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THE CARROT VS. THE STICK IN WORK

TEAM MOTIVATION

by

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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 increase efficiency levels by 11-29%. We find that handicapped incentives promise the highest efficiency levels, and when handicapping is not used certain types of penalties may be more effective than prizes. The implications for work teams and suggestions for practical implementation are discussed.
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TEAM MOTIVATION*

I. Introduction

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 give 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. With asymmetrically endowed individuals (e.g., different abilities), incentive schemes based on contributions relative to endowment (i.e., handicapped incentives) are shown the most effective in eliciting higher levels of giving. The 7% 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. Our

*The author is grateful to the Research Council at Colgate University for funding these experiments. The paper has benefitted from helpful conversations with R. Mark Isaac, the participants of the economics seminars at Colgate University (a joint seminar with Hamilton College) and Utah State University, and the conference participants at the Economic Science Association Fall 1999 meetings in Grenoble, France. Correspondence to the author should be addressed to David L. Dickinson, Department of Economics, Utah State University, 3530 Old Main Hill, Logan, UT 84322-3530.
experimental design also utilizes two different methods of implementing negative incentives, and a key result is that different types of incentives interact differently with handicapping. For example, with no handicapping we find that the negative incentives that more successfully internalize the loss—e.g., a monetary fine—increase efficiency by 5% more than prizes or noninternalized penalties (such as refundable employer-posted bond).

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.²

In exploring a variety of motivation strategies, we should note the existence of penalty strategies 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 1980s that in the 44% of nonunionized manufacturing firms (and 25% of unionized firms) more than 5% of workers are fired annually for poor performance. 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 work place, it is clear that one could use different sorts of “fines” as an alternative method of eliciting the desired behavior.

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 levels of giving increases contributions by even more
than does rewarding based on absolute levels of giving. 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 contribution. This paper, in fact, extends from Dickinson and Isaac to look at the effects of such penalties.

We should also note that our introduction 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. Schotter and Weigelt (1992) use controlled experiments to explore tournaments among heterogeneous-ability subjects. When individuals faced differing cost-of-effect functions the authors find, among other things, that when the rules of the tournament 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 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.

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. We calibrate the size of the prize and the penalty so that their introduction does not create an
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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 given a different
endowment of tokens, \( w_i \) per round (17, 19, 21, or 23), but a given individual’s endowment is
the same in every round. Recall that these heterogeneous endowments of tokens represent
abilities of different team members to contribute towards the group 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 contributed 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

\[
U_i = q(w_i - m_i) + a \sum_i m_i
\]
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. The prize is chosen to satisfy two conditions: the free-riding incentive and the prize saliency condition (see Dickinson and Isaac). Essentially, the condition of prize saliency is one in which the prize is large enough so that every team member has the incentive to try to win the prize outright, but not to win a $1/N$ share of the prize—this, since the tie-breaking rule will be to split the prize upon a tie among two or more team members. The free-riding incentive ensures that the marginal gain of contributing a token to the group account is less than the loss in the absence of any prize. Given the size of the prize chosen, along with our tie-breaking rule, there is no pure-strategy Nash equilibrium in the stage game for either prize treatment (mixed strategy equilibria will be discussed shortly). Pareto efficiency remains at full contributions by all team members. Note the free-riding incentive, the prize saliency condition, and the tie-breaking rule are all critical to the prediction of no pure-strategy Nash equilibrium.

The payoffs under the Absolute Prize treatment is

\begin{align*}
U_i &= q(w_i - m_i) + a \sum_i m_i & \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 & \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/\sum_i m_i & \text{if } m_i = m_j \text{ for the } N' \text{ tied individuals}
\end{align*}

\[(2)\]
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 be compared to the prize treatment (with $P=\$0.20$), we first start with a penalty of $P=\$0.20$. Appendix A establishes penalty saliency for our penalty environment when the size of the penalty is the same as the size of our prize. For our penalty environment to be equivalent in marginal incentives to the prize environments requires not that we merely penalize the low contributor, but rather that we penalize all team members who are not the highest contributor (i.e., the $(N-1)/N$ lowest contributors). To penalize only the lowest absolute or relative contributor, while somewhat similar, is actually a different incentive structure. The payoff to individual $i$ under Absolute Penalty is

