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The Carrot vs. the Stick in Work Team Motivation*

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ABSTRACT

This paper reports on the use of carrot (positive) and stick (negative) incentives as methods of increasing effort among members of work teams. We study teams of four members in a laboratory environment in which giving effort towards the team goal is simulated by eliciting voluntary contributions towards the provision of a public good. We test the efficiency-improving properties of four distinct environments: monetary prizes given to high contributors versus monetary fines assessed to low contributors, where high/low contributor is defined first in terms of absolute contributions and then in terms of contributions relative to abilities—which we call handicapping. Our results show that both carrot and stick can increase efficiency (i.e., contributions) levels by 10-28%. We find that handicapped incentives promise the highest efficiency levels, and when handicapping is not used penalties may be more effective than prizes. The implications for work teams and suggestions for practical implementation are discussed.

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While work teams have risen dramatically in popularity over the last decade, there is still no consensus as to the proper way to motivate individual team members. The potential for shirking and free-riding on the efforts of other team members limits the effectiveness of compensation purely based on team output, while individual piece-rates do not provide cooperative incentives. More sophisticated methods of compensation might involve some combination of payments based on both individual work as well as team output (e.g., profit sharing, productivity gainsharing, or individual bonuses). The focus of this paper is the use of positive versus negative incentives—the carrot versus the stick—in motivating team members to contribute more towards the group goal.

We report on a series of experiments that document significantly higher group giving when carrot or stick incentives are used. The framework used for analyzing the work team problem that motivates this study is a public goods framework (see Alchian and Demsetz (1972) for an early notice of the work team/public good connection). Contributions towards provision of a public good are interpreted as team work effort, while token endowments are interpreted as ability.[1] Team effort (contributions) generates output (payoffs) solely to team members and not to any employer in our framework—we therefore focus on intra-team behavior and response to incentives as opposed to the interaction between a team and an employer. Team members are also asymmetrically endowed with tokens to simulate the differing abilities that members of the same work team may possess.

In our experiments, the experimenter knows each individual's contribution towards the team output, and this may not be true of all institutions in which employers may desire to pay based on team output. Monitoring can, for a cost, improve an employer's knowledge of each individual's contributions towards the team output, and our findings indicate that such monitoring will be desirable for at least some employers.[2] There are, however, some real world instances of work teams in which an individual's contribution towards the team goal is observable at little or no cost. Professional team sports such as Major League Baseball are one such example. There is at least some public goods component to the overall payoff of these athletes, such as improved quality of team play, better chance of winning a championship, etc. Individual player statistics are well publicized and utilized by team managers to allocate various types of individual rewards and penalties (e.g., demotion to the minor leagues or a promotion to the starting lineup). Our study, though not general to all work team situations, covers an important class of work team environments, and our findings may have implications to the broader class of team institutions.

Our results show that rewards or penalties based on an individual's contributions relative to endowment (i.e., handicapped incentives) are usually the most effective in eliciting higher team contribution levels. The additional efficiency improvement due to certain handicapped incentives shows that, while a handicapped incentive scheme would be more costly to implement, employers can often expect to receive more team effort in return. A key result of this study is that different types of incentives interact differently with handicapping. For example, with no handicapping we find that negative incentives—e.g. a monetary fine—increase efficiency by 6% more than positive incentives—e.g., a cash bonus.

We offer these results not only as support for incentives of all types, but also as evidence of their differing complementarities with handicapping. And, while these incentive plans are costly in general, we find that they increase group wealth by an amount greater than the size of the "prize" in the carrot plans (see also Dickinson and Isaac (1998)). In other words, these plans are not only efficiency enhancing but they may be self-funding.[3]

In exploring a variety of motivation strategies, we should note the existence of penalties in a variety of settings. Many examples can be found of firms using negative incentives as a method of eliciting effort: verbal warnings, unpaid leave-of-absence, demotion, dismissal, etc. Pryor (1984) gives evidence from the 1980's that in 44% of nonunionized manufacturing firms (and 25% of unionized firms) more than 5% of workers are fired annually for poor performance. A work team example is found in Johnsonville Foods' use of work teams in the mid-1990's, where employee motivation included the occasional return of designated bonus money as a way of penalizing some team members. Military boot camps, religious schools, and traditional parental discipline are other institutions notorious for the use of negative incentives for motivation. While monetary penalties are not typically used in the workplace, it is clear that one could use different sorts of "fines" as an alternative method of eliciting the desired behavior.

Related research using controlled laboratory experiments shows that penalties imposed by fellow team members can be effective in sustaining higher contribution levels (Ostrom et al (1992), and Fehr and Gächter (2000)). Carpenter (2000) finds that penalties imposed by anonymous team members, "strangers", may not improve team contribution levels if team gains from an individual's contribution are relatively low. Results from Fehr and Gächter (2000) show that fellow team member punishment is most effective when preserving the same group composition across decision periods, suggesting that long-term group cohesion may be a key factor in making internal sanctions most effective. Sefton et al (2000) compares the effects of penalties and rewards internally imposed by team members, and their results show that team contributions are highest when allowing team members to penalize some *and* reward others as they choose. Giving team members sanctioning and/or rewarding authority is, however, rare within the corporate culture of self-managed work teams, and many work team members report no desire to determine fellow team members' pay (WSJ, April 12, 1995). The results from our experiments have perhaps more clear implications for commonly used work teams that utilize an external team manager to allocate pay. Our comparison of a fixed prize and penalty allocated under well-defined contractual rules also eliminates fellow team members' potentially "irrational" use of the authority to sanction, which has been observed in Fehr and Gachter (2000), Ostrom et al (1992), and Sefton et al (2000).

Dickinson and Isaac (1998) report on a series of experiments that analyze team production by studying public goods provision. What is original in their study is the introduction of individual monetary rewards or "prizes" for high absolute contribution levels in one treatment, and for high relative (to endowment) contribution levels in another treatment. Both treatments are found to significantly increase contribution levels compared to a baseline of no prizes, and rewarding individuals based on relative contribution levels increases group contributions by even more than does rewarding based on absolute contribution levels. The apparent promise of calculated compensation schemes that introduce such individual rewards leads us to wonder about the possibilities and applicability of similarly calculated penalties for low levels of contributions. This paper, in fact, extends from Dickinson and Isaac to look at the effects of such penalties.

