After the Tournament: Outcomes and Effort Provision

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ABSTRACT:

Modeling the incentive effects of competitions among employees, economists have largely ignored the potential for such competitions to affect effort provision after the competitions finish. In a laboratory experiment, we examine whether competition outcomes affect the provision of post-competition effort. We find that subjects who lose arbitrarily decided tournaments choose lower subsequent effort levels than subjects who lose tournaments decided by their effort choices. We explore the preferences underlying this behavior and show that subjects' reactions are related to their preferences for meritocratic outcomes.

Keywords: competitions, behavioral spillovers, counterproductive behavior, experiment
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I. Introduction

Competitions among workers for bonuses and promotions are often used by firms to elicit effort when effort is not fully contractible. The widespread use of tournaments as incentive mechanisms led economists to extensively investigate features of these contests such as the effects on effort provision of sabotage, prize and tournament structure, participant feedback, and multi-stage contests (e.g., Schotter and Weigelt 1992; Tong and Leung 2002; Carpenter et al. 2010; Harbring and Irlenbusch 2011; Altmann et al. 2012). The tournament literature to date, however, overlooks an important—and fundamental—feature of actual workplace tournaments: the end of the tournament is rarely the end of the road.

In practice, participants in workplace competitions typically continue to exert effort on behalf of the firm after the competition finishes, and the outcomes of these competitions may influence post-competition performance. In this study, we use a laboratory experiment to investigate whether and when competitions generate behavioral spillovers on subsequent effort provision.[1] There is good reason to think that such behavioral spillovers might exist. Ample evidence from both psychology and economics suggests that individuals engage in behaviors that are self-defeating in terms of monetary payoffs—especially when experiencing negative emotional states such as those that might follow a lost competition (Baumeister and Scher 1988; Loewenstein 2000; Thau et al. 2007).

Perhaps the best-known example of agents acting in a manner inconsistent with their monetary best interests in the experimental literature is that of ultimatum game responders turning down positive offers. Often rationalized as reflecting fairness concerns, Houser and Xiao

[1] Bednar et al. (2012) use the term "behavioral spillovers" to describe situations in which decisions made in one game influence the choice of strategy in another game being played simultaneously. We use the term to denote instances when the *outcome* of a game has an effect on a *subsequent* choice, but we use the term in the same spirit.

(2005) show that sometimes this is a way of venting frustration with one's counter party. Similarly, Grosskopf and Lopez-Vargas (2014) demonstrate in a Power-to-Take game that some individuals pay for the opportunity to vent their feelings even when venting is costly and one's counter party will not read the message. Similarly, industrial/organizational psychologists have documented so-called "counterproductive workplace behaviors" (CWBs). Defined as "volitional acts that harm or are intended to harm organizations or people in organizations" (Fox & Spector 2004), these behaviors range from increased dislike of coworkers to increased absenteeism and production sabotage. CWBs have significant effects on organizations but are self-defeating for workers in the sense that they increase the likelihood of adverse employment outcomes. Research into CWBs has shown that the emergence of these behaviors can be predicted by workers' feelings or perceptions of injustice (Skarlicki & Folger, 1997; Jones 2009) such as might occur when workers feel that compensation or recognition is awarded to the "wrong" co-worker. Given the extensive evidence of behavioral spillovers in workplaces, designers of incentive schemes need to understand the influence of competitive outcomes on post-competition behavior.

We first analyze behavior in three treatments requiring subjects to make effort choices both during and after a tournament contest. Subjects in these treatments participated in several periods and were paired with a new subject in each period. In each period, subjects competed in a tournament and then participated in a non-competitive production stage. In both the tournament and production stages, subjects chose costly effort or exerted real effort that was converted into output through a known production process. In "rule-based" tournaments, the partner with the higher output won and was awarded a higher payment than the loser. A quarter of all tournaments, however, were "random outcome" tournaments in which the outputs of the partners were disregarded and the winner determined arbitrarily with each partner having equal probability of winning. Subjects did not know whether a tournament was a "rule-based" or "random outcome" tournament until after they made their tournament effort choices. In the production stage, subjects knew both the results of the tournament and how the tournaments had been decided before making their effort choices. All subjects in the production stage earned one-third of their production stage output; the tournament winner also received one-fifth of the tournament loser's production stage output. We introduce the "random outcomes" to allow subjects to feel "hard done by" in some tournaments as negative emotions and feelings of injustice may lead to behaviors in the production stage that are at odds with monetary incentives. We employ this framework in a treatment with induced effort and a noisy production function (IN), a treatment with induced effort and a noiseless production function (IC), and a treatment with a real effort task and a noiseless production function (RC).

Some subjects in our experiment choose or exert high effort levels regardless of the incentives (i.e., in a tournament or in the production stage). As such, there is an unambiguous selection effect: tournaments tend to select "high effort" subjects as winners. Controlling for this individual heterogeneity and the resulting selection effects, we find that, in the most common case in which subjects' tournament outputs determine outcomes, tournament outcomes *do not* have a significant influence on production stage effort choices; this is a reassuring null result given the wide-spread use of competitions. Tournament outcomes do affect production stage effort, however, when the tournament is randomly decided: subjects who lose in random outcome tournaments but would have won in rule-based tournaments choose effort levels that are 13% lower than the mean production stage effort in the IN treatment, 17% lower in the IC treatment, and 7% lower in the RC treatment.

We employ two additional treatments to shed light on the preferences behind these effort reductions. In the Rotating Winners treatment (RW), we pair subjects with new partners in the production stage, ensuring that tournament winners are always paired with tournament losers and vice versa. We find similar effort reductions to those in the IN and IC treatments, which indicates that effort reductions following random losses are not aimed directly at the beneficiary of one's own misfortunes. In the Repeated Production Stage treatment (RPS), we find evidence that effort reductions following arbitrarily decided tournaments are a "hot state" reaction: subjects withdraw effort only in the short-run when a tournament is followed by multiple production stages.[2] Using survey instruments, we find that the effort reductions in response to losing randomly decided tournaments are correlated with subjects' preferences for merit-based outcomes. Losers who feel that outcomes should reflect effort reduce their post-tournament effort more than other subjects when the tournament outcome disregards effort choices.

Our study makes three contributions to economists' understanding of the incentive effects of competitions. First, our findings indicate that tournaments are effective mechanisms for identifying individuals who exert high levels of effort regardless of the circumstances. Second, we establish that the outcomes of competitions can affect the behavior of participants after the competition ends. Third, our findings highlight an uncomfortable reality for firms: perceptions of workplace competitions count. If workers believe a promotion or bonus decision to have been arbitrary, capricious, or unfair, they may exert less effort subsequently than had they lost "fair and square." As such, it is in the interest of firms to promote transparency and objectivity when deciding contests to avoid such grievances. Unfortunately for firms, such contests may be used precisely when performance is difficult to measure in an objective fashion.

[2] A "hot state" is when one is acutely experiencing "visceral factors" or passions that are short-lived but intense (Loewenstein 2000).

II. Related Literature

A comprehensive review of the experimental contest literature can be found in Dechenaux, Kovenock, and Sheremeta (2012), but a few studies bear particular mention. Our experiment involves an effort choice in a tournament followed by a second effort choice under a different compensation scheme, whereas others have studied multi-stage tournaments in which subjects make a series of effort choices to win a tournament. Tong and Leung (2002) had subjects submit effort levels over successive stages with the subject with the highest realized output summed over all stages winning the tournament. They find that total effort levels were significantly higher in these dynamic tournaments than in strategically equivalent, one-stage tournaments. Similarly, Altmann et al. (2012) find that first stage effort in a two-stage tournament was significantly higher than the equilibrium first stage effort level and higher than the observed effort level in a strategically equivalent, one-stage tournament. In the Altman et al. study and in our experiment, subjects' first stage effort choices reflect the option value of winning, but our study differs from both the Tong and Leung and Altman et al. experiments in that the production stage effort choice is strategically independent of the tournament effort choice if a subject is profit-maximizing. There are multiple effort choices to be made in our experiment, but one is clearly *after* the competition ends.

Sometimes subjects in our experiment produce more output than their partner but lose the tournament because the outcome is randomly determined, which may seem unfair.[3] Preferences for "fairness" have been incorporated into tournament models. Grund and Sliwka (2005) show that more inequality-averse agents—agents who dislike unequal outcomes but prefer having

[3] "Unfair" competitions with ex ante asymmetric competitors have been considered in several papers (e.g., O'Keefe, Viscusi, and Zeckhauser (1984) and Schotter and Weigelt (1992)), but in our experiment ex ante symmetric competitors participate in tournaments occasionally decided by an arbitrary and potentially unfair decision rule.

more than others to having less than others—exert higher effort in tournaments than less inequality-averse agents to avoid losing and ending up with a lower payoff than others. Such difference aversion models, however, cannot account for reciprocity or "intentions" concerns, which has given rise to models incorporating both the intentions of one's counterparty and payoff inequality (e.g., Rabin 1993; Falk et al. 2003; Dufwenberg and Kirchsteiger 2004; Charness and Rabin 2005). None of these models, however, provides a sufficient explanation for our finding that tournament losers reduce their production stage effort in randomly-decided tournaments. Distributional concerns may be drivers of behaviors that appear self-defeating, but this effort reduction in response to random tournament losses would only tend to exacerbate income differences. Likewise, the intentions of one's counterparty may determine behavior in non-laboratory settings, but the capriciousness of the randomly decided tournaments to which subjects react in our experiment is independent of any subject's actions or intentions.

For this reason, we investigate whether procedural fairness concerns drive reactions to tournament outcomes by examining the correlation between subjects' measured preferences for meritocratic outcomes and responses to random tournament outcomes. Bolton et al. (2005) showed that procedural fairness concerns are related to decisions in the battle-of-the-sexes and ultimatum games. Unfair allocations—those in which one player received almost all the pie and the other almost nothing—were found to be more acceptable to subjects when implemented by an unbiased random procedure that assigned equal probabilities to both the unfair and the fair allocations than when the unfair allocation was chosen by another subject. By contrast, we find that subjects' effort choices respond to capricious outcomes even though the random procedure occasionally determining tournament outcomes is unbiased, which suggests that procedural fairness concerns may operate differently when subjects condition choices on prior effort and outcomes. This finding is similar to results in experiments in which endowments or property rights were earned in real effort tasks in dictator, ultimatum, or trust games (Hoffman and Spitzer 1985; Fahr and Irlenbush 2000). Subjects, for example, kept more as a dictator if the size of the pie was the result of the subject's effort or allocated more to the responder if the responder's performance "earned" the responder more of the pie (Oxoby and Spraggon 2006). Similarly, subjects in our experiment react strongly against outcomes contrary to what their efforts ought to have earned them.

Our experiment identifies behavioral spillovers in which tournament outcomes influence effort choices after the tournament. The notion that competitors' assessments of tournament outcomes may influence their effort decisions has also been incorporated into tournament models. Kräkel (2008) models "emotional" agents who feel either pride when outperforming others in a tournament or disappointment when failing to do so. Similarly, Gill and Stone (2010) model agents who value getting their "just deserts" in a tournament. While these models incorporate the idea that competitors care about tournament outcomes themselves in addition to the monetary rewards attached and adjust their tournament effort accordingly, neither considers how such preferences influence effort choices *after* the tournament.

Two final papers closely related to ours are Gill and Prowse (2012a) and Johnson and Salmon (2014). Gill and Prowse find that women on average reduce their effort in tournaments following losses in prior tournaments while men reduce their tournament effort only in response to losing a large prize. The crucial difference between our studies is that we examine reactions to tournament outcomes in a non-strategic setting after the tournament ends where they observe reactions in subsequent tournaments. While tournament effort choices might reasonably be informed by success or failure in previous tournaments in their setting, subjects paid according to a piece-rate in our production stage have no reason to condition effort choices on tournament outcomes.[5] Johnson and Salmon (2014) examine production following assignment to boss and worker roles. Various rules assign subjects to the roles of worker or boss, whose compensation is partly determined by whether the worker meets a production quota. Johnson and Salmon hypothesize that workers may attempt to sabotage the subject in the boss role and that subjects who face higher production quotas in the worker role will be discouraged and work less, but they find limited evidence of sabotage and discouragement. In their study, however, subjects are not in direct competition with other subjects for the boss role, which precludes identifying behavioral spillovers from competition to the post-competition phase. Further, varying the production quotas permits the study of discouragement but also introduces a non-pecuniary consideration other than the rule assigning subjects to roles that may affect effort. Our design allows us to focus on the direct spillover from competition to subsequent effort.

III. Experimental Design

A total of 302 undergraduate subjects at Simon Fraser University participated in one of five treatments: the induced effort and noisy output treatment (IN), the induced effort and certain output treatment (IC), the real effort and certain output treatment (RC), the rotating winner treatment (RW), and the repeated production stage treatment (RPS). Table 1 summarizes the sessions, which lasted about two hours each. The instructions to subjects for all treatments and screenshots of the user interface can be found in the Appendix. The experiment was

[5] Subjects in their experiment make effort decisions sequentially such that the "second mover" knows how many tasks the "first mover" has completed before starting the tasks. Gill and Prowse (2012b) show that second-movers facing a rival who expended significant effort exerted less effort to avoid feeling disappointment should they lose, reinforcing the notion that subjects care about tournament outcomes themselves.

programmed in zTree (Fischbacher 2007). We first describe the treatments and then the equilibrium strategies and our behavioral hypotheses.

III.A Induced and Real Effort Treatments

The induced effort IN and IC treatments consisted of forty periods broken into two stages each. Subjects were randomly paired with a different subject in each period, a matching procedure that subjects were made aware of in the instructions. At the beginning of each session, subjects were assigned a color, red or blue. In every period, one subject in each pairing was "Red" and the other was "Blue." The first stage in each period was the tournament stage, while the second stage was the production stage.

In the tournament stage, subjects chose "effort" levels (e) between 0 and 6 specified to the nearest hundredth. Effort was converted into output (Y) according to the production function

$$Y = 120e + \varepsilon$$

where ε was drawn from a uniform distribution over the interval [-2, 2] for the IN treatment. The cost of effort to subjects in experimental currency units (ECUs, CD$1 = 20 ECUs) was given by

$$C(e) = 10e^2$$

Two mechanisms were used to determine the winner of each tournament. In rule-based periods, the partner who produced more output was declared the winner. In random outcome periods, the partner of a randomly selected color was declared the winner regardless of the players' outputs. Subjects did not know whether the period would be a rule-based or random outcome period until after they had selected their tournament effort levels. In the instructions, subjects were informed that in any period there was a 25% chance the outputs would be disregarded and the winner of the tournament stage would be determined by color with both Red and Blue players having equal probabilities of being selected as the winner. In all periods, subjects learned their output, the other player's output, and the rule-based outcome of the tournament. That is, subjects knew whether the randomness of random outcome periods affected the outcome. Regardless of how the winner of the tournament stage was decided, the winner received a payment of 162 ECUs, while the loser received a payment of 90 ECUs.