$$U_i = q(w_i - m_i) + a \sum_i m_i - \left( \frac{N-1}{N} \right) P^*$$

if $m_i < m_j$ for all $j \neq i$

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

if $m_i > m_j$ for all $j \neq i$

$$U_i = q(w_i - m_i) + a \sum_i m_i - \frac{P^*}{N^t}$$

if $m_i = m_j$ for the $N^t$ tied individuals

Interpreting the $>, =, and <$ conditions in (3) as those for relative contributions yields 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. The formal proofs are available upon request.

The non-existence of pure strategy equilibria in the penalty and prize treatments does not, of course, imply that there are no equilibria. Mixed strategy equilibria will certainly exist. The
large number of pure strategy choices for each individual makes the calculation of mixed strategy equilibria for the 4 person-game prohibitively difficult. However, some useful insights can be gleaned from a simplified 2-person game example.

Assume a 2-person prize incentive game with endowments 18 and 22, \( a = 0.75 \), and \( P = 7 \). These parameters ensure we have the free-riding condition as well as prize saliency. If we simplify the strategy space to the choice of either \( m_i = 0 \), \( m_i = w_i \), or \( m_i = 0.5w_i \), then the game yields no pure strategy Nash equilibrium. A mixed strategy equilibrium can be calculated where the low endowment individual mixes between \{0, 0.5w_i, w_i\} with probabilities \{43\%, 18\%, 39\%\} and the high endowment individual mixes between \{0, 0.5w_i, w_i\} with probabilities \{64\%, 32\%, 4\%\} for an Absolute Prize game. The mixing equilibrium in the corresponding Relative Prize game is \{21\%, 57\%, 22\%\} and \{36\%, 29\%, 35\%\} for the low and high endowment individuals, respectively. The mixed strategy equilibria change with the initial parameterization of the game (e.g. \( w_1 = 10 \), \( w_2 = 14 \), \( a = 0.74 \), and \( P = 4 \) yields a different mixing equilibrium)\(^8\), but such equilibria seem to have in common the following: the low endowment individual mixes across strategies somewhat more equally in Absolute Prize than in Relative Prize (where an interior level of contributions is more likely chosen); the high endowment individual almost never fully contributes in Absolute Prize, and in Relative Prize mixes somewhat equally across the three strategy choices.

A preview of the results (see Figure 3) shows that individuals of all endowment levels seem to contribute either all or nothing to the team account. As such, if our simplified games yield insights that can be generalized to a larger strategy space and a larger number of players, it does not seem that individuals are playing a mixed strategy equilibrium. Indeed, the assumption that each player's randomization is statistically independent of the opponents' is most likely not
true. We note in the results section that players' contributions are statistically significantly affected by what opponents had done in the previous round.

3. Experimental Procedures

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. Each treatment consists of 8 rounds and so each experimental team member makes 40 decisions in the experiment.

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. 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).

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.”

As previously noted, we implement the penalty incentives in two different ways. A basic penalty that may not be internalized by the worker is accomplished by endowing each subject with an additional $.20 in startup cash (in addition to the token endowment) for each round. Any subject who does not place the most tokens (absolute or relative) in the group account forfeits the additional $.20 cents (or partially forfeits it if tied for high contributions). We call the handicapped and no-handicapped version of this incentive structure Relative and Absolute Penalty. A related penalty scheme that may be more successful at internalizing the loss (and therefore changing the individual’s reference point) would actually take $.20 away from the subjects’ earnings at the end of the round if not a high contributor—but no additional startup cash is provided. 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. We call these treatments Relative and Absolute Internalized Penalty.