We should also note that our use of both penalties and prizes into the team production environment creates a tournament element in the decision-making process. Once workers are handicapped for ability levels, the tournament theory results from Lazear and Rosen (1981) would imply that a rank-order tournament exists as a theoretically optimal labor contract. Support of the predictions of tournament theory is found in Bull *et al.* (1987). Our experiments, however, involve a combined method of payment to team members as opposed to giving one payment per individual and so are not directly comparable to the Lazear and Rosen framework.[4] Schotter and Weigelt (1992) use controlled experiments to explore tournaments among heterogeneous-ability subjects. When individuals faced differing cost-of-effort functions the authors find, among other things, that when the tournament rules are altered to favor the disadvantaged group, effort levels increased in the whole group. Our results are consistent with these and with Dickinson and Isaac in that the creation of equity through handicapping actually *increases* efficiency. One key difference is that Schotter and Weigelt create a Pareto optimal Nash equilibrium at full contributions in their experiments. In this paper, we purposefully create an environment in which there is no pure strategy Nash equilibrium at full contributions.[5]

2. The Experimental Environment and the Penalties

Our intent is to objectively compare the incentive effects of rewarding individuals with a monetary prize to those of penalizing individuals with a similar monetary fine. The framework for the penalty structure we use follows the reward structure of Dickinson and Isaac.[6] We calibrate the size of the prize and the penalty so that they do not create a pure strategy equilibrium prediction of higher contribution levels relative to the baseline. The two prize treatments are called Absolute Prize and Relative Prize for the treatments that give a monetary prize to the individual who contributes the highest amount in absolute terms (Absolute Prize) and relative to endowment (Relative Prize). The Relative treatment, therefore, refers to the incentive environment with handicapping. Similarly, we will refer to the penalty treatments using the terms Absolute and Relative to describe no-handicapping and handicapping, respectively.

We first discuss the payoff functions and prize levels used in the prize treatments. Teams are comprised of N=4 individuals per team, and individuals are given an endowment of tokens in each round of a multi-round set of decisions (a treatment). Individuals are each randomly given a different per round endowment of tokens, w_i, (17, 19, 21, or 23), but a given individual's endowment is the same in every round of a treatment. Individuals also maintain their relative endowment rank for the entire experiment, such that high (low) endowment individuals remain so for all treatments. Recall that these heterogeneous endowments of tokens represent abilities of different team members to contribute towards the group or public good.

In a given round, each individual then makes a decision of how many tokens to keep in a private account which generates 1 cent per token for that individual, and how many to place in a group account which, for each token contributed, generates 1/2 cent for each member of the team. As such, each individual has the dominant strategy incentive to not contribute any tokens to the group account and thus free-ride off other team members. The group payoff, however, would be maximized if everyone contributes all tokens to the group account—this is the Pareto efficient outcome. These are the classic multiperson Prisoner's Dilemma incentives. Per round payoffs for each team member i are represented by the payoff function

(1) $$U_i=q(w_i-m_i)+a\sum_i m_i$$

Here, w_i is the endowment, m_i is the number of tokens contributed to the group account (so $\sum_i m_i$ is the size of the public good), and q and a are payoff conversion parameters that can be adjusted to alter the marginal payoffs of contributing tokens. In equation (1), the first term represents the team member's private account payoffs, and the second term represents the group account payoffs. For our experiments described above, we have q=1 and a=1/2.

For the prize treatments, a prize P^+ of size P^+=\$.20 is given for high absolute and relative contribution levels. In the event that there is a tie for high contributions (either relative or absolute) among two or more team members, the prize is split evenly among those who are tied.

With P^+=\$.20 there is an incentive to free-ride since marginal gain of contributing a token to the group account is less than the loss in the absence of any prize. Given the prize level, along with our tie-breaking rule, there is no pure-strategy Nash equilibrium in the stage game for either prize treatment.[7] Pareto efficiency remains at full contributions by all team members. The payoffs under the Absolute Prize treatment are

$$
(2) \qquad
\begin{aligned}
U_i &= q(w_i - m_i) + a\sum_i m_i && \text{if } m_i < m_j \text{ for at least one } j \neq i \\
U_i &= q(w_i - m_i) + a\sum_i m_i + P^+ && \text{if } m_i > m_j \text{ for all } j \neq i \\
U_i &= q(w_i - m_i) + a\sum_i m_i + P^+/N^t && \text{if } m_i = m_j \text{ for the } N^t \textit{ tied individuals}
\end{aligned}
$$

For Relative Prize, payoffs are also given in (2) if we interpret the >, =, and < conditions as referring to relative contributions.

To proceed in constructing a penalty treatment that will compare with the prize treatment (with P^+=\$.20), we first start with a penalty of P^-=\$.20. For the penalty treatments we endow each individual with an additional 10 tokens per round, which helps control for any wealth effects across treatments. Finally, for the penalty environment to have the exact same marginal payoff incentives as the prize environment we penalize *all* team members who are not the highest contributor (i.e., we penalize the N-1 lowest contributors). To penalize only the lowest absolute or relative contributor is actually a different incentive structure—though undoubtedly an interesting one. In the event that N^t team members are tied for high contributions, each of those individuals would pay a $\left(\frac{N^t - 1}{N^t}\right)$ portion of the penalty.[8] The payoff to individual *i* under Absolute Penalty is

$$U_i = q(w_i - m_i) + a\sum_i m_i - P^- \qquad \text{if } m_i < m_j \text{ for at least one } j \neq i$$

(3) $$U_i = q(w_i - m_i) + a\sum_i m_i \qquad \text{if } m_i > m_j \text{ for all } j \neq i$$

$$U_i = q(w_i - m_i) + a\sum_i m_i - \left(\frac{N^t - 1}{N^t}\right)P^- \qquad \text{if } m_i = m_j \text{ for the } N^t \text{ tied individuals}$$

The differences in (2) and (3) are only in terms of the token endowments per round, and not in terms of the behavioral incentives of the treatments. Interpreting the >, =, and < conditions in (3) as those for relative contributions shows payoffs for Relative Penalty. Pareto efficiency is still at full contributions. As in the prize treatments, there are 20 cents in marginal gains to be distributed among the team members, and so Pareto optimality is independent of whether incentives are a prize or an avoided penalty. The proofs that we have no pure strategy Nash equilibrium prediction in either Penalty treatment are similar for those in the prize treatments.[9] The formal proofs are available upon request.[10]

3. Experimental Procedures[11]

Experiments were hand run with one 4-person team in the room at a time. Information on endowments and contributions of each team member is private information in these experiments. In each round, team members make the allocation decision between the private and group accounts. Each experiment consists of all 5 treatments (baseline and the 4 incentive treatments) and, while the incentive treatments are always randomized in order, the baseline is always the first treatment.[12] Each treatment consists of 8 rounds and so each experimental team member makes 40 decisions in the experiment. Subjects were not aware of when or what the changes would be from one treatment to the next, nor that there would be five total treatments.[13]

After allocation decisions have been made, the experimenter circulates through the room and documents each individual's contribution of tokens to the group account. Total contributions to the group account are announced and written on the blackboard, and team members referred to a Table of Payoffs from the group account which informed them what their own earnings would be in that round for all possible contingencies of tokens placed in the group account.[14] Individual contribution levels were never revealed, and communication is not allowed during the experiments (team members are scattered in a large room with their backs facing each other to avoid any nonverbal communication).[15]

The difference between the Baseline versus incentive treatments is that, once total contributions to the group account have been announced, the high contributor to the group account is announced. Only the token amount (or percentage of contributions) is announced, however, and the individual who contributed that high amount is never identified. For a prize treatment there is an announcement that "the individual who placed the high number (or percentage) of tokens in the group account will add $.20 to his or her earnings for this round." We refer to the prize treatments as Absolute and Relative Prize for the non-handicapped and handicapped, respectively, approach to implementing the prize.