We include the noise term ε in output because it precluded ties in the tournaments and makes interpretation of the results much simpler. The random component of output ε was very small relative to total output in the IN treatment to ensure that responses to random outcomes that differed from rule-based outcomes were responses to the treatment (i.e., the random outcomes) rather than to the vagaries of the random component of output. The no-noise IC treatment examines the importance of the additional source randomness by setting $\varepsilon = 0$.

After the tournament stage, subjects entered the production stage in which they again produced output by choosing effort. The production function and the costs of effort were the same as in the tournament stage. Subjects had as much time as they wished to use an on-screen calculator to determine what their costs would be for any level of effort.[6] All subjects earned one-third of their production stage output less their effort costs, while tournament stage winners also received an amount equal to one-fifth of their partner's output. In the context of an organization, the tournament stage might represent the competition for a promotion and the production stage what happens when former rivals take up their new positions in the corporate hierarchy. The payment to the tournament winner based on the loser's production stage output might reflect the fact that the performance of a manager's subordinates influences his pay.

[6] Subjects had access to a calculator in both stages that displayed the cost of any effort level and provided a range in which output would fall for any effort choice. In the tournament stage, the calculator provided their earnings for each potential outcome of the tournament; in the production stage it calculated earnings for the subject's projected output.

Reactions to perceived arbitrariness in competition outcomes may depend on whether individuals invest real effort in the competition if such an investment is linked to an expectation about how the fruits of that investment should be allocated (e.g., Hoffman et al. 1994). To examine this possibility, some subjects participated in the real-effort RC treatment. Subjects had 90 seconds in the tournament stage to do addition problems in which they summed three two-digit numbers. Whichever subject completed more problems in rule-based periods won and received a payment of $10; the loser received a payment of $3. Subjects were informed that 25% of tournaments would be random outcome tournaments as in the IN and IC treatments. In both the RC and IC treatments, ties in the tournament stage were possible. Subjects were informed that ties would be broken randomly with both subjects having an equal chance of being declared the winner. In the production stage, subjects again had 90 seconds to do addition problems, and they were paid $0.10 for each correctly completed problem. In addition, the tournament winner received $0.08 for each problem correctly completed by the loser. Due to the additional time necessary for the adding task, subjects only participated in 20 periods in the RC sessions.

At the end of all sessions, subjects completed a questionnaire measuring risk attitudes using the Holt-Laury paired lottery instrument (Holt and Laury 2002), the Big 5 personality traits (Goldberg 1992), optimism-pessimism (Scheirer et al. 1994), locus of control (Rotter 1966), and "preference for merit." This last scale measures how strongly individuals feel rewards should be tied to effort (Davey et al. 1999). Subjects were paid a show-up fee and their earnings for two randomly selected periods and one randomly selected decision on the Holt-Laury measure.

III.B Rotating Winner Treatment

The RW treatment proceeded exactly as in the IN treatment in the tournament stage. In the production stage, however, subjects were matched with new partners. Winners in the tournament stage were matched with tournament losers from another pairing and received one-fifth of their production stage partner's output. In the new pairings, subjects did not know whether their partner had won or lost a tournament due to randomness, nor did they know their production stage partner's tournament output.

III.C Repeated Production Stage Treatment

The tournament stage of the RPS treatment proceeded exactly as in the IN treatment, but subjects participated in four production stages following every tournament. Every subject received one third of his output less his costs in each production stage while the tournament winner also received one fifth of the tournament loser's output in each production stage. Subjects participating in the RPS treatment completed fewer periods (in most sessions 30 periods) because each period was longer.

III.D Equilibrium Strategies and Behavioral Hypotheses

Although we are not interested in testing equilibrium predictions in the tournament stage, the unique mixed strategy equilibrium for the tournament stage in the IC treatment can be identified following Nalebluff and Stiglitz (1983). In this equilibrium, symmetric agents randomize over effort choices between 0 and $\bar{e}$, where $\bar{e}$ is a function of the experimental parameters. Specifically, the probability that any effort level is chosen is proportional to the marginal costs of that effort level such that higher effort levels with higher marginal costs are chosen with greater likelihood. The tournament with noisy output in our IN treatment corresponds to a special case of the contests studied by Che and Gale (2000). They show that in such tournament competitors randomize over discrete effort levels between 0 and some $\bar{e}$ with the probability of choosing each of these discrete effort levels increasing in the marginal cost of the effort level. This mixed strategy is not unique, however, because there exists a payoff-equivalent family of strategies in which competitors spread some of the probability mass around the discrete effort levels.[7] To wit, the behavior in the IN treatment seems likely to look much like that in the IC treatment. The full details of the equilibrium strategies in the IN and IC treatments—which are not the focus of this study—can be found in the Appendix. Regardless of whether production is certain or noisy, the profit maximizing effort choice in the production stage of the IN and IC treatments is 2. Because the costs of real effort are unknown to us, we cannot make predictions about behavior in the tournaments in the RC treatment.

The organizational psychology literature concerning self-defeating behaviors and CWBs leads us to suspect that post-tournament effort choices will reflect preferences not captured in the benchmark model. Specifically, we hypothesize that subjects will respond to capricious tournament losses—losses in which factors other than effort are pivotal—by reducing their effort. This is an easily imagined consequence of workplace competition: a worker feels that—in spite of his hard work—a promotion was awarded to an undeserving coworker and subsequently reduces his effort. We further hypothesize that capricious tournament outcomes and post-tournament effort might be related for two reasons. First, effort reductions may be directed at one's tournament counterparty. In a two-person contest, capriciousness working against one party necessarily works in favor of the other, which could lead to negative emotions such as jealousy or envy (e.g., Vecchio 2000). Such an effect would be particularly significant in firms where competitive outcomes affect subsequent earnings and hierarchical relationships. If a subject withholds production stage effort to punish the person who benefitted at his/her expense, we would not expect to see effort reductions in the RW treatment because—as we make sure the

[7] No equilibrium in pure strategies exists in this setting.

subjects are aware of in the instructions—the production stage partner is not the same as the tournament partner.

Second, effort reductions may be a visceral, emotional reaction to the tournament outcome that fades with time. Reducing one's effort or engaging in some other sort of negative behavior at work may serve as a catharsis, but over time also makes it more likely that one will be fired. If subjects express their frustrations over tournament outcomes in the immediate aftermath of the tournament before "cooling off" and acting in their material best interests, we would expect effort reductions to be smaller in subsequent production stages in the RPS treatment following a capricious outcome.

IV. Findings

IV.A Tournament Effort

Our focus is on effort provision after and in response to the competition rather than on behavior in the tournaments themselves, but the tournament effort choices and the resulting outcomes shape the post-tournament environment. If aggregate subject behavior approximates the equilibrium mixed strategy in both the IN and IC treatments, we should observe higher effort levels being chosen more frequently up to an upper bound, $\bar{e}$, determined by the experimental parameters. The distributions of tournament effort choices in the IN and IC treatments in figure 1 are qualitatively similar to those we would expect if subjects adhered to the mixed strategy equilibrium: more costly effort levels are chosen more frequently up to a point beyond which higher effort levels are chosen very infrequently. Subjects, however, overprovide effort. Table 2 provides the mean tournament stage efforts for the IN, IC and RC treatments. The average tournament efforts in the IN and IC treatments are 2.34 and 2.14, respectively, while the expected equilibrium effort choices are 1.43 and 1.79.[8] The 75th percentiles of the observed effort choices in these treatments are 3.00 and 3.01, respectively, while the largest effort levels in the supports of the equilibrium mixed strategies are only 2.11 and 2.89. Thus, in both treatments considerably more than 25% of all effort choices cannot be rationalized.[9,10]

Considering average tournament effort choices obscures a trend of decreasing tournament effort over the course of a session in both the IN and IC treatments. The mean tournament efforts in the first five periods of the IN and IC treatments, 2.58 and 2.28, are significantly larger than the mean efforts in the last five periods, 2.07 (p=0.002) and 1.96 (p=0.072)—a trend common to both tournament winners and losers as the top panel of figure 2 illustrates.[11] The average tournament effort among winners, however, is higher than 2.5 in *all* rule-based periods in the IN and IC treatments, meaning that many winners are choosing effort levels outside the support of the equilibrium mixed strategy *even after 40 periods*. In the next subsection, we discuss a possible explanation for this overprovision of effort—namely that some individuals are "high effort" types who choose high effort levels regardless of the incentive scheme.

We have no equilibrium prediction against which to compare observed effort levels in the RC treatment as subjects' costs of effort are unobserved. Figure 3 presents frequency distributions for the number of problems correctly solved by tournament winners and losers.

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[8] We assume subjects play the non-unique mixed strategy equilibrium discussed in the Appendix in the IN treatment.

[9] Women choose significantly higher effort levels in the tournament stages than men in the IN and IC treatments, but there is no significant difference between the numbers of problems solved by men and women in the RC treatment.

[10] Decheneaux et al. (2012) observe that subjects overbid on average in experimental all-pay auctions and Tullock contests but not in experimental tournaments, a difference that they conjecture may be due to the large noise terms necessary to ensure an equilibrium in pure strategies in tournaments. Our results are consistent with this hypothesis.

[11] All of the p-values reported in sections IV.A and IV.B are for t-tests that account for clustering at the subject level.

Subjects completed between 0 and 24 problems in the tournament stage with a mean of 7.22 problems solved. Unlike the IN and IC treatments, the number of problems solved increased significantly from 6.48 in the first 5 periods to 7.71 in the last 5 periods (p=0.000), which suggests that subjects got better at the real effort task with experience.

IV.B Production Stage Effort Provision

Table 3 summarizes the average effort levels in the production stage for the IN, IC and RC treatments and provides p-values for tests of equality of these means with the profit-maximizing effort level in the induced effort treatments. Clear from table 3 and the top panel of figure 2 is that subjects in the induced effort treatments on average choose effort levels that are significantly above the profit-maximizing level of two. Further, winners in all three treatments choose significantly higher production stage effort on average than losers. Figure 2, which shows that the tournament and production stage efforts of winners are higher on average than those of losers throughout the session for both real and induced effort, provides evidence that tournaments serve as selection mechanisms: subjects who exert high effort levels in any incentive environment are more likely to win tournaments and subsequently provide high effort levels in the production stage.[12]

Winning and losing, however, do not fully describe tournament outcomes; *how* one wins or loses may also be important. Table 3 further decomposes the production stage efforts for winners and losers by whether subjects won or lost in a rule-based or random outcome period.

[12] An alternative explanation for the relationship between tournament outcomes and subsequent effort provision is that subjects fail to recognize that the profit-maximizing production stage effort choice is independent of tournament outcomes. In unreported sessions we explored this possibility in a treatment in which there was no relationship between the tournament outcome and the production stage payoffs. Winners in this treatment also provide significantly more effort than losers (2.43 versus 2.28, p-value=0.007)—suggesting that strategic confusion cannot explain the relationship between tournament outcomes and subsequent effort provision.

Subjects who lost in a random outcome period in the IN treatment chose significantly lower effort levels than losers who lost in rule-based periods (p-value 0.058). Losers in randomly decided tournaments in the IC treatment also exert less effort than losers in rule-based tournaments—though the difference is not statistically significant—while losers of randomly decided real-effort tournaments actually complete significantly more problems than losers of rule-based tournaments.

The mean effort levels reported in table 3 *understate* the extent of any effort reduction following a random tournament loss if the selection effect described above influences tournament outcomes. To illustrate, suppose subjects are of two types: high effort individuals who choose high effort levels in both stages and low effort individuals who choose low effort levels in both stages. If high effort types are more likely to win tournaments than low effort types, high effort types will be disproportionately represented among the winners in the production stage, while low effort types will be disproportionately represented among the losers. This selection alone would lead to the differences between winners and losers in mean production stage effort that we observe. This selection would also influence the comparisons based on whether subjects won or lost in rule-based or randomly decided tournaments. In randomly decided tournaments, more high effort individuals would be losers than in rule-based tournaments, while more low effort individuals would be winners. This would tend to inflate the average production stage effort of losers in randomly decided tournaments relative to that of losers in rule-based tournaments while reducing the average production stage effort of winners in randomly decided tournaments relative to that of winners in rule-based tournaments.

The unconditional comparisons of the mean production stage effort levels in table 3 are also affected by changes in subjects' effort levels over the course of the session as figure 2 illustrates. To examine how tournament outcomes influence post-tournament behavior while accounting for unobserved subject heterogeneity and changes in behavior over time, table 4 presents regression estimates that address these issues in the IN, IC and RC treatments. We begin by analyzing production stage effort choices in the IN treatment. In column 1, we regress a subject's production stage effort on a dummy variable equal to one if the subject won the tournament and period dummies.[13] Consistent with the comparisons of means in table 3, tournament winners choose production stage effort levels that are an estimated 0.362 effort units higher than tournament losers—a large and statistically significant difference given that the average effort level in this treatment is 2.5.

In column two, we add dummies indicating how a subject won or lost when the outcome was randomly determined. Specifically, these dummies indicate whether a subject would have won a rule-based tournament but lost the randomly decided tournament, would have won a rule-based tournament and won the randomly decided tournament, would have lost a rule-based tournament and lost the randomly decided tournament, and would have lost a rule-based tournament but won the randomly decided tournament. In some cases the random outcome reversed the rule-based outcome conditional on effort choices, while in other cases the random outcome was no different than the rule-based outcome would have been. Subjects knew whether they had won and whether a random resolution of the tournament had affected the outcome when choosing their production stage effort level.

Including indicators for how subjects won or lost in randomly determined periods, the estimated effect of being a tournament winner (0.342) is almost identical to that in column 1. There is some evidence of effort reductions in random outcome periods: subjects who lost a

[13] We use eight dummy variables for blocks of five periods. The results are similar if we use individual period dummies or a linear time trend.

randomly decided tournament and would have lost in a rule-based tournament reduce their production stage effort by a statistically significant 0.194 effort units. Otherwise, the estimates in column 2 suggest that subjects do not respond to random tournament outcomes in the production stage.

As discussed above, unobserved heterogeneity among subjects in their tendencies to provide effort independent of the incentives to do so would result in the estimates in column 2 overestimating the effect of losing in a random period when one would have won in a rule-based period and underestimating the effect of winning in a random period when one would have lost in a rule-based period. To address this issue, we jointly estimate models of tournament stage effort and production stage effort with subject fixed effects. We regress effort choices from both stages on a dummy for whether the observation comes from a tournament stage, a dummy for an observation from a production stage when the subject won the tournament, time dummies and their interactions with the tournament dummy, and subject fixed effects. The subject fixed effects capture heterogeneity in the form of a tendency to choose high effort levels across different incentive environments because they are constrained to be the same in both the tournament stage effort model and the production stage effort model.[14]

We resoundingly reject the hypothesis of no unobserved heterogeneity among subjects (F-test p-value=0.000 for all treatments). Figure 4 displays the difference between the mean fixed effects of winners and losers across periods in the IN, IC, and RC treatments. The mean value of the subject fixed effects for winners is less than the mean value for losers just once in thirty rule-based periods in the IN treatment, while this difference is negative in three of ten

[14] The fixed effects capture differences in ability in the RC treatment. The source of the heterogeneity in the induced efforts is less clear, but we suspect that subjects anchor on an effort choice and adjust from there, both across periods and stages within a period.

random outcome periods and less than 0.18 in all but one random outcome period. In rule-based periods of the IN, IC, and RC treatments, the distributions of fixed effects for winners are significantly different from those for losers, but the distributions are not significantly different in random outcome periods.[15] Rule-based tournaments select as winners those subjects who choose high effort levels on average regardless of the incentive scheme—selection which is undone when tournaments are randomly decided.