Appropriate announcements are made in all Penalty treatments so that individuals know whether or not they subtract (or “forfeit”) 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 forfeit the additional 20 cents for this round. All others will forfeit the entire 20 cents for this round.” For the Absolute Internalized 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 for the Relative and Relative Internalized Penalty treatments, and the announcements of
both penalties and prizes were altered appropriately in the event that more than 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 20 experiments were run using undergraduates recruited primarily from introductory level economics courses at Colgate University in the spring of 1998 and 1999. Ten experiments involved a Baseline, Prize and Penalty treatments (absolute and relative) and 10 others involved a Baseline, Prize and Internalized Penalty treatments (absolute and relative). 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 $18.11, ranging from a high of $21.25 to a low of $14.75. The aggregate experimental results are shown in Figure 1, with a separate graph for each set of 10 experiments.

It is apparent from Figure 1 that the incentive treatments are effective in raising team efficiency levels. Efficiency (contributions) tends 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. In addition to higher contributions in the incentive treatments, the dispersion in contributions across endowment levels is also larger in the incentive treatments.
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 averaged 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). Further, non-handicapped incentives seem to increase this variance by even more (p-value of at least .05 on each pairwise comparison except for comparing Relative and Absolute Prize from the top graph of Figure 2 (here, p=.10)).

It is important to note that if an employer implements nonhandicapped incentives, though cheaper and still effective in improving efficiency (especially with internalized penalties), group stability may be harmed the most. 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.

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 individuals either try as hard as they can or shirk completely? While such extremes are probably not very realistic, we could easily interpret a contributions level of zero as 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.\(^\text{18}\) 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.

Figure 3 would also cast doubt on the possibility that individuals are playing a mixed strategy equilibrium. Even under loose interpretations of “complete free-riding”, “50% contributions”, and “full contributions”—those not requiring exact 0%, 50%, or 100% contributions—high endowment players contributed all of their tokens 60%-70% of the time in the non-handicapped treatments. While simplified, the 2-person example given in Section 2 suggests less frequent full contributions. Also, the low-endowment individual in our example played 50% contributions relatively more frequently in the mixing distribution example for handicapped incentives. Our results show that contributions between 33%-66% of an individual’s endowment is the *least* chosen option by the average individual of any endowment level. It is possible that our example is too simplified to handle the larger strategy space of the actual experiment, but we may also speculate that the mixed strategy equilibrium may not be played due to a violation of the assumption of independence or players’ randomization. This conclusion is supported in the following regression analysis.

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**FIGURE 3 HERE**

**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.  

A final variable, Dispar, is used to measure the revealed disparity in the level of token endowments at any point in the experiment. 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—this can be revealed in the announcement of the high contribution level in any of the Absolute treatments—the perceived probability of enjoying the benefits of the incentive treatment decreases. Therefore, the variable Dispar controls for the level of information on endowments that is currently available to each team member. Table 1 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. This modeling of the constant term is supported by Lagrange multiplier and Hausman tests of the contributions equation. Table 2 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 2, while the last
two columns reestimate these models including a control for revealed endowment information. Note that several of the variables in Table 1 explicitly account for the fact that individual observations within a given team are not independent of one another.\textsuperscript{20}

\section*{TABLE 2 HERE}

Consistent with the existing literature on voluntary contribution mechanism experiments, the coefficient on \textit{Round} suggests a decay in contributions as the final round of the treatment approaches, and its magnitude suggests that individual contributions will decline by 16\% over the course of the treatment, \textit{ceteris paribus}. The constant term suggests that about 40\% of an individual’s tokens are contributed in the first round of the baseline treatment independent of other behavioral factors.