As previously noted, we implement the penalty incentives by taking $.20 away from a subject's earnings at the end of the round if he/she is not a high contributor. To compensate for the income effect of this second type of penalty scheme, we raise each subject's per round endowment of tokens by 10.[16] We call the handicapped and non-handicapped version of this incentive structure Relative and Absolute Penalty. An alternative way of implementing the penalties was explored but not reported in this paper (results are, however, available upon request). The alternative approach was to endow each subject with an additional $.20 in startup cash, as opposed to the larger token endowment, and then all subjects who were not high contributors would forfeit the additional $.20. While this could be considered a penalty, it is actually payoff equivalent to our prize treatments. Further, statistical analysis with all pooled data showed no statistically significant difference in behavioral responses when this method of penalizing was used versus awarding prizes.[17] The true effects of penalties seem to be felt only when the penalty is internalized by the team member, a point to be noted when contemplating a real-world penalty incentive.[18]

Announcements are made in all Penalty treatments so that individuals know whether or not they subtract some, all, or none of the $.20 penalty in that round. For the Absolute Penalty treatment, the announcement is that "the individual who contributed X tokens will **not** subtract 20 cents from earnings for this round. All others will subtract 20 cents from earnings for this round." Appropriate adjustments were made in the Relative Penalty treatments, and the announcements of both penalties and prizes were altered appropriately in the event that more that one individual tied in contributing the most tokens (absolute or relative) to the group account for that round.

While no pure-strategy Nash equilibrium exists in the stage game for the incentive treatments, there is the dominant strategy Nash equilibrium at complete free-riding in the baseline. As such, the incentive treatments and the baseline are not fully comparable, but it will serve as a useful comparison to the incentive treatment in terms of team efficiency. Total earnings for each team member in any round are the private plus group account earnings and, when applicable, the addition of any prize or subtraction of any penalty. Once the experiment was completed, subjects were paid their earnings individually, in private, and in cash.

4. Results

A total of 10 experiments were run using undergraduates recruited primarily from introductory level economics courses at Colgate University in the spring of 1998. The experiments lasted approximately 1 hour and 45 minutes each. In addition to earnings from participation in the experiment, subjects were also paid a $5 show up fee. Average total payoffs for all subjects were $17.57, ranging from a high of $21.00 to a low of $14.75. The aggregate experimental results are shown in Figure 1.

It is apparent from Figure 1 that the incentive treatments are effective in raising team contribution levels.[19] Contributions tend to be higher when handicapping is used, and all incentive treatments increase efficiency above the baseline. Relative Prize appears to elicit the highest efficiency levels. Table 1 shows the mean percentage contribution levels of each treatment for each of the ten experimental teams. Nonparametric Mann-Whitney U-tests confirm that each treatment increases contributions (i.e., efficiency) relative to the Baseline (p=.05). Of course, we have previously noted that the treatments create mixed strategy equilibria at positive contributions, but the increased contributions in the incentive treatments are nonetheless indicative of the value of incentives in environments where free-riding may otherwise dominate.

We also test for behavioral differences within the incentive treatment. U-tests indicate the following: RelPrz increases contributions compared to RelPen (p=.05), RelPrz increase contributions compared to AbsPrz (p=.01), there is no statistically significant difference in mean contribution levels in AbsPen and RelPen, and AbsPen has mean contribution levels marginally insignificantly higher than AbsPrz (p=.11). Keep in mind, however, that the nonparametric analysis fails to control for many other potential determinants of contribution levels. We mention this since the parametric analysis, to be discussed shortly, finds a statistically significant different in comparing AbsPrz and AbsPen. In fact, this is a key result of this study.

Intragroup variance in contributions

In addition to the basic efficiency results, employers managing work teams are presumably interested in the cohesion of the work team. One factor that might threaten this cohesion would be an incentive scheme that created a wide gap between effort levels of the high and low effort supplier in the team project. Figure 2 shows average contributions by endowment levels for all experiments. It is apparent that the dispersion in contribution levels is larger in the incentive treatments compared to the Baseline (p=.01 in the Mann Whitney U-tests on the aggregate differences).[20] Further, non-handicapped incentives seem to increase this variance by even more (p=.05 in comparing AbsPen and RelPen, and p=.10 in comparing AbsPrz and RelPrz).

Figure 3 highlights another interesting detail of the aggregate results. Figure 3 shows the distributions of contributions for each endowment level, averaged across all experiments. From this we see that contributions follow a bimodal distribution—team members most frequently contribute all or nothing. How realistic is it that actual workers either try as hard as they can or shirk completely? While such extremes are probably not very realistic, we could easily interpret zero contributions being effort at the minimum required level for employment. The decision in the experiment would then be analogous to individuals choosing how much *above minimum required* effort they will supply towards the team's goals.[21] It is then more sensible that team members might contribute the minimum expected amount when they feel that the benefits of the incentive program are out of reach, while others might try their hardest.

Treatment Effects and Behavioral Model

For a basic test of the treatment effects we model individual team member contributions as a function of the treatment within the experiment as well as the round within the treatment. It has been noted that these incentive experiments involve a more complicated "game" than the simple baseline contributions exercise. While this paper does not attempt to construct a theoretical model that would generate our experimental outcomes, we include a second empirical specification that includes additional behavioral variables. The behavioral variables chosen reflect the potential importance of how individuals respond to what happened in the previous round: whether they benefited from the incentive treatment (e.g., won the prize), whether they shared the benefits, whether they *could have* received the benefits (had they given more), cumulative experimental earnings from previous rounds, and also own-contributions relative to the average of the remaining 3 team members.[22]

A final variable, *Dispar*, measures the revealed disparity in token endowments during non-handicapped treatments. The announcement of highest number of tokens contributed during the non-handicapped treatments provides some (imperfect) information on ability levels. Suppose, for example, that your token endowment is 19, and the high contributor in the round is 16—*Dispar* would then be equal to zero for the next round and all subsequent rounds until the high contributor gives, say, 22 tokens. For the next round *Dispar* is then equal to 3 (22-19) for that individual for all subsequent treatment rounds, unless a high contributor gives more than 23 tokens, etc.—for *handicapped* treatments, *Dispar* is set equal to zero for all rounds since no endowment information is revealed. A larger *Dispar* for an individual implies that he/she cannot contribute the most if others contribute most or all of their endowments. A simple theory based on expected utility can easily show that once a lower endowment team member becomes aware that a higher endowment members exists in the group the perceived probability of enjoying the benefits of the incentive decreases. Therefore, the variable *Dispar* controls for the level of information on endowments that is currently available to each team member. Table 2 gives the variables and their descriptions.