Given this evidence of non-trivial heterogeneity among subjects in their provision of effort regardless of incentives, we report in column 3 of table 4 the estimates when we jointly estimate the model of production stage effort in column 2 and the tournament model with common subject fixed effects. Using only within-subject variation, the estimates in column 3 indicate that being a tournament winner does not have a significant effect on production stage output once we control for unobserved heterogeneity among the subjects. Winners do not exert more effort in the production stage following a win because of their exuberance at winning or for any other reason. The estimated effects of being a winner on production stage effort in columns 1 and 2 stem entirely from the tendency of individuals who choose high effort levels in *both* environments to win tournaments.[16]

The estimated effects of tournament outcomes on production stage effort in random outcome periods without controlling for such heterogeneity will only be biased when the random outcome is different from the outcome that would have prevailed had the output rule been used to decide the tournament. Consistent with this expectation, we observe that winning by chance

[15] In rule-based periods, the p-values for the Kolmogorov-Smirnov tests of equality of the distributions of fixed effects are 0.000 for all treatments. In the random outcome periods, the p-values are 0.147, 0.859, and 0.982 for the IN, IC, and RC treatments, respectively.

[16] In results available from the authors, we test whether men and women respond differently in the production stage to tournament losses. We find no evidence of gender differences.

when one would have won under the output rule is associated with essentially no change in production stage effort while losing when one would have lost in a rule-based period is associated with a reduction in production stage effort of 0.158 effort units—both effects similar to what we observe when we do not account for selection in column 2. By contrast, controlling for unobserved subject heterogeneity leads to significantly different estimated effects from those in column 2 when the random outcome is at odds with what would have prevailed in a rule-based period. Losing a randomly decided tournament when one would have won under the output rule is associated with an estimated reduction in the effort of 0.32 effort units—12.8% of the average production stage effort. Winning a randomly decided tournament when one would have lost under the output rule is associated with a 0.30 effort unit increase in production stage effort. There are several possible psychological explanations for this positive effect. For instance, it could be a compensatory rationalization of the win (Gaucher et al. 2009), guilt-induced helping (Cunningham et al. 1980), or a "house money" effect (e.g., Harrison 2007).

The IN treatment has the virtue of making ties extremely unlikely which simplifies the analysis, but subjects confront two sources of randomness: the small noise term and the random outcome tournaments. The IC treatment without noise in output assesses the importance of the noise term. The RC treatment, which also involves no noise in output, sheds light on the extent to which our findings generalize to settings in which individuals exert real effort. In columns 4 and 5 of table 4, we estimate models for the IC and RC treatments similar to that in column 3 accounting for the possibility of ties in these treatments as subjects may react to the arbitrariness of tiebreakers.[17] In columns 4 and 5, we allow the effects of winning a tournament and the effects of random outcomes to vary based on whether the rule-based outcome was reached via a

[17] There were no ties in the IN treatment, but 22 (96) pairings ended in ties in the IC (RC) treatments.

tie breaker.[18] We fail to reject the null hypothesis that the marginal effects of the different random outcomes when there were no ties in the tournament stage are equal in the IN and IC treatments (p=0.391). Notably, subjects in the IC treatment who would have won a rule-based tournament not determined by a tie but lost a random outcome tournament reduced their effort by 0.41 units—equivalent to 16.6% of the average production stage effort—while those who would have lost a rule-based tournament but won due to the random outcome increased their effort choice by 0.34 units. By precluding ties, the small noise term allows for simpler analysis without significantly affecting behavior, so we use this production function from the IN treatment in the subsequent RW and RPS treatments.

While the reactions to random tournament outcomes in the IN and IC treatments were similar, the reactions in the real effort treatment were somewhat different. In the real effort treatment, subjects responded significantly to losing a random outcome tournament by reducing their production stage output regardless of whether they would have won the tournament under the output rule. "Unlucky" random outcome losers solved 0.49 fewer production stage problems—7.1% of the average production stage effort—than rule-based losers (the omitted category) while random outcome losers who would have also lost under the output rule solve 0.38 fewer problems. In effect, losers in random outcome periods in the real effort treatment uniformly pout during the production stage. Unlike the induced effort treatments, "lucky" winners in random outcome periods do not increase their effort in the subsequent production stage. This difference with the induced effort treatments may reflect the nature of the constraints subjects face when exerting real effort: subjects could easily withdraw effort but they may find

[18] In random outcome periods, subjects learned the rule-based tournament outcomes and thus would also have known how a tiebreaker would have affected the outcome had the rule-based outcome prevailed.

exerting more effort in response to "lucky" wins difficult given their ability and the time-limit. This may also be instructive about the spillover effects of competitions one might expect outside the lab. For example, if two workers work 55 hours a week leading up to a promotion decision, the disgruntled non-promoted worker can easily cut back to 40 hours a week, but the winner may find it difficult to increase his weekly hours just as our subjects find it easy to decrease but not to increase their effort in the real effort treatment.

Gill and Prowse (2012a) find that tournament outcomes influence effort choices in subsequent tournaments. Their results are consistent with a model of "just deserts" in which agents try to bring subsequent earnings in line with beliefs about what one deserves. Similar desert concerns, however, cannot rationalize our findings. If desert concerns were at work, one would expect undeserving winners (losers) to reduce (increase) their production stage effort, while the behavior of deserving winners and losers would not be influenced by the random outcomes. This is not what we observe as being an undeserving winner has no impact on production stage effort in the RC treatment while being a deserving loser in random outcome periods reduces effort in both the IN and RC treatments. As such, we investigate alternative explanations in the next section.

IV.C Understanding Reactions to Random Outcomes

In our experiment, subjects are identical ex ante, and their displeasure with the perceived capriciousness of random tournament outcomes might be aimed at the direct beneficiary of their bad luck—their partners in the tournament stage. The RW treatment tests this hypothesis that "unlucky" losers harbor an animus towards those who benefit from their bad luck—out of envy for example—by matching subjects with new partners between the tournament and production stages in a treatment that is otherwise identical to the IN treatment. If subjects reduce their effort to reduce the total payout to the subject who benefitted at their expense, then tournament outcomes will not be related to production stage effort in the RW treatment. Column 1 of table 5 reports the estimates from the jointly estimated tournament and production stage models with subject fixed effects for the RW treatment. We fail to reject the equality of the coefficients of the random outcome dummies with those from the IN treatment in column 3 of table 4. The data do not support the hypothesis that subjects reduce their production stage effort to hurt the beneficiary of their bad luck in random outcome tournaments.

We also hypothesized that effort reductions may be "hot state" reactions to perceived unfairness. As subjects "cool down" and weigh the potential consequences of effort reductions, they may no longer reduce their effort. To test this hypothesis, subjects participated in four production stages after the tournament in the RPS treatment. In columns 2 to 5 of table 5, we report the estimated coefficients for the production stage effort model jointly estimated with the tournament effort model with subject fixed effects allowing the effects of tournament outcomes to vary across production stages. We fail to reject the hypothesis that the random outcome coefficients for the first production stage of the RPS treatment are equal to those in the IN treatment in table 4. Moreover, we fail to reject the null hypothesis that the estimated random outcome coefficients in columns 3 through 5 are jointly equal to zero for each production stage after the first. Consistent with our hypothesis, effort responses to random outcomes appear to be short-lived. Tournament designers and managers who wish to mitigate the behavioral spillovers from competition should focus on the period immediately following the resolution of a contest.

Our final hypothesis is that subjects with a strong preference for meritocratic outcomes—which we measure using the Preference for Merit Principle Scale (PMP)—will reduce their effort more than other subjects when this sensibility is offended and the link between effort and outcomes is severed in random outcome tournaments.[19] Although our hypothesis relates effort reductions to preferences for merit, PMP scores for subjects in the IN treatment are significantly correlated with their conscientiousness scores (ρ = 0.341, p = 0.008). Moreover, industrial/organizational psychologists have found that the Big 5 personality traits (i.e., openness/intellect, agreeableness, extroversion, conscientiousness, and emotional stability) are related to how counterproductive behaviors are expressed (Salgado 2002, Mount and Johnson 2006, Bolton et al. 2010). As such, we augment the specification in column 3 of table 4 for the IN treatment by introducing interactions between the random outcomes and PMP and each of the Big 5 personality traits in the production stage effort model in the specification reported in table 6 to examine more broadly whether reactions to random tournament outcomes are related to observable subject characteristics.[20]

Consistent with our hypothesis, subjects with strong preferences for meritocratic outcomes react more strongly than other subjects to losing tournaments randomly—regardless of whether they would have won under the output rule—by reducing their production stage effort. When a subject loses a randomly decided tournament, the estimates imply that a one standard deviation increase in the PMP score is associated with an estimated 0.25 (0.32) unit reduction in production stage effort when the subject would have lost (won) under the output. When subjects win in randomly decided tournaments, however, their preferences for merit are unrelated to their

[19] Higher PMP scores indicate that subjects feel more strongly that their rewards ought to be consistent with their actions; the complete scale can be found in the Appendix.
[20] The scores for the Big 5 traits and the PMP have been standardized such that an increase of one unit for each measure corresponds to a one standard deviation increase within our sample.

production stage behavior, suggesting that subjects with strong preferences for merit only chafe at non-meritocratic outcomes when these outcomes are unfavorable.[21]

V. Conclusion

The end of a workplace competition is rarely the end of an employment relationship, which opens the possibility that competitive outcomes may spillover into the post-competition workplace. Psychologists have shown that individuals often act in self-defeating or counterproductive ways when faced with perceived inequity of precisely the sort that may arise when competitions are decided in an environment of imperfectly observed effort and potentially subjective evaluation (Schwarzwald et al. 1992; Lemons and Jones 2001; Schaubroeck and Lam 2004). Though mostly ignored by economists studying tournaments, firms may need to manage the potential behavioral spillovers from competitions once the competition is finished if some workers "pout" in counterproductive and possibly even destructive ways.

Using a laboratory experiment, we find that post-competition effort choices are related to competitive outcomes in two ways. First, tournaments have the beneficial—if not surprising—feature that they tend to select as winners subjects who choose higher effort levels regardless of the compensation scheme. Second, controlling for this individual heterogeneity in effort choices, subjects who lose in randomly decided tournaments significantly reduce their post-tournament effort relative to their effort following tournaments decided using an output rule in all treatments.

[21] None of the relationships between personality traits and reactions to random outcomes that we observe are consistent with prior studies relating personality to self-defeating behaviors or CWBs. More extroverted ("open" or "intellectually oriented") subjects reduce (increase) their production stage effort more than other subjects when they would have won a tournament under the output rule but lost randomly. More conscientious subjects increase their effort when they win randomly decided tournaments that they would have won under the output rule, while more emotionally stable subjects reduce their effort more than other subjects when they lose tournaments that they would have lost under the output rule. We obtain almost identical estimates with respect to PMP omitting the personality interactions.

In contrast to Bolton et al. (2005), this effort reduction occurs in spite of the fact that the random procedure occasionally determining the tournament outcome is unbiased in the sense that it does not favor one subject over another and that subjects are aware that this unbiased random procedure may determine the outcome in any tournament. Furthermore, effort reductions following arbitrary losses occur in different settings with real and induced effort, suggesting that the phenomenon may be quite general.

To understand these reactions to tournament outcomes, we establish through additional treatments that the effort reductions were not aimed at the direct beneficiaries of the randomness and that the reactions to competitive outcomes dissipate as subjects make several post-tournament effort choices. The latter finding implies that managing behavioral spillovers may be most important in the short-run—although our findings also indicate that these short-run spillovers may be quite large. Finally, we show that effort reductions following randomly decided tournaments are highly correlated with subjects' preferences for merit: losers who prefer that outcomes be closely tied to their efforts reduced their post-tournament effort more than other subjects when the tournament outcome was decided randomly rather than by the output rule.

Recent studies have examined how non-monetary preferences and motivations ranging from fear of being exploited by the firm (Barlting et al. 2012, Carpenter and Dolifka 2013), symbolic rewards in the workplace (Besley and Ghatak 2008, Kosfeld and Neckerman 2010), lack of trust in employers (Falk and Kosfeld 2006), and the legitimacy of authority within the firm (Tyler and Blader 2003, 2005) influence workers' behaviors. We examine a fundamental way in which non-monetary, behavioral considerations can influence workplace behavior: people do not like losing. In particular, people do not like losing when they perceive the outcome to be unfair or capricious, and this sensibility may influence their subsequent behavior. Our findings suggest that individuals' decisions after a competition are a function of the competition outcomes and whether the process determining these outcomes was arbitrary and unfair. In his seminal paper on tournaments, Rosen (1986) modeled competitions that motivate workers over the long run of their careers. In the short-term, however, good workers may quit in an emotional moment or otherwise force a manager to discipline them for dips in productivity. In order for the long-term incentives modelled by Rosen to work out as firms would wish, tournament designers and a firm's leadership may need to ensure that workers weather the short-term disappointment of a lost competition. In particular, firms should take pains to ensure that competitions are perceived to be fairly decided lest disgruntled employees take their frustrations out on the firm's bottom line.