From Table 2 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 efficiency in team giving (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 2 show that efficiency is increased by the incentive treatments from 11 to 29\%, depending upon the treatment. In column two we see that nonhandicapped incentives offer smaller efficiency gains 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 available to team members. Comparing columns two and four of Table 2 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 2 show the results from similar estimations which include the additional behavioral variables.
In the specifications of the last two columns of Table 2, we evaluate the coefficients of the Absolute treatments at the mean level of Dispar for each endowment level to breakdown the estimated treatment effects accounting for the level of endowment information the team members have. When including the joint effect of Dispar and the nonhandicapped treatments, the percentage efficiency improvements for AbsIntPen, AbsPen, and AbsPrz for endowment levels high to low are, respectively, 38, 26, 11, -2: 33, 21, 6, -9: and 33, 20, 6, -8 in the basic treatment effects model (column four), and 32, 23, 12, 2: 27, 18, 6, -5: 28, 19, 7, -3 in the full specification (column five). As such, average team efficiency increases by 18.25%, 12.75%, and 12.75% in the AbsIntPen, AbsPen, and AbsPrz treatments of the base model, and by 17.25%, 11.5%, and 12.75% in the full specification. These efficiency gains are then comparable to columns two and three of Table 2 for the Absolute treatments, but it highlights the fact that efficiency improvements are estimated to be quite high for the high endowment individual and quite low (even negative) for the low endowment individual compared to the Baseline.

Focusing and the models in columns two and three of Table 2, handicapped incentives generally improve efficiency the most. However, when handicapping is not used internalized penalties are more effective than prizes or noninternalized 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, Table 2, we note that when handicapping is used, prizes and noninternalized penalties generate 11-12% greater efficiency than internalized penalties. However, when no handicapping is used, internalized penalties increase efficiency by 5-6% more than prizes or noninternalized penalties. Also, if prizes or noninternalized penalties are used they increase efficiency by 16% more when used with handicapping as opposed to no handicapping (all results are from F-tests of the pairwise difference in coefficients). Most comparisons are significant at
the .01 level, although the most intriguing result—that internalized penalties are more effective when no handicapping is used—is significant at the .10 level. This last result is salient and suggests that penalties and prizes, while substitutable to some extent in eliciting additional giving 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. Focusing on column three of Table 2, 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, but the coefficient is statistically insignificant.

Team members apparently also feel some regret when they could have received benefits of the incentive program but did not. In fact, the positive and precisely estimated coefficient on Oppwin suggests that when this is the case, team members contribute an additional 15% in the next round. Though small in magnitude, the coefficient on TotalEarn suggests that as cumulative earnings rise, contributions fall. The magnitude of the coefficient suggests that for each extra $1.00 in cumulative earnings, the team member decreases contributions each round by
10% (about 2 tokens). It is possible, though, that this variable is capturing the cumulative experience of the team member in the group giving environment.

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.

If we next focus our attention on the same behavioral model including the control for revealed endowment information (column five), we see that some of the coefficients in column three were capturing some of the effect of the revealed ability information. Coefficients on the endowment level dummies are all statistically insignificant in the model of column three, but in column five the highest two endowment levels will actually contribute a lower percentage of their tokens to the group account, holding other factors constant. Given heterogeneous endowment levels, this would occur if, ceteris paribus, all team members contribute about the same absolute number of tokens. The significance of the other coefficients is not affected by the inclusion of Dispar, but the magnitude of the coefficients on Oppwin and Benefit does decrease.
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 12%-29% 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%-18%) and also a wider variance in giving within the team—the latter may negatively affect team cohesion. 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 well-internalized penalties.25

We should note that our penalties might not be what first come to an employer’s mind when considering penalties. We established internalized penalties as a viable means of eliciting effort by increasing the initial endowment of all team members and then fining everyone except the team member 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 probable when dealing with
those who have a large amount of data available on their work performance (e.g., professional team athletes), and they would not require a well-internalized penalty to be effective.

Consider that an employer could post a bond to each worker at the beginning of a work period. If the work period is short, the employee may not internalize the bond money. If the work period is long then the employee may internalize the money to a greater extent. The requirement of internalized penalties for the most effective nonhandicapped incentives may suggest that basic fines are more effective in nonhandicapped environments than bond posting.

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 10 or more tokens are contributed by the team, the incentive is funded (since this generates 20 cents in group-wide wealth). In our optimally matched incentive programs, Relative Prize increases team contributions on average by about 24 tokens, and Absolute Internalized Penalty increases team contributions by about 21.5 tokens—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 refund an employer posted bond, for example, should be specific as to whether it is partially or fully refunded, under what conditions this occurs, and the bond would need to be posted at the
beginning of each work period. These are important details to the successful implementation of any penalizing incentive program.

