 and is in line with the findings reported by Bornstein *et al.* (1990).

Note that the effect of time is consistent with the idea that behavior converges to the equilibrium solution. As can be seen in Fig. 1, there is a sharp decrease in productivity over time in the Team condition, a sharp increase in productivity over time in the Competition condition, and no time effect on productivity in the Personal condition. On the average, a group in the Team condition picked 160 kg in the first 20-min period, as compared with 120 kg in the last 20 min ($F[1, 11] = 21.6$, $p < .001$). In the Competition condition, on the other hand, the average group picked

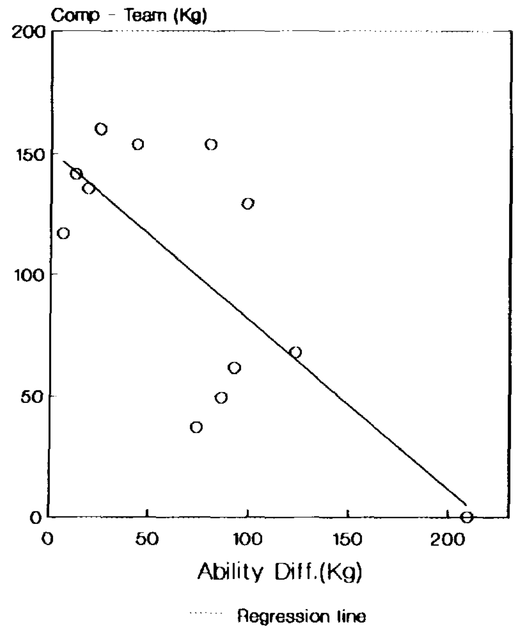

FIG. 2. The effectiveness of the competition as a function of the difference between the abilities of the competing dyads.

172 kg in the first half of the competition and 208 kg in the second half ($F[1, 11] = 18.1, p < .001$).

Differential Abilities

To examine the effect of differential abilities (Hypothesis 3), we calculated two difference scores for each group. The first score involved the absolute difference in ability between the two dyads as reflected by the respective performance of their members in the Personal condition. For instance, if, in the Personal condition, the members of Dyad A picked 96 and 104 kg, respectively, whereas the members of Dyad B picked 100 and 110 kg, the difference score is $|(110 + 100) - (96 + 104)| = 10$.

The second difference score involves the effectiveness of the intergroup competition. This score was calculated by subtracting the group's performance in the Team condition from its performance in the Competition condition. For example, if a group picked 304 kg in the Team condition and 396 kg in the Competition condition, the effectiveness-of-competition score for the group is $396 - 304 = 92$.

Figure 2 plots the two difference scores. Each of the 12 groups is represented as a point in the figure where the horizontal axis represents the difference in abilities while the vertical axis represents the effectiveness of the competition. In accordance with hypothesis 3, the effectiveness of the intergroup competition diminishes as the difference between the abilities of the two dyads increases. The linear trend is significant $r = -.74$, $p < .006$.[6]

DISCUSSION

The first conclusion of the present study is stated purely at the empirical level. The study has demonstrated that intergroup competition eliminates free riding in a lifelike setting in which asymmetric players make continuous decisions in an ongoing interaction.

Game theory facilitated our study in two important ways. First, it enabled us to abstract the main properties of the social situations of interest and present them in the form of payoff structures, or games. Second, the theory helped us solve the games by specifying how players ought to behave if they follow certain principles of rationality. Based on a game-theoretic analysis of an abstract orange grove dilemma, we hypothesized that: (1) rewarding group members on a collective basis will lead to a production loss as compared to individually based rewarding scheme; (2) dividing the group into two teams and paying a bonus to the more productive team will eliminate free riding and restore production levels; (3) the effectiveness of the competition will increase the more similar the competing teams are with respect to overall ability of their respective members.

It is important to emphasize that these hypotheses apply only to the abstract models and not to the original social situations (Hardin, 1982). Nevertheless, ". . .If we have both accurately abstracted the situation to a game and correctly analyzed what choices might reasonably or "rationally" be made in the game, then we would hope to be able to translate those choices back into real situations, where they become our predictions of what people will do. Insofar as they actually do the things we predict, we gain confidence in the general method, the particular model, and the particular strategic analysis, and we can think of ourselves as having offered an explanation of what is going on" (Hamburger, 1979, p. 248).

The fact that all three hypotheses were strongly supported by data obtained in an actual orange-picking task suggests that our abstract models corresponded quite well with the reality of the experimental task. It also indicates that game theory can provide valuable predictions and adequate explanations of actual behavior. Whereas the first conclusion is self-evident, the second assertion needs some more elaboration.