References

Altmann, S., Falk, A. & Wibral, M. (2012) "Promotions and incentives: The case of multistage elimination tournaments," *Journal of Labor Economics*, 30, pp.149 – 174

Bartling, B., Fehr, E. & Schmidt, K. (2012) "Use and abuse of authority: A behavioral foundation of the employment relation," *University of Zurich Working Paper No. 98*

Baumeister, R. & Scher, S. (1988) "Self-defeating behavior patterns among normal individuals: Review and analysis of common self-destructive tendencies," *Psychological Bulletin*, 104, pp. 3-22

Baye, M., Kovenock, D., & de Vries, C. (1996) "The all-pay auction with complete information," *Economic Theory*, 8 (2), pp. 291-305

Bednar, J., Chen, Y., Liu, T. & Page, S. (2012) "Behavioral spillovers and cognitive load in multiple games: An experimental study," *Games and Economic Behavior*, 74, pp. 12-31

Besley, T. & Ghatak, M. (2008) "Status incentives," *American Economic Review*, 98 (2), pp. 206-211

Bolton, L., Becker, L. & Barber, L. (2010) "Big Five trait predictors of differential counterproductive work behavior dimensions," *Personality and Individual Differences*, 49, pp. 537–541

Bolton, G., Brandts, J. & Ockenfels, A. (2005) "Fair procedures: Evidence from games involving lotteries," *The Economic Journal*, 115 (506), pp. 1054–1076

Carpenter, J., Matthews, P. & Schirm, J. (2010) "Tournaments and office politics: Evidence from a real effort experiment," *American Economic Review*, 100, pp. 504-517

Carpenter, J. & Dolifka, D. (2013) "Exploitation aversion: When financial incentives fail to motivate agents," *IZA Discussion Paper No. 7499*

Charness, G. & Rabin, M. (2002) "Understanding social preferences with simple tests," *Quarterly Journal of Economics,* 117*,* pp. 817–869

Che, Y.K. & Gale, I. (2000) "Difference-form contests and the robustness of all-pay auctions," *Games and Economic Behavior,* 30*,* pp. 22–43

Cunningham, M., Steinberg, J. & Greve, R. (1980) "Wanting to and having to help: Separate motivations for positive mood and guilt-induced helping," *Journal of Personality and Social Psychology*, 38 (2), pp. 181-192

Davey, L., Bobocel, D., Hing, L. & Zanna, M. (1999) "Preference for the Merit Principle scale: An individual difference measure of distributive justice preferences," *Social Justice Research*, 12 (3), pp. 223-240

Dechenaux, E., Kovenock, D. & Sheremeta, R. (2012) "A survey of experimental research on contests, all-pay auctions and tournaments," *Discussion Papers, Research Professorship & Project "The Future of Fiscal Federalism" SP II 2012-109, Social Science Research Center Berlin (WZB)*

Dufwenberg, M. & Kirchsteiger, G. (2004) "A theory of sequential reciprocity," *Games and Economic Behavior*, 47 (2), pp. 268-298

Falk, A., Fehr, E. & Fischbacher, U. (2003) "On the nature of fair behavior," *Economic Inquiry,* 41*,* pp. 20–*2*6

Falk, A. & Kosfeld, M. (2006) "The hidden cost of control," *American Economic Review,* 96 (5)*,* pp. 1611-1630

Fahr, R. & Irlenbusch, B. (2000) "Fairness as a constraint on trust in reciprocity: earned property rights in a reciprocal exchange experiment," *Economics Letters,* 66, pp. 275-282

Fischbacher, U. (2007) "zTree: Zurich Toolbox for Ready-Made Economic Experiments," *Experimental Economics,* 10 (2), pp. 171-178

Fox, S. & Spector, P. (2004) <u>Counterproductive Work Behavior: Investigations of Actors and Targets</u>. Washington, DC: APA Press

Gaucher, D., Hafer, C., Kay, C. & Davidenko, N. (2009) "Compensatory rationalizations and the resolution of everyday undeserved outcomes" *Personality and Social Psychology Bulletin*, 36 (1), pp. 109-118

Gill, D. & Prowse, V. (2012a) "Gender differences and dynamics in competition: The role of luck," *Oxford Department of Economics Discussion Paper 564*

Gill, D. & Prowse, V. (2012b) "A structural analysis of disappointment aversion in a real effort competition," *American Economic Review*, 102(1), pp. 469-503

Gill, D. & Stone, R. (2010) "Fairness and desert in tournaments," *Games and Economic Behavior*, 69 (2), pp. 346-364

Goldberg, L. (1992) "The development of markers for the Big-Five factor structure," *Psychological Assessment*, 4, pp. 26-42

Grosskopf, B. & Lopez-Vargas, K. (2014) "On the demand for expressing emotions," *Working Paper*

Grund, C. & Sliwka, D. (2005) "Envy and compassion in tournaments*," Journal of Economics & Management Strategy*, 14 (1), pp. 187-207

Harbring, C. & Irlenbusch, B. (2011) "Sabotage in tournaments: Evidence from a laboratory experiment," *Management Science*, 57, pp. 611-627

Harrison, G. (2007) "House money effects in public good experiments: Comment," *Experimental Economics*, 10 (4), pp. 429–437

Hauser, D. & Xiao, E. (2005) "Emotion expression in human punishment behavior," *Proceedings of the National Academy of Sciences*, 102(20), pp. 7398-7401

Hoffman, E., McCabe, K. & Smith, V. (1994) "Preferences, property rights, and anonymity in bargaining games," *Games and Economic Behavior*, 7, pp. 346-380

Hoffman, E. & Spitzer, M. (1985) "Entitlements, rights, and fairness: an experimental examination of subjects' concepts of distributive justice," *Journal of Legal Studies*, 14, pp. 259-297

Holt, C. & Laury, S. (2002) "Risk aversion and incentive effects," *American Economic Review*, 92 (5), pp. 1644-1655

Johnson, D. & Salmon, T. (2014) "Sabotage vs. Discouragement: Which dominates post-promotion tournament behavior?" *working paper*

Jones, D. (2009) "Getting even with one's supervisor and one's organization: relationships among types of injustice, desires for revenge, and counterproductive work behaviors," *Journal of Organizational Behavior*, 30 (4), pp. 525–542

Kosfeld, M. & Neckerman, S. (2010) "Getting more work for nothing? Symbolic awards and worker performance," *IZA Working Paper No. 5040*

Kräkel, M. (2008) "Emotions in tournaments," *Journal of Economic Behavior and Organization*, 67, pp. 204-214

Lazear, E. & Rosen, S. (1981) "Rank-order tournaments as optimum labor contracts," *Journal of Political Economy*, 89 (5), pp. 841-864

Lemons, M. & Jones, C. (2001) "Procedural justice in promotion decisions: Using perceptions of fairness to build employee commitment," *Journal of Managerial Psychology*, 16 (4), pp. 268-281

Loewenstein, G. (2000) "Emotions in economic theory and economic behavior," *American Economic Review*, 90 (2), pp. 426-432

Mount, M., Ilies, R. & Johnson, E. (2006) "Relationship of personality traits and counterproductive work behaviors: The mediating effects of job satisfaction," *Personnel Psychology*, 59, pp. 591–622

Nalebuff, B. & Stiglitz, J. (1983) “Prizes and Incentives: Towards a General Theory of Compensation and Competition,” *The Bell Journal of Economics*, 14 (1), pp. 21-43

O’Keeffe, M., Viscusi, W. & Zeckhauser, R. (1984) “Comparative reward schemes,” *Journal of Labor Economics*, 2 (1), pp. 27–56

Oxoby, R. & Spraggon, J. (2008) “Mine and yours: Property rights in dictator games,” *Journal of Economic Behavior and Organization*, 65 (3-4), pp. 703-713

Rabin, M. (1993) “Incorporating fairness into game theory and economics,” *American Economic Review*, 83, pp. 1281–1302

Rosen, S. (1986) “Prizes and incentives in elimination tournaments,” *American Economic Review*, 76 (4), pp. 701-715

Rotter, J. (1966) “Generalized expectancies for internal versus external control of reinforcement,” *Psychological Monographs General and Applied*, 80 (1, Whole No. 609)

Salgado, J. (2002) “The Big Five personality dimensions and counterproductive behaviors,” *International Journal of Selection and Assessment,* 10, pp. 117–125

Schaubroeck, J. & Lam, S. (2004) “Comparing lots before and after: Promotion rejectees’ invidious reactions to promotees,” *Organizational Behavior and Human Decision Processes*, 94 (2004), pp. 33-47

Scheier, M., Carver, C. & Bridges, M. (1994) “Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): A re-evaluation of the Life Orientation Test.” *Journal of Personality and Social Psychology*, 67, pp. 1063-1078

Schotter, A. & Weigelt, K. (1992) “Asymmetric tournaments, equal opportunity laws, and affirmative action: Some experimental results,” *Quarterly Journal of Economics*, 107, pp. 511-539

Schwarzwald, J., Koslowsky, M. & Shalit, B. (1992) “A field study of employees’ attitudes and behaviors after promotion decisions,” *Journal of Applied Psychology*, 77 (4), pp. 511-514

Skarlicki, D. & Folger, R. (1997) “Retaliation in the workplace: The roles of distributive, procedural, and interactional justice,” *Journal of Applied Psychology*, 82, pp. 434-443

Thau, S., Aquino, K., & Poortvliet, P. (2007) “Self-defeating behaviors in organizations: The relationship between thwarted belonging and interpersonal work behaviors,” *Journal of Applied Psychology*, 92(3), pp. 840-847

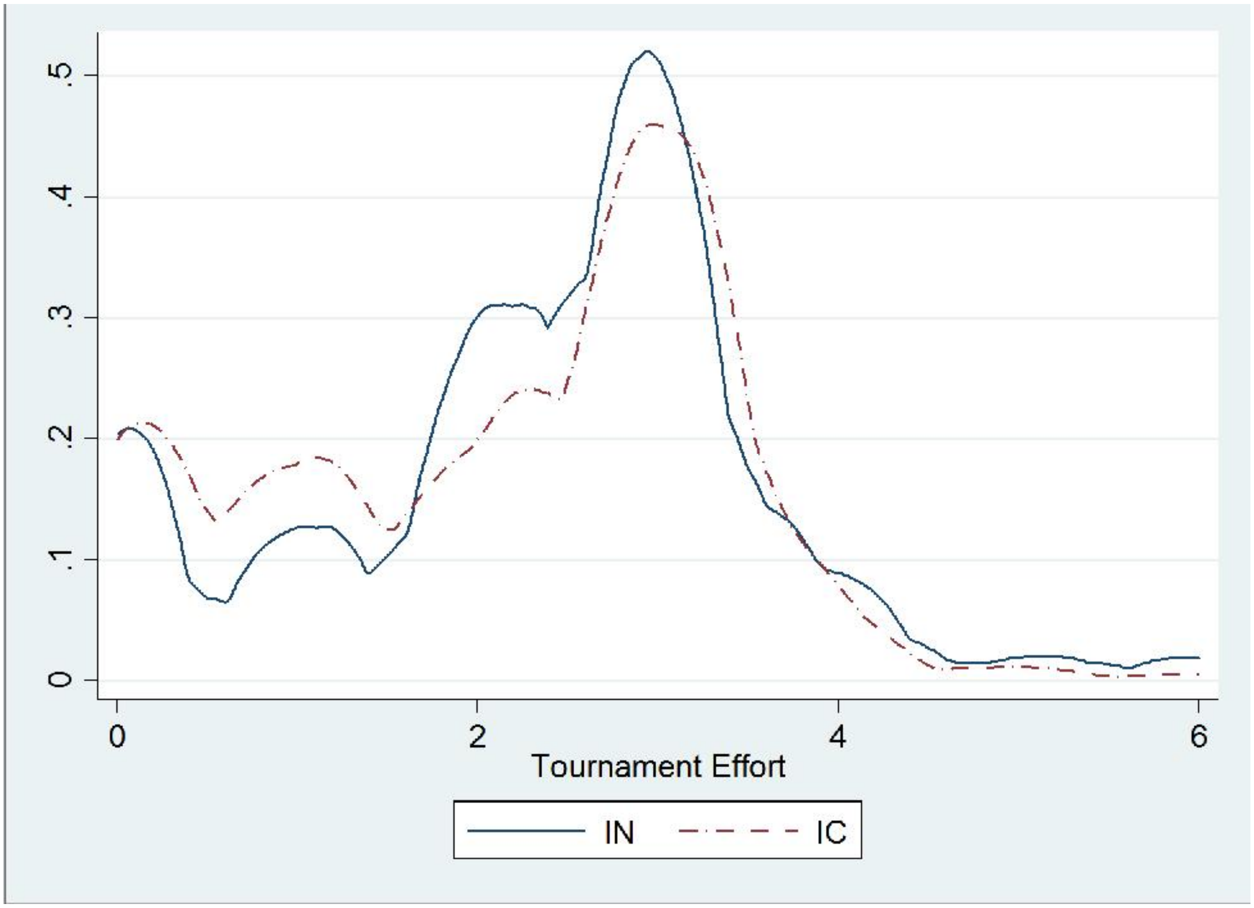
Tong, K. & Leung, K. (2002) “Tournament as a motivational strategy: Extension to dynamic situations with uncertain duration,” *Journal of Economic Psychology*, 23, pp. 399-420

Tyler, T. & Blader, S. (2003) "Procedural justice, social identity, and cooperative behavior," *Personality and Social Psychology Review*, 7, pp. 349-361

Tyler, T. & Blader, S. (2005) "Can businesses effectively regulate employee conduct? The antecedents of rule following in work settings," *Academy of Management Journal*, 48 (6), pp. 1143-1158

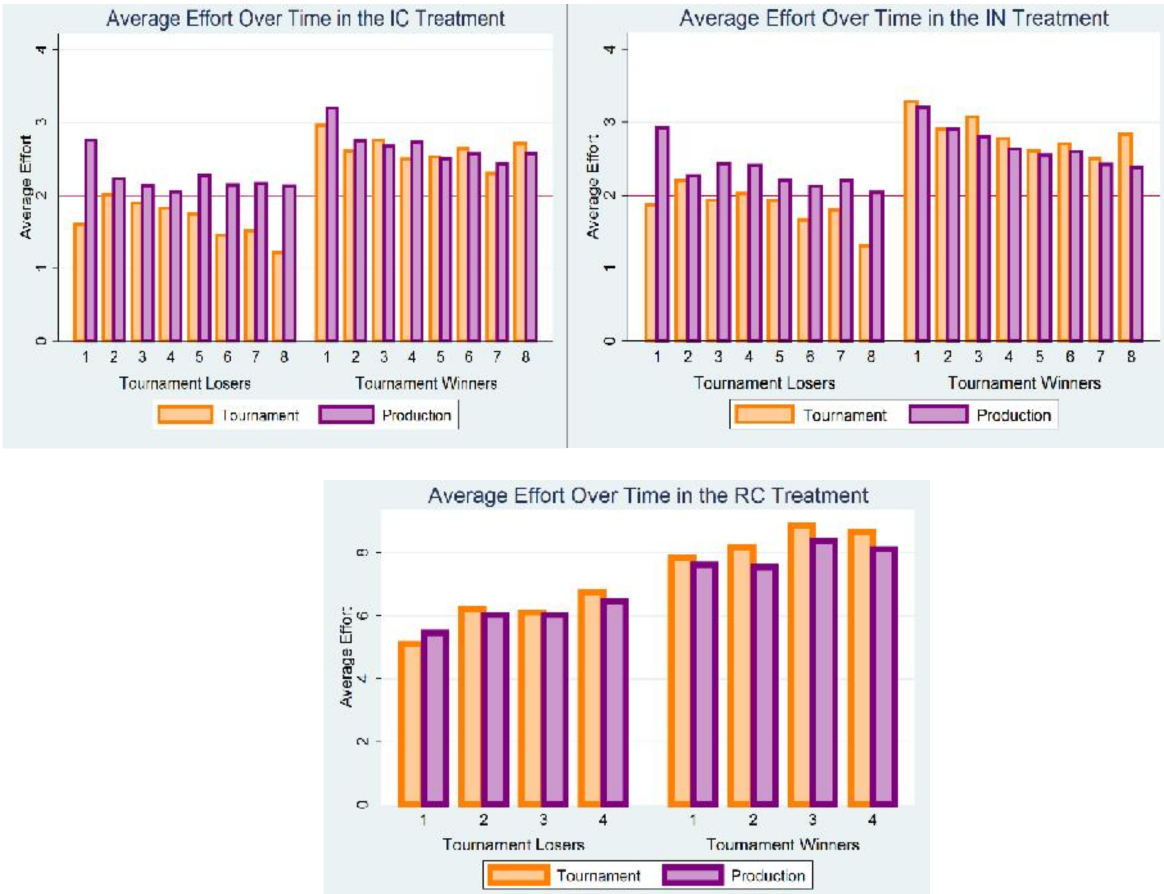
Vecchio, R. (2000) "Negative emotion in the workplace: Employee jealousy and envy," *International Journal of Stress Management*, 7 (3), pp. 161-179