A drawback of the particular production function implicit in the public good determination 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, are immune to complete free-riders (assuming that others provide effort). A more realistic team production function might include a higher degree of team member interdependence. An extreme case would be $Y = A \times \min\{y_1, y_2, y_3, y_4\}$ ($A = \text{scale constant}$). 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, team interdependence may be an 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.

ENDNOTES
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 (2000).

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.

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.

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

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.

To see that this quasi-penalizing of team members tied for high contributions is equivalent, note that if \( N \) 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 \( (N-1)/N \) of the prize. The loss to those who were tied and now are not high contributors is \( 1/N \) of the prize. With the penalty environment, if \( N \) 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 \( (N-1)/N \) 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 $1/N^4$ of the penalty. Given that the penalty and prize are of the same size, this tie-breaking rule establishes the penalty treatments as identical in marginal incentives to the prize treatments.

7 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 (see penalty saliency condition). 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 out--at this point the argument starts over again. A similar argument follows for the Relative Penalty treatment as well as for the prize treatments.

8 A more simplified normal form game with strategies of only $m_i=0$ or $m_i=w_i$ yields a pure strategy Nash equilibrium where both individuals free ride. A larger strategy space is necessary to highlight our desired results.

9 In this alternative parameterization, the Absolute Prize mixing equilibrium is $\{25\%, 31\%, 44\%\}$ for the low and $\{63\%, 31\%, 6\%\}$ for the high endowment individual, whereas the Relative Prize equilibrium is $\{13\%, 75\%, 12\%\}$ for the low and $\{38\%, 25\%, 37\%\}$ for the high endowment individual.

10 A complete set of all experimental instructions is available from the author by request.

11 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 treatment helped “train” the subjects in the basic institution before the added details of the penalty treatments are seen.

12 In the actual experimental instructions and procedures, terms such as “group” and “private” accounts were actually labeled accounts X and Y. Similar neutral language was used throughout the instructions and procedures. The “Prize”, for example, was referred to as the “additional 20 cents.”

13 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.

14 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 problem is compounded by the group dynamic.

15 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).

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

17 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 2). For each round, maximum and minimum contributions are taken and averaged across the 10 experiments in which the same treatments were completed by each team (recall that some experiments used internalized penalties, and some used penalties). The gap still exists if one calculates the gap in percentage giving rather than absolute giving.

18 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.

19 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.

20 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 in any behavioral variables, yields coefficient estimates on treatment variables that are virtually
identical in magnitude and significance as the estimates of Table 2 (results available upon request).

21 Here, we calculate the effect of Dispar separately for the average team member by evaluating the coefficient at the mean level of Dispar for each endowment level for all experiments.

22 A separate regression on data from the 10 experiments that included the internalized penalty treatments (rather than the pooled data from all 20 experiment) finds significance at the 5% level for this result.

23 This calculation excludes the $5 show-up fee from cumulative earnings, as does the variable TotalEarn.

24 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.

25 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.

26 On the other hand, shorter work periods may mean that less information is revealed on abilities. This would tend to make all types of nonhandicapped incentives more effective.

27 This production function and the idea of including more team interdependence were suggested to me by Alessandro Rossi.
### TABLE 1

**variable names and descriptions**

<table>
<thead>
<tr>
<th>VARIABLE NAME</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Givei, (Dependent Variable)</td>
<td>=% of tokens contributed to team (group) account</td>
</tr>
<tr>
<td>Hi, MidHi, Midlow</td>
<td>=Dummy variables for Highest, 2\textsuperscript{nd} highest, and 3\textsuperscript{rd} highest endowment levels in team</td>
</tr>
<tr>
<td>AbsPen, AbsRelPen, AbsPrz, RelPen, RelIntPen, RelPrz, Benefit</td>
<td>=Dummy variables for each incentive treatment</td>
</tr>
<tr>
<td>Share</td>
<td>=1 if individual received incentive benefits (by him/herself or shared) in previous round</td>
</tr>
<tr>
<td>TotalEarn</td>
<td>=number of individuals who shared in incentive benefits in previous round</td>
</tr>
<tr>
<td>Round</td>
<td>=subject’s cumulative earning (in cents) for the experiment in current round</td>
</tr>
<tr>
<td>Oppwin</td>
<td>=the round of the treatment (i.e., 1-8)</td>
</tr>
<tr>
<td>Deviate</td>
<td>=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)</td>
</tr>
<tr>
<td>Dispar</td>
<td>=your deviation from the rest of the team’s average contribution level. Your contribution (absolute) minus residual group mean contributions (absolute levels)</td>
</tr>
<tr>
<td>Total Observations</td>
<td>=the size of the revealed disparity in token endowments in any prior round of the experiment</td>
</tr>
</tbody>
</table>