The individual-level contributions equation is estimated using a random effects model. The assumptions implicit in such a model are that the team members drawn for these experiments were sampled from a large population of individuals whose individual specific constant terms are randomly distributed across individuals. Lagrange multiplier and Hausman tests of the contributions equation support this modeling of the constant term. Table 3 shows the results of these GLS estimations. The results of the basic test of treatment effects and the full behavioral model are shown in the second and third columns of Table 3, while the last two columns reestimate these models including a control for revealed endowment information. Note that several of the variables in Table 2 explicitly account for the fact that individual observations within a given team are not independent of one another.[23]

Consistent with the existing literature on voluntary contribution mechanism experiments, the coefficient on *Round* suggests a decay in contributions as the final round of the treatment approaches, and its magnitude suggests that individual contributions will decline by 14% over the course of the treatment, *ceteris paribus*. The constant term suggests that about 42% of an individual's tokens are contributed in the first round of the baseline treatment independent of other behavioral factors.

From Table 3 we also see that the treatment variables are all statistically significant and positive. The magnitude of each coefficient represents that treatment's contribution to total team efficiency or contributions (since these results assume that each team member would increase percentage giving by the same amount). As such, the second and third columns of Table 3 show that efficiency is increased by the incentive treatments from 10 to 28%, depending upon the treatment and specification. In column two we see that nonhandicapped incentives offer smaller efficiency gains on average than handicapped incentives. Column four, however, sheds some light on this issue. Column four shows the results from the estimation when controlling for the level of endowment information revealed to team members through the high contribution announcements. Comparing columns two and four of Table 3 we note that efficiency improvements are actually larger in the nonhandicapped treatments once we control for the level of endowment information. Columns three and five of Table 3 show the results from similar estimations which include the additional behavioral variables. What this implies is that the higher average efficiency of the handicapped treatments is due to the fact that each team member knows that he/she could earn the prize (or avoid the penalty) from contributing—no matter how high another team member's ability may be. Contributions are, on average, lower in the non-handicapped treatments because lower ability individuals realize that they can be out-contributed by higher ability individuals.

By combining the effects of *Dispar* and the non-handicapped treatments in columns 4 and 5 of Table 3, we arrive at roughly similar estimates of efficiency gains from identical treatments in columns 2 and 3 of Table 3. In other words, the non-handicapped treatment effects shown in columns 2 and 3 can be subdivided into separate effects for each endowment level. The effect of such non-handicapped incentive is to greatly increase contributions of the higher endowment team members while only slightly increasing, or sometimes even decreasing, contribution levels of the lower endowment team members.[24] In practice, however, suppressing the information on the efforts of a prize winner is not likely. While controlling for revealed endowment information is possible through statistical methods, the net effects of the various incentive treatments are more logically compared by examining the estimations in columns 2 and 3 of Table 3.

Focusing on the models in columns two and three of Table 3, handicapped incentives improve efficiency the most on average. However, when handicapping is not used internalized penalties are more effective than prizes or noninteralized penalties. We reject the hypothesis that the coefficients on all of the incentive treatments are equal (p=.00). Under the base specification of column two, we note that when handicapping is used, prizes generate a 12% larger efficiency gain than penalties (p=.00). However, when no handicapping is used, penalties increase efficiency by 6% more than prizes (p=.06. For the behavioral model in column 3, p=.05). Also, if prizes are used they increase efficiency by 17% more when used with handicapping as opposed to no handicapping (p=.00).[25] This result that penalties are more effective than prizes when no handicapping is used suggests that penalties and prizes, while substitutable to some extent in eliciting additional effort in team environments, have quite different complementarities with absolute versus handicapped levels of contributions.

The introduction of additional behavioral variables decreases the magnitudes of the coefficients on the treatment variables, but not their significance or ordering. It also substantially improves the explanatory power of the models. In column three of Table 3, we note that several of the coefficients of the behavioral variables are statistically significant and their interpretation provides additional insights into team giving. The positive and statistically significant coefficient on *Benefit* is quite large in magnitude at .18. As such, being the sole recipient of the benefits of a Prize treatment (or the benefits of a Penalty treatment by way of not having any earnings subtracted) increases one's contributions by 18% on top of the incentive effects of the treatments themselves. The coefficient on *Share* implies that the positive effects of

Benefit would be diluted slightly when sharing the benefits of any incentive treatment. Team members apparently also feel some regret when they could have received benefits of the incentive program but did not. In fact, the positive coefficient on *Oppwin* suggests that when this is the case, team members contribute an additional 11% in the next round.

The final variable of behavioral interest, *Deviate*, is a significant determinant of contributions and the positive sign on its coefficient suggests that individuals contributing above their residual team average tend to contribute more in the following round, whereas those contributing less than their residual team average tend to contribute less. The magnitude of the coefficient is consistent with Dickinson (1998). Though apparently small, the magnitude of .01 actually implies a nontrivial change in absolute levels of individual-level contributions. For example, suppose that the residual group mean level of (absolute) tokens is 20 and you contributed 10. Then deviate=-10, and the coefficient on Deviate implies that in the following round your contributions percentage will decline by 10%. This implies a change in contributions of two to three tokens in the next round depending upon your initial endowment. Its positive sign suggests that those who contribute the bulk of the team's tokens will continue to do so while those who free-ride more than others will continue to do so, *ceteris paribus*.[26]

Finally, in the behavioral model including the control for revealed endowment information (column five), we see that some of the coefficients in column three were capturing the effect of the revealed ability information. The significance of the coefficients on all treatment variables and most other coefficients is not affected by the inclusion of *Dispar*, but the coefficients on *Oppwin* and *Benefit* lose their significance.