Figure 1: Kernel density plots of tournament stage effort choices in the induced effort treatments



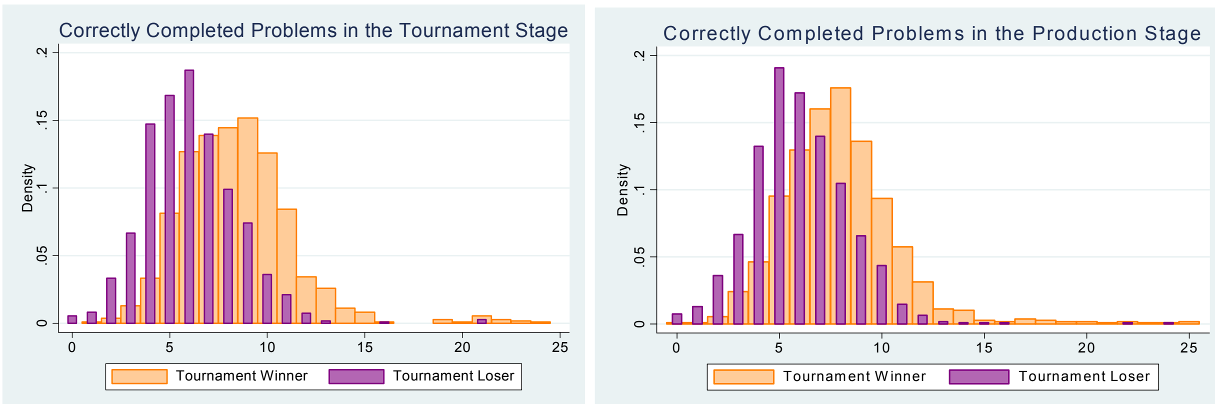
Note: Generated using Epanechnikov kernel functions. There are 2,400 observations for the IN treatment and 2,240 observations for the IC treatment.

Figure 2: Average effort over time



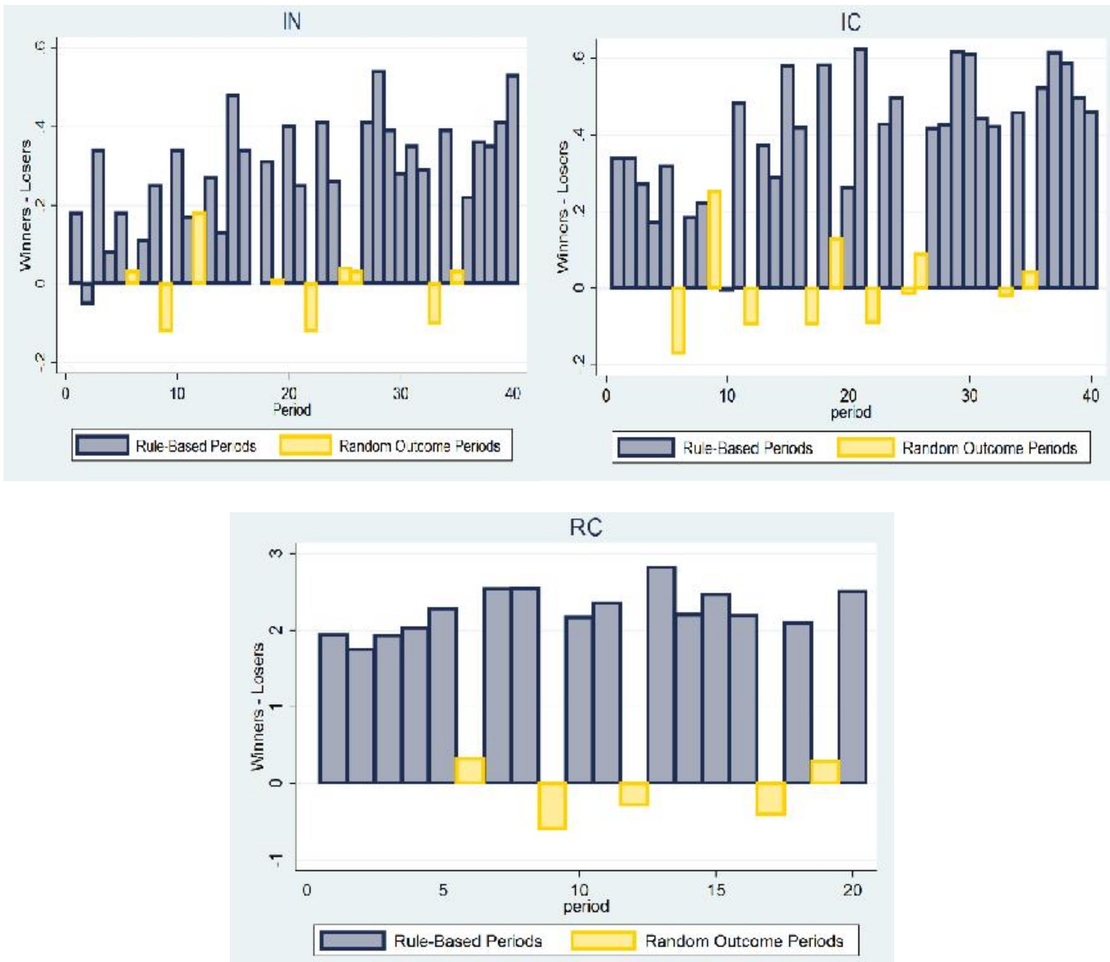
Note: The x-axis breaks up periods into groups of five. The first bar represents the average effort choice in periods 1-5, the second average effort choice in periods 6-10, and so on. The horizontal line at $e = 2$ represents the profit-maximizing effort level in the production stage of the induced effort treatments.

Figure 3: Distribution of the number of problems solved in the real effort treatment



Note: There are 2160 observations reflected in each panel.

Figure 4: Difference between the means of fixed effects for tournament winners and tournament losers across periods



Note: The subject fixed effects were estimated by regressing subjects' effort choices in both stages on an indicator for whether the effort observation comes from a tournament stage, an indicator of whether a production stage observation comes from a subject who won the tournament, time dummies (in blocks of 5 periods), and interactions of the time dummies with the tournament indicator.

Table 1: Summary of experimental sessions

Session type	Number of sessions	Number of subjects	Subject-tournament observations Rule-based outcome	Random outcome	Average earnings
Induced effort, noisy output (IN)	7	60	1800	600	$24.00
Induced effort, noiseless output (IN)	6	56	1680	560	$22.00
Real effort (RC)	9	108	1620	540	$25.13
Rotating Winners (RW)	4	44	1152	412	$23.56
Repeated Production Stage (RPS)	4	34	640	212	$27.36
Total	30	302	6892	2324	$24.35

Note: Sessions were conducted at Simon Fraser University. Subjects participated in only one session. For all treatments except the Repeated Production Stage treatment, the number of subject-production stage observations will be equal to the number of subject-tournament observations; for the Repeated Production Stage treatment, there are four subject-production stage observations for each subject-tournament observation.

Table 2: Average tournament effort by treatment and tournament outcome

	IN	IC	RC
Overall	2.34	2.14	7.22
	(1.23)	(1.24)	(2.90)
Tournament Winners	2.84	2.63	8.39
	(1.06)	(1.08)	(2.89)
Rule-Based Outcomes	3.02	2.79	8.71
	(0.96)	(0.99)	(2.79)
Random Outcomes	2.27	2.13	7.41
	(1.16)	(1.19)	(2.96)
Tournament Losers	1.84	1.66	6.05
	(1.18)	(1.20)	(2.39)
Rule-Based Outcomes	1.66	1.48	5.61
	(1.10)	(1.13)	(2.04)
Random Outcomes	2.37	2.19	7.35
	(1.24)	(1.24)	(2.84)

Note: Standard deviations in parentheses.

Table 3: Average production stage effort by treatment and tournament outcome

	IN	IC	RC
Overall	2.50[a]	2.46[b]	6.95 [c]
	(1.23)	(1.19)	(2.81)
	[0.000]	[0.000]	
Tournament Winners	2.69[d]	2.68[e]	7.92 [f]
	(1.21)	(1.21)	(2.86)
	[0.000]	[0.000]	
Rule-Based Outcomes	2.70[g]	2.72[h]	8.19 [i]
	(1.23)	(1.23)	(2.84)
	[0.000]	[0.000]	
Random Outcomes	2.64[j]	2.57[k]	7.09 [l]
	(1.14)	(1.16)	(2.76)
	[0.000]	[0.000]	
Tournament Losers	2.32[m]	2.24[n]	5.99 [o]
	(1.23)	(1.12)	(2.41)
	[0.000]	[0.017]	
Rule-Based Outcomes	2.36[p]	2.25[q]	5.74 [r]
	(1.24)	(1.11)	(2.14)
	[0.000]	[0.014]	
Random Outcomes	2.22[s]	2.20[t]	6.75 [u]
	(1.17)	(1.16)	(2.95)
	[0.041]	[0.087]	

p-values of comparisons of means

Overall	IN	IC	RC
a-b [0.7151]	d-m [0.0000]	e-n [0.0003]	f-o [0.0000]
d-e [0.9745]	g-j [0.3067]	h-k [0.0448]	i-l [0.0000]
m-n [0.4820]	p-s [0.0583]	q-t [0.5203]	r-u [0.0000]
g-h [0.9220]			
j-k [0.6688]			
p-q [0.3873]			
s-t [0.8929]			

Note: Standard deviations in parentheses. The P-values in brackets in the upper panel are for two-sided t-tests of the null hypothesis that the average effort is equal to 2, the profit maximizing effort in the production stage in the induced effort treatments. The hypotheses tested in the lower panel are that the two means in question are equal. All tests allow for clustering at the subject level.

Table 4: Models of production stage effort in the IN, IC & RC treatments

	(1)	(2)	(3)	(4)	(5)
1 if 1st stage winner	0.362***	0. 342***	0.043	0.036	0.160*
	(0.078)	(0.082)	(0.084)	(0.111)	(0.083)
1 if random loser (rule loser)		-0.194**	-0.158*	0.056	-0.384***
		(0.085)	(0.081)	(0.079)	(0.146)
1 if random loser (rule winner)		0.020	-0.321**	-0.408***	-0.495**
		(0.134)	(0.135)	(0.113)	(0.191)
1 if random winner (rule loser)		-0.015	0.296***	0.343**	-0.088
		(0.106)	(0.092)	(0.137)	(0.137)
1 if random winner (rule winner)		0.002	-0.005	-0.036	-0.017
		(0.070)	(0.059)	(0.064)	(0.135)
1 if observation from tournament stage			-0.460***	-0.676***	-0.021
			(0.148)	(0.170)	(0.089)
1 if 1st stage winner due to a tiebreaker				0.343	0.099
				(0.504)	(0.158)
1 if 1st stage loser due to a tiebreaker				-0.287	-0.328**
				(0.298)	(0.159)
1 if random loser (rule loser) and rule loss due to a tiebreaker				-0.764	0.566
				(0.550)	(0.406)
1 if random loser (rule winner) and rule win due to a tiebreaker				2.107***	1.036*
				(0.324)	(0.627)
1 if random winner (rule loser) and rule loss due to a tiebreaker				-1.727***	0.221
				(0.488)	(0.626)
1 if random winner (rule winner) and rule win due to a tiebreaker				0.226	-0.583
				(2.144)	(0.408)
Treatment	IN	IN	IN	IC	RC
Jointly estimated with model of tournament effort and subject fixed effects	No	No	Yes	Yes	Yes
R^2	0.062	0.063	0.227	0.218	0.384

*** — significant at 1% level, ** — significant at 5% level, * — significant at 10% level

Note: Robust standard errors clustered at the subject level in parentheses. All models include period dummies equal to one if the observation comes from a particular block of 5 periods. That is, the first dummy is equal to one if the observation comes from periods 1-5, the second dummy is equal to one if the observation comes from periods 6-10, and so on. The dependent variable in columns (1) and (2) is the production stage effort choice. The dependent variable in columns (3) – (5) is the effort choice from either stage. In columns (3) – (5), the omitted category is a loser in a rule-based period in the production stage, and the specification includes eight period block dummies interacted with the stage (tournament or production).

Table 5: Production stage effort models in Rotating Winner and Repeated Production Stage treatments

	Treatment				
	Rotating Winner	Repeated Production Stage			
Variable		First Production Stage	Second Production Stage	Third Production Stage	Fourth Production Stage
	(1)	(2)	(3)	(4)	(5)
1 if 1^{st} stage winner	-0.063	-0.118	0.157*	0.099	0.021
	(0.112)	(0.147)	(0.088)	(0.111)	(0.027)
1 if random loser (rule loser)	-0.106	-0.090	0.285	0.104	-0.010
	(0.125)	(0.138)	(0.173)	(0.173)	(0.033)
1 if random loser (rule winner)	-0.348**	-0.374**	0.275	0.153	0.036
	(0.140)	(0.150)	(0.167)	(0.158)	(0.037)
1 if random winner (rule loser)	0.277	0.275**	-0.050	0.031	0.039
	(0.188)	(0.127)	(0.111)	(0.198)	(0.042)
1 if random winner (rule winner)	-0.036	-0.075	-0.040	-0.132	-0.029
	(0.089)	(0.069)	(0.078)	(0.094)	(0.024)
1 if observation from tournament stage	-0.363*	0.509**			
	(0.199)	(0.208)			
1 if observation from production stage after first production stage			-0.171**	-0.101	-0.031
			(0.077)	(0.089)	(0.019)
p-value of hypothesis test that coefficients are jointly equal to 0			0.323	0.607	0.456
R^2	0.274	0.322			

*** — significant at 1% level, ** — significant at 5% level, * — significant at 10% level

Note: Standard errors clustered at the subject level are in parentheses. Both specifications jointly estimate models of the tournament and production stage effort choices with common subject fixed effects as in column (3) of table 4. The dependent variable is the effort choice in either the tournament or production stage, and both models include eight period block dummies. The omitted category is a loser in a rule-based period in the production stage.