Total Observations=3200
### TABLE 2

Random Effects Modeling of Individual-level % Contributions

**Dependent variable=Give**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coef. (p-value)</th>
<th>Coef. (p-value)</th>
<th>Coef. (p-value)</th>
<th>Coef. (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>.41 (.00)*</td>
<td>.43 (.00)*</td>
<td>.39 (.00)*</td>
<td>.46 (.00)*</td>
</tr>
<tr>
<td>AbsIntPen</td>
<td>.18 (.00)*</td>
<td>.16 (.00)*</td>
<td>.38 (.00)*</td>
<td>.32 (.00)*</td>
</tr>
<tr>
<td>AbsPen</td>
<td>.12 (.00)*</td>
<td>.11 (.00)*</td>
<td>.33 (.00)*</td>
<td>.27 (.00)*</td>
</tr>
<tr>
<td>AbsPrz</td>
<td>.13 (.00)*</td>
<td>.11 (.00)*</td>
<td>.33 (.00)*</td>
<td>.28 (.00)*</td>
</tr>
<tr>
<td>RelIntPen</td>
<td>.17 (.00)*</td>
<td>.12 (.00)*</td>
<td>.17 (.00)*</td>
<td>.15 (.00)*</td>
</tr>
<tr>
<td>RelPen</td>
<td>.28 (.00)*</td>
<td>.20 (.00)*</td>
<td>.29 (.00)*</td>
<td>.24 (.00)*</td>
</tr>
<tr>
<td>RelPrz</td>
<td>.29 (.00)*</td>
<td>.21 (.00)*</td>
<td>.29 (.00)*</td>
<td>.25 (.00)*</td>
</tr>
<tr>
<td>Round</td>
<td>-.02 (.00)*</td>
<td>-.02 (.00)*</td>
<td>-.02 (.00)*</td>
<td>-.02 (.00)*</td>
</tr>
<tr>
<td>Hi</td>
<td>---</td>
<td>.00 (.95)</td>
<td>---</td>
<td>-.09 (.04)*</td>
</tr>
<tr>
<td>Midhi</td>
<td>---</td>
<td>-.05 (.24)</td>
<td>---</td>
<td>-.13 (.00)*</td>
</tr>
<tr>
<td>Midlow</td>
<td>---</td>
<td>-.01 (.90)</td>
<td>---</td>
<td>-.03 (.44)</td>
</tr>
<tr>
<td>Benefit</td>
<td>---</td>
<td>.18 (.00)*</td>
<td>---</td>
<td>.08 (.02)*</td>
</tr>
<tr>
<td>Share</td>
<td>---</td>
<td>-.01 (.35)</td>
<td>---</td>
<td>.00 (.70)</td>
</tr>
<tr>
<td>TotalEarn</td>
<td>---</td>
<td>-.001 (.00)*</td>
<td>---</td>
<td>-.001 (.01)*</td>
</tr>
<tr>
<td>Oppwin</td>
<td>---</td>
<td>.15 (.00)*</td>
<td>---</td>
<td>.06 (.01)*</td>
</tr>
<tr>
<td>Deviate</td>
<td>---</td>
<td>.01 (.00)*</td>
<td>---</td>
<td>.01 (.00)*</td>
</tr>
<tr>
<td>Dispar</td>
<td>---</td>
<td>---</td>
<td>-.08 (.00)*</td>
<td>-.06 (.00)*</td>
</tr>
<tr>
<td>$R^2$</td>
<td>.07</td>
<td>.16</td>
<td>.11</td>
<td>.18</td>
</tr>
</tbody>
</table>