5. Implications and Concluding Remarks

These results have numerous implications for the work team manager. A wide variety of incentive plans can increase work team effort. In general, we find that employers or work team managers can expect to get what they pay for. Implementing a handicapped incentive scheme requires ability information, but the cost of gathering the ability information is rewarded through 10%-28% higher efficiency levels. Equity is not, therefore, incompatible with efficiency (consistent with Schotter and Weigelt (1992) and Dickinson and Isaac (1998)). This result is not entirely due to better incentives with handicapping, but in part due to the fact that nonhandicapped incentives reveal ability information to team members. The net result is that nonhandicapping provides smaller efficiency gains (11%-17%) and also a wider variance in giving within the team—the latter may negatively affect team cohesion. We presume that a foundation for effective work teams is some sense of "togetherness". It is hard to imagine this persisting in an environment in which the effort supply of individual team members remains so asymmetric.

Given that ability information is costly to gather, employers facing the highest costs of gathering information may be *ex ante* inclined to not use any handicapping. It is an important implication of this paper that employers resolved to using absolute incentive mechanisms may improve efficiency the most through using penalties.[27]

For penalties to be an effective incentive device it is important that the individual internalize the penalty. Our experimental method of accomplishing this is similar to assessing a monetary fine on all team members except the one who supplies the greatest effort during each period (e.g., fine all but the salesperson bringing in the most business). Practically speaking, for those employees whose output is easily measured (e.g., sales or vegetable picking), and when it is quite costly to gather ability information (e.g., temporary or seasonal workers), such monetary fines may promise the largest efficiency gains. Alternatively, handicapping would be more feasible when dealing with those who have a large amount of data available on their work performance (e.g., professional team athletes), and our results suggest that prizes would be more effective than penalties in such instances.

In the case of both positive and negative incentives, the incentive programs may be self-funding. That is, the additional wealth generated by the introduction of the incentive program is more than the size of the incentive used. Of course, this does not take into account the cost of gathering information of effort and/or ability, but it is a step towards making the incentives viable in the workplace. In our experiments, when the team contributes 10 or more tokens *over the amount contributed in the Baseline*, the incentive is funded (since this generates 20 cents in additional group-wide wealth). In our optimally matched incentive programs, Relative Prize increases team contributions on average by about 21 tokens (26%), and Absolute Penalty increases team contributions by about 14 tokens (17%)—both incentive programs could conceivably fund the incentive through some type of internal taxation. This possibility is a clear area for additional research and experimentation.

While the possibility of an innovative type of penalizing that promises higher efficiency gains under certain circumstances is attractive and novel, we should not forget that such penalties may deteriorate employee moral. Additional research must be expended to further explore the possibility of the penalizing programs. Logistically, any contractual agreement that would allow for monetary fines to be assessed to workers should be common knowledge and specific as to the conditions under which this occurs. These are important details to the successful implementation of any penalizing incentive program.

A drawback of our public goods production function is that it implies independence of individual team inputs (as is true of most experimental public goods mechanisms). In other words, team output, and therefore team payoffs, is immune to complete free-riders as long as other team members contribute additional effort. A more realistic team production function might include a higher degree of team member interdependence. An extreme case would be $Y=A*\min\{y_1,y_2,y_3,y_4\}$(A=scale constant).[28] How such a production function affects the marginal incentives to contribute is obviously important to fully understand how such interdependence might affect team outcomes. Nonetheless, the degree of team interdependence may be quite important in identifying the best incentive environment.

Finally, we have not tested the long-run properties of the incentive environments. Nonhandicapped incentives tend to increase the gap between the high effort individual and the rest of the team, whereas the handicapped incentive creates a broader base of interest for the employees since anyone can at least share in part of the incentive. Nonhandicapped incentives may not encourage the work team cohesion that is typically desired. Also, penalties may foster bad relations in the long-run between employer and employees. These incentives may then be more effective in short-term work relationships. This final point highlights another area where further study would be useful.

References

Alchian, A. and Demsetz H. (1972) "Production, Information Costs, and Economic Organization." *American Economic Review*, 62, 777-795.

Bull, C., Schotter, A. and Weigelt K. (1987). "Tournaments and piece rates: An experimental study." *Journal of Political Economy*, 95, 1-33.

Carpenter, J. (2000) "Punishing Free Riders: The Role of Monitoring Group Size, Second-Order Free-Riding and Coordination." mimeo, Middlebury College.

Dickinson, D. L. (1999) "An Experimental Examination of Labor Supply and Work Intensities" *Journal of Labor Economics*, 17(4) Part 1, 638-670.

Dickinson, D. L. (1998) "The Voluntary Contributions Mechanism with Uncertain Group Payoffs." *Journal of Economic Behavior and Organization*, 35, 517-533.

Dickinson, D L. and Isaac, R. M. (1998) "Absolute and Relative Rewards for Individuals in Team Production." *Managerial and Decision Economics*, 19, 299-310.

Fehr, E. and Gächter S. (2000) "Cooperation and Punishment in Public Goods Experiments." *American Economic Review*, 90(4), 980-994.

Isaac, R. M. and Walker, J. M. (1988b) "Communication and Free-Riding Behavior: The Voluntary Contributions Mechanism." *Economic Inquiry*, 26, 585-608.

Kahneman, D. and Tversky, A. (1979) "Prospect Theory: An Analysis of Decision Under Risk." *Econometrica,* 47(2), 263-291.

Lazear, E. and Rosen, S. (1981) "Rank-order tournaments as optimal labor contracts." *Journal of Political Economy*, 89, 841-864.

"My Colleague, My Boss" J. S. Lublin. The Wall Street Journal, April 12, 1995 pR4 col. 1.

Nalbantian, H. R. and Schotter, A. (1997) "Productivity Under Group Incentives: An Experimental Study." *American Economic Review*, 87, 314-341.

Ostrom, E., Walker, J. and Gardner, R. (1992) "Covenants with and without a Sword: Self-Governance is Possible." *American Political Science Review*, 86: 404-417.

Palfrey, T. R. and Rosenthal, H. (1991) "Testing for Effects of Cheap Talk in a Public Goods Game with Private Information." *Games and Economic Behavior*, 3, 183-220.

Pryor, F. L. (1984) "Incentives in Manufacturing: the Carrot and the Stick." *Monthly Labor Review*, 107(7), 40-43.

Schotter, A. and Weigelt, K. (1992) "Asymmetric tournament, equal opportunity laws, and affirmative action: Some experiment results." *Quarterly Journal of Economics,* 107, 511-539.

Sefton, M., Shupp, R. and Walker, J. (2000) "The Effect of Rewards and Sanctions in Provision of Public Goods." Working paper, Indiana University Center on Philanthropy and Workshop in Political Theory and Policy Analysis van Dijk, F., Sonnemans, J. and van Winden, F. (2001) "Incentive Systems in a Real Effort Experiment." *European Economic Review*, 45(2), 187-214.