Table 6: Production stage effort models including preference for merit & personality interactions in the IN treatment

		Random Outcome Dummies Interacted with					
Variable		PMP	Ext	Agr	Con	Emo	Ope
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1 if 1st stage winner	0.058	-0.121	-0.089	0.008	0.148	-0.137	0.029
	(0.084)	(0.097)	(0.080)	(0.114)	(0.098)	(0.141)	(0.088)
1 if random loser (rule loser)	-0.252***	-0.245**	-0.153	0.026	-0.084	-0.368***	0.036
	(0.092)	(0.102)	(0.122)	(0.097)	(0.131)	(0.135)	(0.087)
1 if random loser (rule winner)	-0.196	-0.315**	-0.285**	0.174	0.074	0.097	0.439**
	(0.141)	(0.136)	(0.115)	(0.160)	(0.137)	(0.194)	(0.169)
1 if random winner (rule loser)	0.275**	0.047	-0.124	0.086	-0.033	0.020	0.168
	(0.103)	(0.104)	(0.106)	(0.130)	(0.119)	(0.126)	(0.146)
1 if random winner (rule winner)	0.012	-0.087	0.096	0.049	0.096	0.059	0.009
	(0.052)	(0.084)	(0.076)	(0.079)	(0.087)	(0.086)	(0.071)
1 if observation from tournament stage	-0.466***						
	(0.149)						
R^2	0.240						

*** — significant at 1% level, ** — significant at 5% level, * — significant at 10% level

Note: Standard errors clustered at the subject level are in parentheses. The specification jointly estimate models of the tournament and production stage effort choices with common subject fixed effects. The dependent variable is the effort choice in either the tournament or production stage. The specification includes eight period block dummies interacted with the stage (tournament or production). The omitted category is a loser in a rule-based period in the production stage. PMP is the Preference for Merit, “Ext” is Extroversion, “Agr” is Agreeableness, “Con” is Conscientiousness, “Emo” is Emotional Stability, and “Ope” is Openness/Intellect. All personality measures and the PMP are standardized within the sample to have mean zero and standard deviation one.

<u>Material below not intended for publication</u>

Appendix: Mixed Strategy Equilibrium for Tournament Stage with Induced Effort

Consider a two-stage model consisting of a tournament stage and a post-tournament production stage. In the tournament stage, two workers compete by choosing a costly effort level (e) to produce noisy output (Y). Output is given by the production function $Y = ae + \varepsilon$, where ε is a random component of output with mean zero and variance σ^2. The cost of effort is given by $C(e)$ where $C' > 0$ and $C'' > 0$.

With probability $1 - \mu$, the tournament is won by the worker who produces more output. With probability μ, the winner of the tournament is determined randomly with each competitor being equally likely to win. The probability μ is common knowledge. The competitors make effort choices before learning whether the outcome of the tournament will be decided based on the output rule or by chance. The tournament winner receives payment W, while the loser receives L ($W > L$).

In the production stage, the costs of effort and the production function are the same as in the tournament. Each worker chooses effort to produce output and is paid according to a piece rate, αY. In addition, the tournament winner receives a fraction β of the tournament loser's production stage output, Y_P^L.

The production stage payoffs to the tournament winner and loser are $\alpha Y_P^W + \beta Y_P^L$ and αY_P^L, respectively. The profit-maximizing production stage effort levels are the same for both players given that they have the same production and cost functions. Denote this profit-maximizing effort level as e^* and the expected production stage profits for tournament winners and losers as $E\pi_W^*$ and $E\pi_L^*$.[22] Given these expected payoffs in the production stage, the workers ($i = 1,2$) choose effort levels (e_i) in the tournament stage to maximize their expected earnings:

$$\mu\left[\frac{1}{2}(W + E\pi_W^*) + \frac{1}{2}(L + E\pi_L^*)\right] + (1-\mu)\left[P(e_i)(W + E\pi_W^*) + \left(1 - P(e_i)\right)(L + E\pi_L^*)\right] - C(e_i)$$

The probability of winning conditional on effort e_i, $P(e_i)$, is given by

$$P(e_i) = prob(Y_i > Y_j) = prob\left(e_i - e_j > \frac{\varepsilon_j - \varepsilon_i}{a}\right) = G(e_i - e_j)$$

where $G(\cdot)$ is the cumulative distribution function of $\xi = (\frac{\varepsilon_j - \varepsilon_i}{a})$. The first-order condition for each worker *i* is given by

$$\frac{\partial P}{\partial e_i}(1-\mu)(W + E\pi_W^* - L - E\pi_L^*) - C'(e_i) = 0$$

where $\frac{\partial P}{\partial e_i} = g(e_i - e_j)$. The second order condition for each worker *i* is given by

$$\frac{\partial^2 P}{\partial e^2_i}(1-\mu)(W + E\pi_W^* - L - E\pi_L^*) - C''(e_i) < 0$$

The second-order condition must be satisfied to guarantee the existence of a symmetric Nash equilibrium in pure strategies (Lazear and Rosen 1981). No pure strategy equilibrium exists in our experiment as the parameter values in the experiment are such that the second-order condition is not satisfied.

For notational simplicity in what follows, define $\Lambda = \mu\left[\frac{1}{2}(W + E\pi_W^*) + \frac{1}{2}(L + E\pi_L^*)\right] + (1-\mu)(L + E\pi_L^*)$ and $\Omega = (1-\mu)(W + E\pi_W^* - L - E\pi_L^*)$. Intuitively, Ω is the expected difference in total gross earnings between winning and losing the tournament, while $\Omega + \Lambda$ are

[22] In the production stage, the worker's maximization problem, irrespective of tournament outcome, is $\max_e \alpha e + \varepsilon - C(e)$, the solution to which is given by $\alpha = C'(e)$, or $e^* = C^{-1}(\alpha)$.

the total expected gross earnings conditional on having exerted enough effort in a rule-based tournament.[23]

A.1 No noise

Tournament contests without noise (i.e., $\varepsilon = 0$) were first analyzed in Nalebuff and Stiglitz (1983). We assume worker $i's$ expected payoff is given by

$$U(e) = \Lambda + P(e > e_j)\Omega - C(e)$$

No equilibrium in pure strategies exist: were workers to play a symmetric, pure strategy effort level, workers could always guarantee winning rule-based tournaments by deviating and exerting slightly more effort than their rival. With two workers there is a unique symmetric equilibrium in mixed strategies (Baye et al. 1996). To find the equilibrium mixed strategies, denote the distribution of the maximum effort choice faced by worker i as $H(\cdot)$ and note that workers are symmetric. In equilibrium, the worker's expected payoff must be the same for all effort levels in the support of the equilibrium mixed strategy $q\colon \mathbb{R}+ \to [0,1]$:

$$U(e) = \Lambda + H(e)\Omega - C(e) = k \text{ for any } e \text{ in the support of } q$$

There exists some maximum effort choice, $\bar{e}$, that satisfies $U(0) = k = U(\bar{e})$, or $\Lambda - C(0) = \Lambda + \Omega - C(\bar{e})$. Here, $C(0) = 0$, which allows implies $\bar{e} = C^{-1}(\Omega)$. Likewise for any effort in the support of the equilibrium mixed strategy $\Lambda - C(0) = \Lambda + H(e)\Omega - C(e)$, i.e., the worker always has the option of exerting no effort and taking the loser's prize, so he must be indifferent between this and any positive effort level. Rearranging, the equilibrium probability distribution

[23] In the repeated production stage treatment, $\Lambda = \mu\left[\frac{1}{2}(W + 4E\pi_W) + \frac{1}{2}(L + 4E\pi_L)\right] + (1 - \mu)(L + E\pi_L)$ and $\Omega = (1 - \mu)(W + 4E\pi_W - L - 4E\pi_L)$.

over effort choices is given by $\mathrm{H}(e) = \frac{\mathrm{C}(e)}{\Omega}$, which implies that the probability that any effort level is chosen ($\mathrm{h}(e)$) is proportional to its marginal costs with higher effort levels being more likely to be chosen.

A.2 Noisy Output

Now suppose that $\varepsilon \square [-b, b]$ in both the tournament and production stages such that output is noisy. We have the following proposition:

Proposition A1: In the tournaments in our experiment with convex effort costs of the form $C(x) = ax^2$ if $\Omega s - C'(0) \leq \sum_{i=2}^{k} C'(e_i) \leq \Omega$ for some integer $k \geq 2$, then there exists a symmetric equilibrium in mixed strategies in which workers assign masses $n_1, n_2, \ldots, n_k$ to effort levels $x_1, x_2, \ldots, x_k$, where

$$(1)\quad n_1 = 1 - \frac{\sum_{i=2}^{k} C'(e_i)}{\Omega s},\ n_i = \frac{C'(e_i)}{\Omega s}\ \square\ i \geq 2 \text{ and}$$

$$(2)\qquad x_1 = 0, x_i = \frac{1}{2s} + \frac{i-1}{s}\ \square\ i = 2, \ldots, k.$$

where $s = \frac{a}{2b}$.

The proof of Proposition A1 is a trivial extension of Che and Gale's (2000) proofs of their Proposition 3 and Corollary 3 when effort costs are convex as opposed to linear. Che and Gale (2000) also observe that this equilibrium in mixed strategies is not unique. Specifically, there exists a family of payoff-equivalent equilibria in which workers spread the mass a bit around the mass points; see Che and Gale (1998) for a full discussion. The fact that this equilibrium is not unique precludes empirical investigation of whether subjects in our experiment play equilibrium strategies in the tournament stages. Nevertheless, a further observation from Che and Gale (2000) is useful in setting our expectations for behavior in tournament play.

Specifically, Che and Gale show in their Proposition 8 that the cumulative distribution of equilibrium effort levels in contests of this form converges uniformly to the cumulative distribution of effort levels in the case with no-noise (i.e., an all-pay auction) as s goes to infinity. This is easy to see in the mixed strategy equilibrium they characterize as the step size between mass points ($\frac{1}{s}$) goes to zero as s goes to infinity while the density associated with each (ever closer together) mass point is proportional to the (increasing) marginal cost of effort as in the no-noise case. Thus we expect the observed behavior in our tournaments to be much the same in both the no-noise treatment and the noisy treatment in which $s = 15$.

In the remainder of this appendix section, we sketch out derivation the above equilibrium mixed strategy as in Che and Gale (2000) for the sake of completeness. Define the piecewise linear success function, worker i's probability of winning a rule-based tournament as a function of the *difference* between the efforts of a worker and his rival, to be $f(e_i - e_j) = \max\{\min\{\frac{1}{2} + s(e_i - e_j), 1\}, 0\}$, where e_i is the effort of worker i. The rate at which worker i's probability of winning increases in his effort choice is denoted by s, where $s = \frac{a}{2b}$ in our setting. The probability that worker i wins is equal to 1 whenever $e_i - e_j \geq \frac{1}{2s}$. That is, whenever worker i chooses an effort level that is at least $\frac{1}{2s}$ units of effort greater than the level chosen by worker j no realization of the noise terms for i and j will be sufficient to outweigh the difference in their effort choices.

Consider the following strategies for two workers: worker 2 assigns masses $n_1, n_2, \ldots, n_k$ to effort levels $x_1, x_2, \ldots, x_k$ for some $k \geq 2$, and worker 1 assigns masses $m_1, m_2, \ldots, m_k$ to effort levels $y_1, y_2, \ldots, y_k$. Suppose that

$$x_1 = y_1 = 0$$

$$x_2 \in \left[\frac{1}{2s}, \frac{1}{s}\right], y_2 \in \left[\frac{1}{2s}, \frac{1}{s}\right]$$

(3) $\quad x_i - x_{i-1} = y_i - y_{i-1} = \frac{1}{s}$ for $i = 3, \ldots k$

If workers use these strategies, pinning down x_2 and y_2 determines the locations of all subsequent mass points.

For any $x \geq 0$, let $i(x) \in argmin_j |x - y_j|$ be the index of y_j closest to x. The payoff to worker 1 of exerting effort $x \geq 0$ if worker 2 employs this strategy is given by

$$U_1(x) =$$

$$\begin{cases} \Omega n_1 \left[\frac{1}{2} + sx\right] + \Lambda - C(x) & \text{if } x \leq y_2 - \frac{1}{2s} \\ \Omega \left\{ n_1 \left[\frac{1}{2} + sx\right] + n_2 \left[\frac{1}{2} + s(x - y_2)\right] \right\} + \Lambda - C(x) & \text{if } x \in \left[y_2 - \frac{1}{2s}, \frac{1}{2s}\right] \\ \Omega \left\{ \left(\sum_{d=1}^{i(e)-1} n_d \right) + n_{i(x)} \left[\frac{1}{2} + s\left(x - y_{i(x)}\right)\right] \right\} + \Lambda - C(x) & \text{if } x \in \left[\frac{1}{2s}, y_k + \frac{1}{2s}\right] \\ \Omega + \Lambda - C(x) & \text{if } x > y_k + \frac{1}{2s} \end{cases}$$

For these to be equilibrium strategies, several conditions must be satisfied. First, Worker 1 must attain local maxima at $x_2, \ldots, x_k$. The fact that $x_i - x_{i-1} = y_i - y_{i-1} = \frac{1}{s}$ for $i = 3, \ldots k$ implies that $i(x_j) = j$. As such, a sufficient condition for worker 1 to achieve these local maxima is that $U'_1(x_i) = \Omega n_i s - C'(x_i) = 0$, which implies that

(4) $$n_i = \frac{C'(x_i)}{\Omega s} \text{ for } i = 2, \dots k$$

Second, worker 1's expected payoff must not increase as he raises his effort from 0. The assumption that $x_1 = 0$ implies that $U_1'(0) = \Omega n_1 s - C'(0) \leq 0$, or

(5) $$n_1 \leq \frac{C'(0)}{\Omega s}$$

Third, worker 1's mass must sum to one:

(6) $$n_1 = 1 - \frac{\sum_{i=2}^{k} C'(e_i)}{\Omega s}$$

Fourth, there must exist some k such that the strategies can be implemented.

Combining (5) and (6) along with the fact that $n_1 \geq 0$ implies

(7) $$0 \leq 1 - \frac{\sum_{i=2}^{k} C'(e_i)}{\Omega s} \leq \frac{C'(0)}{\Omega s} \text{ or } \Omega s - C'(0) \leq \sum_{i=2}^{k} C'(e_i) \leq \Omega$$

Because $C'(0) < C'(e_i)$ for any $i \geq 2$ when $C' > 0$ and $C'' > 0$, there will generically be at most one integer $k \geq 2$ satisfying (7). Assuming indifference between x_1 and x_2 pins down x_2, which pins down the locations of all the other mass points.

Having identified the conditions that must be satisfied for the proposed strategies to be an equilibrium, the proof that these conditions are satisfied goes as follows.