Observation=3200

*Represent significance at the 5% level or better.
FIGURE 1: Aggregate Results

Aggregate Results: Prizes and Internalized Penalties
Data averaged for all team members and aggregated across experiments

Aggregate Results: Prizes and Penalties
Data averaged for all team members and aggregated across experiments
FIGURE 2

Tokens contributed by endowment level--Prizes and Internalized Penalties Experiments: By Tokens*
Data averaged across all 10 experiments

Tokens contributed by endowment level--Prizes and Penalties Experiments: By Tokens*
Data averaged across all 10 experiments
FIGURE 3

Histogram for contribution percentages by endowment level averaged across all 20 experiments.

- High
- Midhi
- Midlo
- Low

x-axis categories are in 5% bins of contributions

x=percent contributions
References


van Dijk, Frans, Joep Sonnemans, and Frans van Winden “Incentive Systems in a Real Effort Experiment.” Forthcoming in *European Economic Review*.
APPENDIX A: Penalty Saliency

The prize saliency condition of Dickinson and Isaac (1998) is that

\[(\max\{w_i\})(1 - \frac{a}{N}) < P < (\min\{w_i\})(N - a)\]

where \(\max\) and \(\min\) refer to the maximum and minimum endowment levels of the team members, respectively. Note the change in notation relative to our equation (1). In Dickinson and Isaac, the payoff function in (1) is written as

\[U_i = q(w_i - m_i) + \frac{a \sum m_i}{N}\]

so that our parameter \(a\) is the same as the Dickinson and Isaac parameter \(a/N\). We will proceed in the appendix using the Dickinson and Isaac parameters. As such, our parameterization as described in the paper is one where \(q=1, a=2,\) and \(N=4\). The bounds for prize saliency, given our parameterization are that \(11.5<P<34\). Since the penalty is essentially a negative prize, we will call the penalty \(P^-<0\) and the prize \(P^+>0\) henceforth.

It is important to note here that in order to mirror the marginal incentives of the prize treatments, we assess a penalty to all individuals who are not the highest contributors. While this may at first seem an unlikely compensation scheme for a real world work environment, the importance of a reference point should be highlighted. For example, promotion policies for top-level jobs tend to promote only a small proportion of workers to these jobs. If a candidate considers him/herself a strong candidate, then to not be promoted may be internalized as a loss or penalty by the worker. In our experimental design we endow the team members with additional earnings or tokens that may be taken away if the member is not the high contributor—we change the reference point of the team member.
If a penalty of \( P^- \) is assessed for *not being the highest* absolute or relative contributor, the gains of contributing \( m_i \) to avoid \( P^- \) are \(-P^- + \frac{am_i}{N}\) and the loss is \( m_i \). We seek to have this gain greater than the loss so that \( m_i < -P^- + \frac{am_i}{N} \) or \( P^- < \frac{am_i}{N} - m_i \). If you share in a \( 1/N \) portion of \( P^- \), then contributing \( m_i \) to avoid this share of the penalty results in a gain of \(-P^- + \frac{am_i}{N}\) and a loss of \( m_i \). We want this gain to be smaller than the loss so that \( m_i > -P^- + \frac{am_i}{N} \) or \( P^- > m_i(a - N) \).

Combining these two conditions gives us \( m_i(a - N) < P^- < \frac{am_i}{N} - m_i \). Since \( P^- < 0 \) we can also express this condition as \( m_i(1 - \frac{a}{N}) < -P^- < m_i(N - a) \). Finally, we can guarantee that this condition is met by tightening the inequalities with respect to the endowment levels used in the team so that \( (\max\{w_i\})(1 - \frac{a}{N}) < -P^- < (\min\{w_i\})(N - a) \). In other words, choosing a penalty of the same absolute value as the prize ensures penalty saliency for the team. Notice that the parametrization in (1) is such that we also have the free-riding incentive.