TABLE 1

Mean Percentage Contributions by Treatment (aggregated over rounds)											
	Team #										
Treatment	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Average**
Baseline	.13	.24	.72 .24 .33 .04 .57 .43 .31 .29								.33
AbsPen	.41	.37	.66 .51 .57 .34 .72 .49 .49 .50								.51
AbsPrz	.33	.47	.40 .47 .46 .43 .55 .32 .53 .51								.45
RelPen	.37	.32	.55 .55 .54 .48 .61 .28 .57 .55								.48
RelPrz	.44	.61	.72 .86 .58 .43 .69 .54 .55 .58								.60

TABLE 2
variable names and descriptions

VARIABLE NAME	DESCRIPTION
$Give_i$ (Dependent Variable)	=% of tokens contributed to team (group) account
Hi, MidHi, Midlow	=Dummy variables for Highest, 2nd highest, and 3rd highest endowment levels in team
AbsPen, AbsRelPen, AbsPrz, RelPen, RelIntPen, RelPrz,	=Dummy variables for each incentive treatment
Benefit	=1 if individual received incentive benefits (by him/herself or shared) in previous round
Share	=number of individuals who shared in incentive benefits in previous round
TotalEarn	=subject's cumulative earning (in cents) for the experiment in current round
Round	=the round of the treatment (i.e., 1-8)
Oppwin	=1 if individual had the opportunity to receive incentive benefits in previous round, but did not (e.g., top contributor was 10 tokens, and your endowment is 17 tokens…you could have received benefits)
Deviate	=your deviation from the rest of the team's average contribution level. Your contribution (absolute) minus residual group mean contributions (absolute levels)
Dispar	=the size of the *revealed* disparity in token endowments in any prior round of the experiment

Total Observations=1600

TABLE 3

Random Effects Modeling of Individual-level % Contributions Dependent variable=$Give_i$				
Variable	**Coef. (p-value)**	**Coef. (p-value)**	**Coef. (p-value)**	**Coef. (p-value)**
Constant	.42 (.00)*	.43 (.00)*	.41 (.00)*	.45 (.00)*
AbsPen	.17 (.00)*	.16 (.00)*	.32 (.00)*	.27 (.00)*
AbsPrz	.11 (.00)*	.10 (.01)*	.26 (.00)*	.22 (.00)*
RelPen	.16 (.00)*	.12 (.00)*	.16 (.00)*	.15 (.00)*
RelPrz	.28 (.00)*	.23 (.00)*	.28 (.00)*	.25 (.00)*
Round	-.02 (.00)*	-.02 (.00)*	-.02 (.00)*	-.02 (.00)*
Hi	---	.003 (.96)	---	-.07 (.33)
Midhi	---	-.08 (.26)	---	-.13 (.06)
Midlow	---	.06 (.34)	---	.04 (.59)
Benefit	---	.18 (.00)*	---	.10 (.02)*
Share	---	-.03 (.04)*	---	-.02 (.22)
TotalEarn	---	-.001 (.12)	---	-.00 (.39)
Oppwin	---	.11 (.00)*	---	.06 (.08)
Deviate	---	.01 (.00)*	---	.01 (.00)*
Dispar	---	---	-.06 (.00)*	-.04 (.00)*
R^2	.06	.15 .08		.16
Observations=1600				

*Represents significance at the 5% level or better.