In the equilibrium strategy, all mass points are separated by $\frac{1}{s}$, except the first two. To ensure that this is an equilibrium, we have to ensure that the worker is indifferent between all effort choices in the support of the mixed strategy. This consists of three steps. First we need to ensure that there is no profitable deviation between the first two mass points. Second, we need to show that worker is indifferent between any two mass points except the first one. Third, we need to show that the worker is indifferent between exerting no effort and exerting positive effort.

By construction of the equilibrium strategy, $U_i(x)$ is (weakly) decreasing for $x \in [0, y_2 - \frac{1}{2s}]$. and increasing for $x \in [y_2 - \frac{1}{2s}, \frac{1}{2s}]$. Taken together, these ensure that there is no profitable deviation between the first and second mass points. Next, (4) implies that $U_i(x)$ is constant for $\in [\frac{1}{2s}, y_k + \frac{1}{2s}]$ and is strictly decreasing for $x > y_k + \frac{1}{2s}$. Finally, we have $U_i(0) = U_i(x)$ for $x \in [\frac{1}{2s}, y_k + \frac{1}{2s}]$. For symmetric workers, the analysis of worker 2's strategy is analogous.

Appendix: Instructions

INSTRUCTIONS (INDUCED EFFORT, UNCERTAIN PRODUCTION)

This portion of the experiment will consist of 40 periods consisting of two stages each. At the beginning of the session, you will be assigned a color, either Red or Blue. Half of all players will be Red, and half will be Blue. The role these colors play will be explained shortly.

At the beginning of each period, you will be randomly paired with another subject of the opposite color. You will be paired with this subject for both stages of the period and then re-matched with a different subject at the beginning of the next period. The basic structure is as follows:

Stage 1

Both you and the other subject will be producing output by choosing an "effort" level which is explained below. Your output will be determined by the following production function

$$Output = 120 \cdot effort + noise$$

where *effort* is the level of effort you choose and *noise* is a random number. The *noise* term will be drawn from a uniform distribution over the interval [-2, 2]. This means that any number between -2 and 2 is equally likely to be the random term added to your output. Note that sometimes this random term will increase your output, sometimes it will decrease it, and sometimes it will neither increase nor decrease your output.

You can choose any level of effort between 0 and 6 in increments of 0.01. That is, your effort choice cannot have any more than 2 numbers after the decimal point. Effort is not free. The cost to you of effort is determined by the following cost function

$$Cost = 10 \cdot effort^2$$

These costs are expressed in terms of experimental currency units (ECUs). This cost of effort will be deducted from your earnings as explained below. Once you and the subject you are paired with have chosen effort levels, the computer will compare the output produced by you and the other subject. If you produce more than your partner during the first stage, then you will receive a payment of 162 ECUs, while if you produce less output than your partner you will receive a payment of 90 ECUs. The exchange rate will be $1=20 ECUs. Your total earnings for stage 1 will be

$$Earnings = Payment - Cost\ of\ effort$$

There will be a calculator on the screen that you can use to determine how much a given level of effort will cost and what your potential output would be for a given effort level. You use the calculator by entering an amount of effort and clicking the "Calculate" button. You submit your effort choice by clicking the "Submit" button. Once you click the Submit button, YOUR EFFORT CHOICE IS BINDING AND CANNOT BE CHANGED.

Stage 2

In stage 2, you will produce output by choosing effort in exactly the same way as in stage 1. The production function, cost of effort, and distribution for the *noise* term will be exactly the same. In this stage, however, the player who received the payment of 90 ECUs in stage 1 will earn $\frac{1}{3}$ of the output he/she produces in stage 2. So if the player produces 180 units of output, he will receive a payment of 60 ECUs. The player who received the payment of 162 in the first stage will also receive $\frac{1}{3}$ of his/her own output in the second stage plus $\frac{1}{5}$ of the output produced by the other player in stage 2.

Example 1:

Suppose you supply 1.85 units of effort in the first stage and the noise term you draw is -0.5, your output will be

$$Output = 120 \times 1.85 - 0.5 = 221.5$$

and your costs will be

$$Cost = 10 \times 1.85^2 = 34.22$$

Suppose your output is higher than that of the player with whom you are paired, your earnings will be

$$Earnings = 162 - 34.22 = 127.78$$

Suppose you supply 0.99 units of effort in the second stage and the noise term you draw is 1.4. Your output will be

$$Output = 120 \times 0.99 + 1.4 = 120.2$$

and your costs will be

$$Cost = 10 \times 0.99^2 = 9.8$$

The player you are paired with supplies 2.1 units of effort in the second stage and the noise term he draws is 0.7, his output will be

$$Output = 120 \times 2.1 + 0.7 = 252.7$$

Because your output was higher in the first stage, you will receive $\frac{1}{3}$ of your output in the second stage AND $\frac{1}{5}$ of the other player's output in the second stage, so your earnings in the second stage will be

$$Earnings = \frac{1}{3}(120.2) + \frac{1}{5}(252.7) - 9.8 = 90.61$$

Example 2:

Suppose you supply 1.9 units of effort in the first stage and the noise term you draw is 0.2, your output will be

$$Output = 120 \square 1.9 + 0.2 = 228.2$$

and your costs will be

$$Cost = 10 \square 1.9^2 = 39.6$$

Suppose your output is lower than that of the player with whom you are paired, your earnings will be

$$Earnings = 90 - 39.6 = 50.4$$

Suppose you supply 1.67 units of effort in the second stage and the noise term you draw is 0. Your output will be

$$Output = 120 \square 1.67 + 0 = 200.4$$

and your costs will be

$$Cost = 10 \square 1.67^2 = 27.89$$

Because your output was lower in the first stage, you will only receive $\frac{1}{3}$ of your output in the second stage, so your earnings in the second stage will be

$$Earnings = \frac{1}{3}(200.4) - 27.89 = 38.91$$

The Role of Colors

In most periods, the stages will proceed as explained above. However, in every period there is a 25% chance that the computer will disregard the outputs produced by you and the player you are paired with in the first stage. In these cases— on average about 10 of the 40 periods we will conduct today — the computer will assign the first stage payments (162 and 90 ECUs) based on colors. In every period in which it disregards first-stage outputs when determining first-stage payments, there is a 50-50 chance that the computer will assign the payment of 162 ECU to the Red player and 90 to the Blue player and a 50-50 chance that it will assign the payment of 162 ECU to the Blue player and 90 to the Red player. You will not be made aware of whether the computer has disregarded the outputs or if it has assigned the higher payment to your color until AFTER you have made your effort decision. You will pay for your first stage effort regardless of whether the computer uses your first stage output to determine payoffs.

When colors are used to assign payments in the first stage, the amount you receive in the second stage will also be determined by which payment the computer assigned you in the first stage. If you were assigned the payment of 90 ECUs in the first stage, then you will receive 1/3 of your second stage output regardless of whether your effort choice resulted in higher or lower output in the first stage. Similarly, if you were assigned the payment of 162 ECUs, you will receive 1/3 of your second stage output and 1/5 of the other player's second stage output regardless of whether your effort choice resulted in higher or lower output in the first stage.

Example 3:

Suppose your color is Red and you supply 1.85 units of effort in the first stage and the noise term you draw is -0.5, your output will be

$$Output = 120 \cdot 1.85 - 0.5 = 221.5$$

and your costs will be

$$Cost = 10 \cdot 1.85^2 = 34.22$$

Suppose the other (Blue) player's output is 200.01. Your output is higher, but the computer disregards your outputs and assigns the Blue player the payment of 162. You are the Red player, so your earnings will be

$$Earnings = 90 - 34.22 = 55.78$$

Suppose you supply 0.99 units of effort in the second stage and the noise term you draw is 1.4. Your output will be

$$Output = 120 \cdot 0.99 + 1.4 = 120.2$$

and your costs will be

$$Cost = 10 \times 0.99^2 = 9.8$$

Even though your output was higher in the first round, because of the computer's decision, you will only receive $\frac{1}{3}$ of your output in the second stage WHILE the other player will receive $\frac{1}{5}$ of your output in the second stage as well as $\frac{1}{3}$ of his own output, so your earnings in the second stage will be

$$Earnings = \frac{1}{3}(120.2) - 9.8 = 30.27$$

We will play 40 rounds. You will be paid for 2 randomly selected rounds out of the 40 and you will not learn which rounds have been selected until all 40 periods have been completed. Following the completion of all 40 rounds, you will be asked to answer a short questionnaire, part of which you will be paid for, before being paid your total earnings and dismissed. In addition to your earnings from the experiment, all subjects will receive a $5 show-up fee. Are there any questions?

INSTRUCTIONS (INDUCED EFFORT, CERTAIN PRODUCTION)

This portion of the experiment will consist of 40 periods consisting of two stages each. At the beginning of the session, you will be assigned a color, either Red or Blue. Half of all players will be Red, and half will be Blue. The role these colors play will be explained shortly.

At the beginning of each period, you will be randomly paired with another subject of the opposite color. You will be paired with this subject for both stages of the period and then re-matched with a different subject at the beginning of the next period. The basic structure is as follows:

Stage 1

Both you and the other subject will be producing output by choosing an "effort" level which is explained below. Your output will be determined by the following production function

$$Output = 120 \cdot effort$$

where *effort* is the level of effort you choose.

You can choose any level of effort between 0 and 6 in increments of 0.01. That is, your effort choice cannot have any more than 2 numbers after the decimal point. Effort is not free. The cost to you of effort is determined by the following cost function

$$Cost = 10 \cdot effort^2$$

These costs are expressed in terms of experimental currency units (ECUs). This cost of effort will be deducted from your earnings as explained below. Once you and the subject you are paired with have chosen effort levels, the computer will compare the output produced by you and the other subject. If you produce more than your partner during the first stage, then you will receive a payment of 162 ECUs, while if you produce less output than your partner you will receive a payment of 90 ECUs. If you produce the same amount of output as your partner, the tie will be broken randomly by the computer. The exchange rate will be $1=20 ECUs. Your total earnings for stage 1 will be

$$Earnings = Payment - Cost\,of\,effort$$

There will be a calculator on the screen that you can use to determine how much a given level of effort will cost and what your output would be for a given effort level. You use the calculator by entering an amount of effort and clicking the "Calculate" button. You submit your effort choice by clicking the "Submit" button. Once you click the Submit button, YOUR EFFORT CHOICE IS BINDING AND CANNOT BE CHANGED.

Stage 2

In stage 2, you will produce output by choosing effort in exactly the same way as in stage 1. The production function and cost of effort will be exactly the same. In this stage, however, the player who received the payment of 90 ECUs in stage 1 will earn $\frac{1}{3}$ of the output he/she produces in stage 2. So if the player produces 180 units of output, he will receive a payment of 60 ECUs. The player who received the payment of 162 in the first stage will also receive $\frac{1}{3}$ of his/her own output in the second stage plus $\frac{1}{5}$ of the output produced by the other player in stage 2.

Example 1:

Suppose you supply 1.85 units of effort in the first stage, your output will be

$$Output = 120 \times 1.85 = 222$$

and your costs will be

$$Cost = 10 \times 1.85^2 = 34.22$$

Suppose your output is higher than that of the player with whom you are paired, your earnings will be

$$Earnings = 162 - 34.22 = 127.78$$

Suppose you supply 0.99 units of effort in the second stage, your output will be

$$Output = 120 \times 0.99 = 118.8$$

and your costs will be

$$Cost = 10 \times 0.99^2 = 9.8$$

The player you are paired with supplies 2.1 units of effort in the second stage, his output will be

$$Output = 120 \times 2.1 = 252$$

Because your output was higher in the first stage, you will receive $\frac{1}{3}$ of your output in the second stage AND $\frac{1}{5}$ of the other player's output in the second stage, so your earnings in the second stage will be

$$Earnings = \frac{1}{3}(118.8) + \frac{1}{5}(252) - 9.8 = 80.2$$

Example 2:

Suppose you supply 1.9 units of effort in the first stage, your output will be

$$Output = 120 \times 1.9 = 228$$

and your costs will be

$$Cost = 10 \times 1.9^2 = 39.6$$

Suppose your output is lower than that of the player with whom you are paired, your earnings will be

$$Earnings = 90 - 39.6 = 50.4$$

Suppose you supply 1.67 units of effort in the second stage, your output will be

$$Output = 120 \times 1.67 = 200.4$$

and your costs will be

$$Cost = 10 \cdot 1.67^2 = 27.89$$

Because your output was lower in the first stage, you will only receive $\frac{1}{3}$ of your output in the second stage, so your earnings in the second stage will be

$$Earnings = \frac{1}{3}(200.4) - 27.89 = 38.91$$

The Role of Colors

In most periods, the stages will proceed as explained above. However, in every period there is a 25% chance that the computer will disregard the outputs produced by you and the player you are paired with in the first stage. In these cases— on average about 10 of the 40 periods we will conduct today — the computer will assign the first stage payments (162 and 90 ECUs) based on colors. In every period in which it disregards first-stage outputs when determining first-stage payments, there is a 50-50 chance that the computer will assign the payment of 162 ECU to the Red player and 90 to the Blue player and a 50-50 chance that it will assign the payment of 162 ECU to the Blue player and 90 to the Red player. You will not be made aware of whether the computer has disregarded the outputs or if it has assigned the higher payment to your color until AFTER you have made your effort decision. You will pay for your first stage effort regardless of whether the computer uses your first stage output to determine payoffs.

When colors are used to assign payments in the first stage, the amount you receive in the second stage will also be determined by which payment the computer assigned you in the first stage. If you were assigned the payment of 90 ECUs in the first stage, then you will receive 1/3 of your second stage output regardless of whether your effort choice resulted in higher or lower output in the first stage. Similarly, if you were assigned the payment of 162 ECUs, you will receive 1/3 of your second stage output and 1/5 of the other player's second stage output regardless of whether your effort choice resulted in higher or lower output in the first stage.

Example 3:

Suppose your color is Red and you supply 1.85 units of effort in the first stage, your output will be

$$Output = 120 \cdot 1.85 = 222$$

and your costs will be

$$Cost = 10 \cdot 1.85^2 = 34.22$$

Suppose the other (Blue) player's output is 200.01. Your output is higher, but the computer disregards your outputs and assigns the Blue player the payment of 162. You are the Red player, so your earnings will be

$$Earnings = 90 - 34.22 = 55.78$$

Suppose you supply 0.99 units of effort in the second stage, your output will be

$$Output = 120 \cdot 0.99 = 118.8$$

and your costs will be

$$Cost = 10 \cdot 0.99^2 = 9.8$$

Even though your output was higher in the first round, because of the computer's decision, you will only receive $\frac{1}{3}$ of your output in the second stage WHILE the other player will receive $\frac{1}{5}$ of your output in the second stage as well as $\frac{1}{3}$ of his own output, so your earnings in the second stage will be

$$Earnings = \frac{1}{3}(118.8) - 9.8 = 29.8$$

We will play 40 rounds. You will be paid for 2 randomly selected rounds out of the 40 and you will not learn which rounds have been selected until all 40 periods have been completed. Following the completion of all 40 rounds, you will be asked to answer a short questionnaire, part of which you will be paid for, before being paid your total earnings and dismissed. In addition to your earnings from the experiment, all subjects will receive a $7 show-up fee. Are there any questions?