Game-theoretic solutions are based on the strong assumption of mu-

[6] The correlation was larger for the six groups who were assigned to the three order conditions in which the Personal condition was before the Competition condition. However, this order effect, like all other order effects, was not significant.

tually expected rationality (Colman, 1982). According to this assumption individual players take the actions of others into account when deciding on a course of action and can adjust their expectations to arrive at an equilibrium solution. Although logically compelling, this formal solution is usually not considered a good predictor of actual behavior (Simon, 1955). Hardin (1982) expressed the view of many when he contended that ". . . formal game theory seldom provides straightforward solutions to practical problems." The major reason for this is that ". . . human beings have bounded rationality and cannot be expected to analyze the payoff matrices of any but the simplest games" (p. 254).

However, there have been recent attempts to provide a different foundation for the theory of equilibrium that does not necessitate strategic rationality assumptions (e.g., Harley, 1981; Maynard Smith, 1984; Nelson & Winter, 1982; Selten, 1991; Roth & Erev, 1993). Rather than deriving equilibrium solutions from optimization assumptions, this new approach explains equilibrium as a result of natural selection and learning (Boyd & Richerson, 1985). Learning does not require any insight into the situation. It can reflect adaptation to success and failure in a trial-and-error fashion. It can also result from imitation of successful others. Either type of learning can steer players in the direction of the game-theoretic equilibrium without having to assume that the players can "analyze the payoff matrices."

If behavior is based on strategic thinking we should expect equilibrium patterns to emerge immediately. In contrast, if behavior is transformed by learning it is expected to gradually approach the equilibrium point. The present study seems to support the latter prediction. As can be seen in Fig. 1, production decreases over time in the Team condition, while it increases over time in the Competition condition. Thus, as they gained more experience with the task, our subjects converged on the equilibria of the respective games.

Additional support for the "convergence on the equilibrium" hypothesis is provided by incidental observations. The experimenter noticed that subjects considered the Team condition very attractive. Subjects who started out in a different condition were happy to hear that they would now be working as a team. They made promises to help each other and contemplated that this payoff rule would enable them to work more efficiently. Indeed, the collective work was quite efficient at first. However, after a few minutes, one or more of the workers slowed down and the others almost immediately followed. A similar occurrence, but in the opposite direction, was recorded in one of the sessions in the Competition condition. After hearing the instructions, one subject had suggested, "Let's not compete. Let's take it easy and split the bonus afterwards." Clearly, this strategy is not collectively stable. If all the players invest minimum effort, any individual player can benefit from working a little harder and winning the competition at the last minute. In fact, this is what happened. Very soon after the competition started, one of the subjects began to speed up, forcing the others to do the same.

What learning rule may account for these results? Consider a simple learning rule which states the following: At each decision point a player modifies his behavior to maximize earnings while assuming that the behavior of all the other players remains constant. This fictitious play rule is a version of a rule suggested by Brown (1951). It hypothesizes that individuals modify their behavior until they reach an equilibrium point (where a unilateral change of behavior is no longer adaptive) without relying on the game-theoretic assumption of common rationality.

Assume that Player *i* chooses an initial working speed and, at a certain point (perhaps when he empties her basket), reevaluates his strategy. In the Team condition, he notices that there are already quite a few oranges in the container and realizes that if everyone else keeps up the good work he can slow down without suffering a big loss in payoffs. If every one follows this learning rule, the model predicts that work speed will decrease with time. The exact "learning curve" depends on the frequency and magnitude of the adaptive adjustments and on the initial work speed.

The same learning rule has different implications in the Competition condition. For example, suppose that when Player *i* empties his basket he notices that the amount of oranges the two teams already picked is approximately equal. If Player *i* speculates that the other players will maintain the same work speed, he may decide to work a little faster in order to win the competition and acquire the reward. If the competition is still tied the next time around, he may try to increase his work speed a little more. If all players use this decision rule, the game will remain tied whereas the work speed will gradually increase.

Although the fictitious play rule can explain the present results, it is by no means the only conceivable explanation. There exists a whole family of learning rules that predict convergence on the equilibrium point. It may very well be that other learning rules are more accurate descriptions of the psychological reality. For example, it is quite possible that our subjects modified their behavior at each decision point in order to avoid being "suckered" (Kerr, 1983). It is also possible that learning took place through simple operant conditioning (see Skinner (1984) for the discussion of the relationship of rationality to operant conditioning). Whereas our data support the notion that subjects learned the situation's payoff structure and adopted their behavior to approximate the game's equilibrium solution, we cannot, at this point, identify the exact learning rule that is responsible for this process.

Finally, while the present study focused on the structural effects of intergroup competition, we do not rule out the possibility that this manipulation affected subjects' behavior by changing their motivational tendencies as well. While it is useful to keep assumptions concerning individual motivation constant when examining the implications of a particular structural change, the distinction between structural and motivational solutions is largely hypothetical. In reality these two types of solutions are complementary, not exclusive. In addition to changing the reward structure intergroup competition is likely to facilitate motivational changes by increasing group-based altruism (Campbell, 1965; Coser, 1956; Kramer & Brewer, 1986; Rabbie, 1982). Intergroup competition may also lead to the emergence of cooperative values and norms and increase group pressure toward conformity with these norms (Rabbie, 1982).

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