FIGURE 1: Aggregate Results

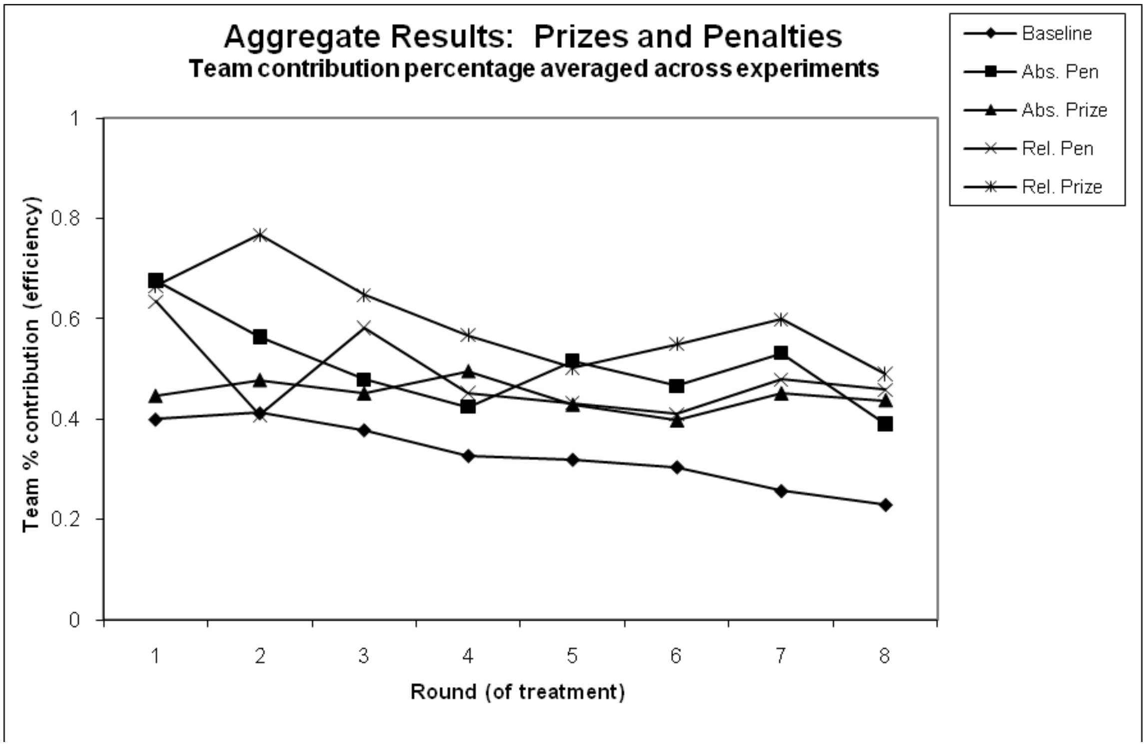
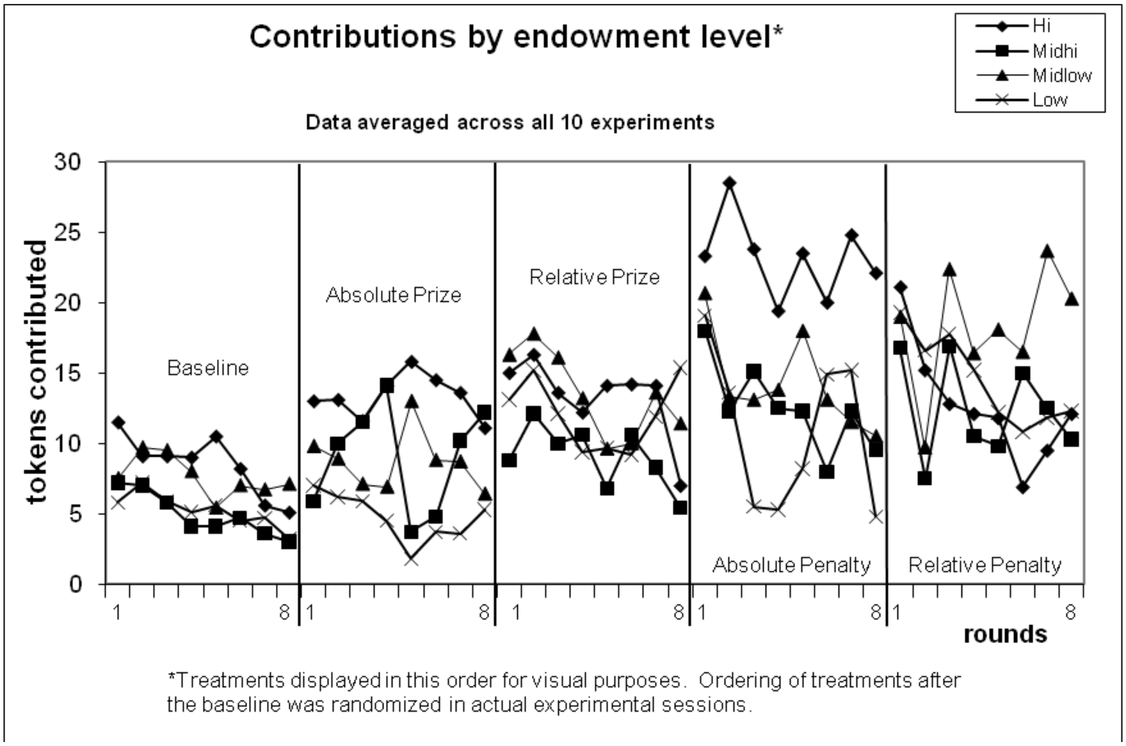
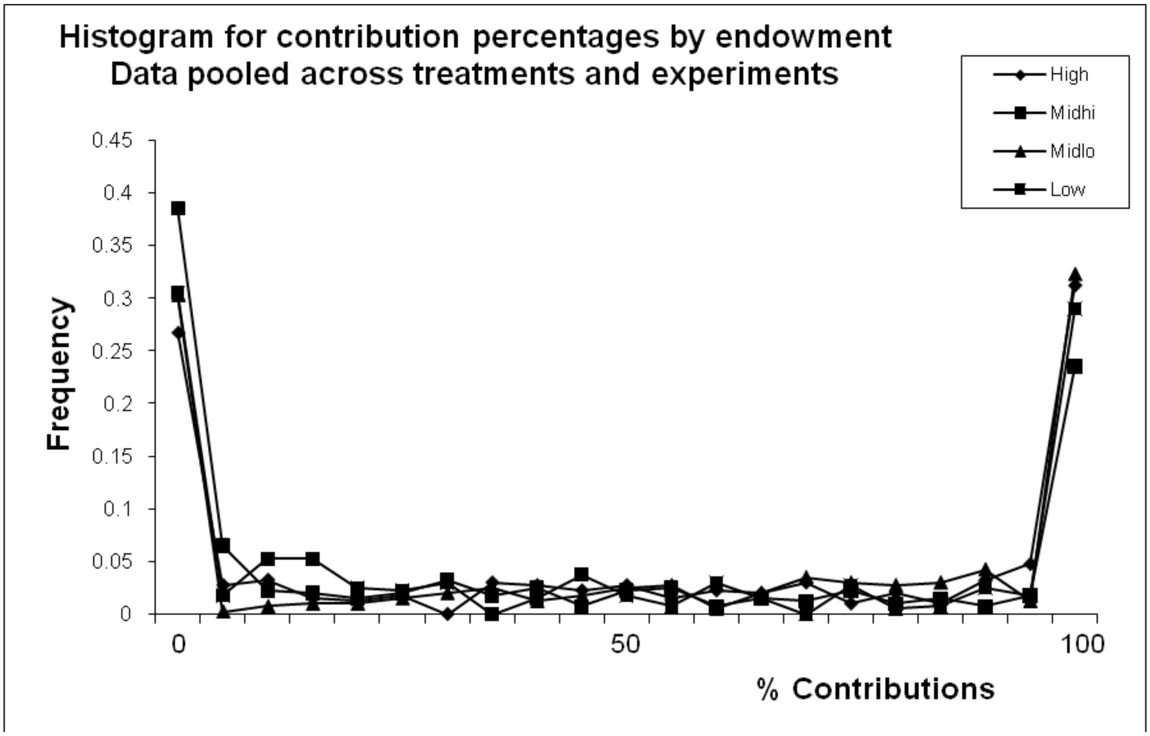


FIGURE 2



Contributions by endowment level*
Data averaged across all 10 experiments
Hi
Midhi
Midlow
Low
tokens contributed
0
5
10
15
20
25
30
Baseline
Absolute Prize
Relative Prize
Absolute Penalty
Relative Penalty
1
8
rounds
*Treatments displayed in this order for visual purposes. Ordering of treatments after the baseline was randomized in actual experimental sessions.

FIGURE 3



Histogram for contribution percentages by endowment
Data pooled across treatments and experiments
High
Midhi
Midlo
Low
Frequency
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
50
100
% Contributions

ENDNOTES

[1] While not addressing the same issues as in this paper, a couple of other experimental studies examine work effort by conducting real effort experiments. The interested reader is directed to Dickinson (1999), and van Dijk, Sonnemans, and van Winden (2001).

[2] Since our results show that both rewards and penalties improve team contributions or effort, there will be some employers for whom the marginal cost of monitoring individual effort will be worth the marginal gain of additional team output. While we suppress these employer benefits in our experiment, we presume that higher levels of team effort have positive effects on employer profits.

[3] While the purpose of this paper is to explore positive and negative incentives with and without handicapping, we do not address the various other forms of team incentives that exist. The reader is directed to Nalbantian and Schotter (1998) for an experimental investigation some common incentive plans.

[4] Furthermore, Lazear and Rosen (1981) implies that a rank ordering of wage payments must be given for any number of team members, whereas our experiment offer only one incentive for the entire team.

[5] The existence of mixed strategy Nash equilibria will be discussed later in the paper.

[6] Dickinson and Isaac's framework differs in that they use 5-member teams where we use 4-member teams. The experimental parameters discussed in this paper are adjusted so that the marginal incentives are comparable.

[7] The prize/penalty size must be strategically chosen to generate a theoretical prediction of no

pure strategy Nash equilibrium (see Dickinson and Isaac). Of course, mixed strategy equilibria will exist for this game. Though it is prohibitively difficult to calculate a closed form solution for mixed strategy equilibria, the data generated are *not* consistent with mixed strategy predictions of this game with a simplified strategy space (i.e., contributions of 0%, 50%, or 100% of the subject's endowment). These results are available from the author upon request.

[8] To see that this quasi-penalizing of team members tied for high contributions is equivalent to tie breaking under prizes, note that if N^t team members are tied for the high contribution level in the prize treatment, and some team members contributes one more token in order to gain the full prize, then the marginal prize gain of that additional token contributed is $(N^t-1)/N^t$ of the prize. The loss to those who were tied and now are not high contributors is $1/N^t$ of the prize. With the penalty environment, if N^t team members are tied with the high contribution level and one team member contributes an additional token, then the marginal gain is that the individual no longer pays the $(N^t-1)/N^t$ share of the penalty. The loss to the rest is that they are now simply "not high contributors" and will therefore pay the full penalty each. Their loss is then $1/N^t$ of the penalty. Given that the penalty and prize are of the same size, the marginal incentives of the treatments are equivalent.

[9] The intuition behind the lack of pure strategy Nash equilibria is as follows: Since some team member is always endowed with more tokens than all the others, it is in his best interest to always avoid the penalty (given the size of the penalty). However, all other team members would then be best off by contributing zero due to the free-riding incentive. Of course, if all others contribute zero, then the high contributor has an incentive to only contribute one token and still avoid the penalty, but this would induce contributions to spiral upward among team members until the individual with the largest token endowment wins—at this point the argument

repeats. A similar argument follows for the Relative Penalty treatment as well as for the prize treatments.

[10] A referee has pointed out that the strategy space of all players is not public knowledge, as the game theoretic analysis assumes. Our statistical results in Table 3 include an independent variable meant to capture team members' response to the incomplete endowment information that is revealed over the course of a treatment.

[11] A complete set of all experimental instructions is available from the author by request.

[12] As we will see, the ordering of efficiency outcomes in Relative Prize, Absolute Prize, and Baseline treatment are identical to those in Dickinson and Isaac where they randomized the ordering of all treatments including the Baseline, and so we do not believe placing the Baseline first affects the results. More importantly for our experiments, initial Baseline treatments helped "train" subjects in the basic institution before the added details of the penalty treatments are seen.

[13] The actual ordering of treatments in the 10 experiments were as follows (baseline=1, AbsPen=2, Absprz=3, RelPen=4, RelPrz=5): 12354, 14253, 12453, 15432, 13452, 12543, 15342, 12543, 13542, 14352.

[14] In the actual experimental instructions and procedures, terms such as "group" and "private" accounts were labeled accounts X and Y. Similar neutral language was used throughout the instructions and procedures. The "Prize", for example, was called the "additional 20 cents."

[15] Previous public goods experiments have shown the efficiency-enhancing effects of nonbinding communication among team members (see, for example, Isaac and Walker (1988b) and Palfrey and Rosenthal (1991)), but the main purpose of these experiments is to explore positive versus

negative incentives as our first step towards evaluating the roles and complementarities of the incentives and the handicapping rule.

[16] This shift in endowments is also useful in mitigating any potential income effects since the new endowment levels are chosen so that expected earnings at the efficient outcome are identical under penalties and prizes. We see this by noting that under prizes, total team earnings at the Pareto optimal outcome are 180 cents (160 cents of group account earnings plus the prize of 20 cents). Under penalties, total team earnings are also 180 cents (240 cents of group account earning **minus** 60 cents in total penalties. This, because only one individual is not assessed the penalty meaning that 3 of 4 individuals are penalized 20 cents each round).

[17] An anonymous referee noted this point. The data from these experiments and the statistical analysis are available from the author upon request.

[18] The notion of a reference point is a critical point in the prospect theory of Kahneman and Tversky (1979). Prospect theory implies that, from a given reference point, loss aversion would render negative incentives more effective than positive incentives in motivating individuals. While reference points and loss aversion may say something about the results in team work environments, the group dynamic compounds the problem.

[19] These results are also consistent with Dickinson and Isaac in that handicapped prizes increased efficiency by an amount greater than non-handicapped prizes.

[20] For these Mann-Whitney tests, the unit of analysis is the difference between the maximum and minimum average contributions for each round (note that this is slightly different then the aggregation by endowment levels shown in Figure 3). For each round, maximum and minimum contributions are taken and averaged across all 10 experiments. The gap still exists if one calculates the gap in percentage giving rather than absolute giving.

[21] Under this interpretation, the strong free-riding incentive of the baseline treatment is similar to theoretical predictions that once minimum effort requirements are made, employees will contribute at minimum effort as an equilibrium prediction.

[22] The variable Deviate, which describes an individual's deviation from the residual group average level of contributions is used in Dickinson (1998) and is a significant determinant of contribution levels in his voluntary contributions mechanism experiments.

[23] An alternative approach would be to simply estimate a model of treatment effect using the team contributions level as the unit of observation. This modeling, while lacking any behavioral variables, yields coefficient estimates on treatment variables that are virtually identical in magnitude and significance as the estimates of Table 3 (results available upon request).

[24] Here, we calculate the effect of *Dispar* separately for the average team member by evaluating the coefficient of *Dispar* at the average value of *Dispar* for each endowment level (averaged across all rounds and experiments for the non-handicapped treatments). When including the joint effect of *Dispar* and the nonhandicapped treatments, the percentage efficiency improvements for *AbsPen,* and *AbsPrz* for endowment levels high to low are, respectively, 32,23,11,1 and 26,17,5,-5 in the base treatment effects model (column four), and 27,21,13,6 and 22,16,8,1 in the full specification (column five). As such, average team efficiency increases by 16.75% and 10.75% in the *AbsPen,* and *AbsPrz* treatments of the base model, and by 16.75% and 11.75% in the full specification.

[25] Results are all from F-tests of the pairwise difference in coefficients.

[26] Dickinson (1998) offers two explanations for the positive sign on the coefficient of Deviate. First, the positive sign will result if, as contributions decay through time, those who are above (below) average contributors experience a slower-than-average (faster-than-average) decay rate

in their contributions (this hypothesis was originally suggested by Stan Reynolds). A second explanation is that below average contributors learn to free ride *even more*, while above average contributors may increase contributions in attempt to “stoke the fire” and get others to contribute.

[27] Perhaps it should not be surprising that institutions such as the military and catholic schools tend to lean toward negative incentives. Such incentives may be complementary with the higher importance they place on absolute standards.

[28] This production function and the idea of including more team interdependence were suggested to me by Alessandro Rossi.