INSTRUCTIONS (REAL EFFORT, CERTAIN PRODUCTION)

This portion of the experiment will consist of 20 periods consisting of two stages each. At the beginning of the session, you will be assigned a color, either Red or Blue. Half of all subjects will be Red, and half will be Blue. The role these colors play will be explained shortly.

At the beginning of each period, you will be randomly partnered with another subject of the opposite color. You will be partnered with this subject for both stages of the period and then re-matched with a different subject at the beginning of the next period. The basic structure is as follows:

Stage 1

In this stage, you will be adding three two-digit numbers. You will have 90 seconds to complete as many of these addition problems as you can. After the 90 seconds are up, the number of addition problems you answered correctly will be compared to the number correctly answered by the subject with whom you are partnered. The subject who answered more questions correctly will receive a payment of $10, while the player who answered fewer questions correctly will receive a payment of $3. If both players answer the same number of questions correctly, the tie will be broken randomly by the computer. YOU MAY NOT USE A CALCULATOR.

Stage 2

In stage 2, you will remain partnered with the same subject and will again be adding three two-digit numbers. You will have 90 seconds to complete as many of these addition problems as you can. In this stage, the subject who solved fewer problems in the first stage will earn $0.10 for each addition problem he completes correctly in this stage. The subject who solved more problems in the first stage will earn $0.10 for each addition problem he correctly completes in this stage as well as $0.08 for each addition problem correctly completed in this stage by the subject who solved fewer problems in the first stage.

Example 1:

Suppose you correctly complete 8 addition problems in the first stage and the subject with whom you are partnered correctly completes 3 addition problems. You will receive $10 for the first stage and your partner will receive $3. In the second stage you correctly complete 8 addition problems and the subject with whom you are partnered completes 6 addition problems. Your earnings for the second stage will be

(0.10 x 8) + (0.08 x 6) = $1.28

While your partner will earn

(0.10 x 6) = $0.60

Example 2:

Suppose you correctly complete 2 addition problems in the first stage and the subject with whom you are partnered correctly completes 3 addition problems. You will receive $3 for the first stage and your partner will receive $10. In the second stage you correctly complete 3 addition problems and the subject with whom you are partnered completes 6 addition problems. Your earnings for the second stage will be

(0.10 x 3) = $0.30

While your partner will earn

(0.10 x 6) + (0.08 x 3) = $0.84

The Role of Colors

In most periods, the stages will proceed as explained above. However, in every period there is a 25% chance that the computer will disregard the number of addition problems correctly completed by you and the subject with whom you are partnered in the first stage. In these cases— on average about 1 in 4 of the periods we will conduct today — the computer will assign the first stage payments ($10 and $3) based on colors. In every period in which the computer disregards the number of correctly completed problems in the first stage when determining first-stage payments, there is a 50-50 chance that the computer will assign the payment of $10 to the Red player and $3 to the Blue player and a 50-50 chance that it will assign the payment of $10 to the Blue player and $3 to the Red player. You will not be made aware of whether the computer has disregarded the number of addition problems you correctly completed or if it has assigned the higher payment to your color until AFTER you have done the addition problems.

When colors are used to assign payments in the first stage, the amount you receive in the second stage will also be determined by which payment the computer assigned you in the first stage. If you were assigned the payment of $3 in the first stage, then you will receive $0.10 for each addition problem you correctly complete in the second stage regardless of whether you correctly completed more or fewer addition problems than your partner in the first stage. Similarly, if you were assigned the payment of $10, you will earn $0.10 for each addition problem you correctly complete in the second stage and $0.08 for each addition problem the subject with whom you are partnered correctly completes in the second stage regardless of whether you correctly completed more or fewer addition problems than your partner in the first stage.

Example 3:

At the beginning of the experiment, you are designated as a "Blue" player. In each period you are partnered with a "Red" player. Suppose you correctly complete 9 addition problems in the first stage and the subject with whom you are partnered correctly completes 4 addition problems, but the computer disregards the number of problems that you and your partner correctly complete and awards the higher payment to the Red player. Because you are the Blue player, you will receive $3 for the first stage while your partner, the Red player, receives $10. In the second stage you correctly complete 8 questions and the other player completes 6 questions. Your earnings for the second stage will be

(0.10 x 8) = 0.80

while your partner will earn

(0.10 x 6) + (0.08 x 8) = $1.24.

We will play 20 periods. You will be paid for 2 randomly selected periods out of the 20 and you will not learn which periods have been selected until all 20 periods have been completed. Following the completion of all 20 periods, you will be asked to answer a short questionnaire, part of which you will be paid for, before being paid your total earnings and dismissed. In addition to your earnings from the experiment, all subjects will receive an $8 show-up fee. Are there any questions?

INSTRUCTIONS (ROTATING WINNERS)

This portion of the experiment will consist of 40 periods consisting of two stages each. At the beginning of the session, you will be assigned a color, either Red or Blue. Half of all players will be Red, and half will be Blue. The role these colors play will be explained shortly.

In the first stage of each period, you will be randomly paired with another subject of the opposite color. You will be paired with this subject for the first stage and then matched with a different subject at the beginning of the second stage in a manner explained below. The basic structure is as follows:

Stage 1

Both you and the subject with whom you are paired will be producing output by choosing an "effort" level which is explained below. Your output will be determined by the following production function

$$Output = 120 \cdot effort + noise$$

where *effort* is the level of effort you choose and *noise* is a random number. The *noise* term will be drawn from a uniform distribution over the interval [-2, 2]. This means that any number between -2 and 2 is equally likely to be the random term added to your output. Note that sometimes this random term will increase your output, sometimes it will decrease it, and sometimes it will neither increase nor decrease your output.

You can choose any level of effort between 0 and 6 in increments of 0.01. That is, your effort choice cannot have any more than 2 numbers after the decimal point. Effort is not free. The cost to you of effort is determined by the following cost function

$$Cost = 10 \cdot effort^2$$

These costs are expressed in terms of experimental currency units (ECUs). This cost of effort will be deducted from your earnings as explained below. Once you and the subject with whom you are paired have chosen effort levels, the computer will compare the output produced by you and the other subject. If you produce more than your partner during the first stage, then you will receive a payment of 162 ECUs, while if you produce less output than your partner you will receive a payment of 90 ECUs. The exchange rate will be $1=20 ECUs. Your total earnings for stage 1 will be

$$Earnings = Payment - Cost\ of\ effort$$

There will be a calculator on the screen that you can use to determine how much a given level of effort will cost and what your potential output would be for a given effort level. You use the calculator by entering an amount of effort and clicking the "Calculate" button. You submit your effort choice by clicking the "Submit" button. Once you click the Submit button, YOUR EFFORT CHOICE IS BINDING AND CANNOT BE CHANGED.

Stage 2

In stage 2, you will be matched with a different subject. Although you are matched with a different subject, each pair of subjects will always have one player who received the payment of 162 in the first stage and one player who received the payment of 90 in the first stage.

You will produce output by choosing effort in exactly the same way as in stage 1. The production function, cost of effort, and distribution for the *noise* term will be exactly the same. In this stage, however, the player who received the payment of 90 ECUs in stage 1—the player who produced *less* than his/her partner in the first stage—will earn $\frac{1}{3}$ of the output he/she produces in stage 2. So if the player produces 180 units of output, he will receive a payment of 60 ECUs. The player who received the payment of 162 in the first stage—the player who produced *more* output than his/her partner in the first stage—will also receive $\frac{1}{3}$ of his/her own output in the second stage plus $\frac{1}{5}$ of the output produced by his/her new partner in stage 2.

Example 1:

Suppose you supply 1.85 units of effort in the first stage and the noise term you draw is -0.5, your output will be

$$Output = 120 \cdot 1.85 - 0.5 = 221.5$$

and your costs will be

$$Cost = 10 \cdot 1.85^2 = 34.22$$

Suppose your output is higher than that of the player with whom you are paired in the first stage, your earnings will be

$$Earnings = 162 - 34.22 = 127.78$$

Suppose you supply 0.99 units of effort in the second stage and the noise term you draw is 1.4. Your output will be

$$Output = 120 \cdot 0.99 + 1.4 = 120.2$$

and your costs will be

$$Cost = 10 \times 0.99^2 = 9.8$$

After being matched with a new partner at the start of the second stage, the player you are paired with in the second stage supplies 2.1 units of effort in the second stage and the noise term he draws is 0.7, his output will be

$$Output = 120 \times 2.1 + 0.7 = 252.7$$

Because your output was higher than that of the person with whom you were paired in the first stage, you will receive $\frac{1}{3}$ of your output in the second stage AND $\frac{1}{5}$ of the output of the player with whom you are paired in the second stage, so your earnings in the second stage will be

$$Earnings = \frac{1}{3}(120.2) + \frac{1}{5}(252.7) - 9.8 = 90.61$$

Example 2:

Suppose you supply 1.9 units of effort in the first stage and the noise term you draw is 0.2, your output will be

$$Output = 120 \times 1.9 + 0.2 = 228.2$$

and your costs will be

$$Cost = 10 \times 1.9^2 = 39.6$$

Suppose your output is lower than that of the player with whom you are paired in the first stage, your earnings will be

$$Earnings = 90 - 39.6 = 50.4$$

Suppose you supply 1.67 units of effort in the second stage and the noise term you draw is 0. Your output will be

$$Output = 120 \times 1.67 + 0 = 200.4$$

and your costs will be

$$Cost = 10 \times 1.67^2 = 27.89$$

Because your output was lower than that of the person with whom you were paired in the first stage, you will only receive $\frac{1}{3}$ of your output in the second stage, so your earnings in the second stage will be

$$Earnings = \frac{1}{3}(200.4) - 27.89 = 38.91$$

The Role of Colors

In most periods, the stages will proceed as explained above. However, in every period there is a 25% chance that the computer will disregard the outputs produced by you and the player you are paired with in the first stage. In these cases— on average about 10 of the 40 periods we will conduct today — the computer will assign the first stage payments (162 and 90 ECUs) based on colors. In every period in which it disregards first-stage outputs when determining first-stage payments, there is a 50-50 chance that the computer will assign the payment of 162 ECU to the Red player and 90 to the Blue player and a 50-50 chance that it will assign the payment of 162 ECU to the Blue player and 90 to the Red player. You will not be made aware of whether the computer has disregarded the outputs or if it has assigned the higher payment to your color until AFTER you have made your effort decision. You will pay for your first stage effort regardless of whether the computer uses your first stage output to determine payoffs.

When colors are used to assign payments in the first stage, the amount you receive in the second stage will also be determined by which payment the computer assigned you in the first stage. If you were assigned the payment of 90 ECUs in the first stage, then you will receive 1/3 of your second stage output regardless of whether your effort choice resulted in higher or lower output in the first stage. Similarly, if you were assigned the payment of 162 ECUs, you will receive 1/3 of your second stage output and 1/5 of second stage output of the player with whom you are paired in the second stage regardless of whether your effort choice resulted in higher or lower output in the first stage. If you were assigned the payment of 90 ECUs in the first stage because of your color, you will be matched with a player who was assigned 162 ECUs in the first stage and vice versa.

Example 3:

Suppose your color is Red and you supply 1.85 units of effort in the first stage and the noise term you draw is -0.5, your output will be

$$Output = 120 \cdot 1.85 - 0.5 = 221.5$$

and your costs will be

$$Cost = 10 \cdot 1.85^2 = 34.22$$

Suppose the other (Blue) player's output is 200.01. Your output is higher, but the computer disregards your outputs and assigns the Blue player the payment of 162. You are the Red player, so your earnings will be

$$Earnings = 90 - 34.22 = 55.78$$

You received 90 ECUs in the first stage and are now matched with a new player who received 162 ECUs in the first stage also because of his/her color. Suppose you supply 0.99 units of effort in the second stage and the noise term you draw is 1.4. Your output will be

$$Output = 120 \times 0.99 + 1.4 = 120.2$$

and your costs will be

$$Cost = 10 \times 0.99^2 = 9.8$$

Even though your output was higher in the first round, because of the computer's decision, you will only receive $\frac{1}{3}$ of your output in the second stage WHILE the player with whom you are now paired will receive $\frac{1}{3}$ of his/her own output and $\frac{1}{5}$ of your output in the second stage because he/she was awarded the payment of 162 ECUs in the first stage. Your earnings in the second stage will be

$$Earnings = \frac{1}{3}(120.2) - 9.8 = 30.27$$

We will play 40 periods. You will be paid for 2 randomly selected periods out of the 40 and you will not learn which periods have been selected until all 40 periods have been completed. Following the completion of all 40 periods, you will be asked to answer a short questionnaire, part of which you will be paid for, before being paid your total earnings and dismissed. In addition to your earnings from the experiment, all subjects will receive a $5 show-up fee. Are there any questions?

INSTRUCTIONS (REPEATED PRODUCTION STAGE)

This portion of the experiment will consist of 30 periods consisting of five stages each. At the beginning of the session, you will be assigned a color, either Red or Blue. Half of all players will be Red, and half will be Blue. The role these colors play will be explained shortly.

At the beginning of each period, you will be randomly paired with another subject of the opposite color. You will be paired with this subject for all five stages of the period and then matched with a different subject also of the opposite color at the beginning of the next period. The basic structure is as follows:

Stage 1

Both you and the subject with whom you are paired will be producing output by choosing an "effort" level which is explained below. Your output will be determined by the following production function

$$Output = 120 \cdot effort + noise$$

where *effort* is the level of effort you choose and *noise* is a random number. The *noise* term will be drawn from a uniform distribution over the interval [-2, 2]. This means that any number between -2 and 2 is equally likely to be the random term added to your output. Note that sometimes this random term will increase your output, sometimes it will decrease it, and sometimes it will neither increase nor decrease your output.

You can choose any level of effort between 0 and 6 in increments of 0.01. That is, your effort choice cannot have any more than 2 numbers after the decimal point. Effort is not free. The cost to you of effort is determined by the following cost function

$$Cost = 10 \cdot effort^2$$

These costs are expressed in terms of experimental currency units (ECUs). This cost of effort will be deducted from your earnings as explained below. Once you and the subject you are paired with have chosen effort levels, the computer will compare the output produced by you and the other subject. If you produce more than your partner during the first stage, then you will receive a payment of 162 ECUs, while if you produce less output than your partner you will receive a payment of 90 ECUs. The exchange rate will be $1=20 ECUs. Your total earnings for stage 1 will be

$$Earnings = Payment - Cost\ of\ effort$$

There will be a calculator on the screen that you can use to determine how much a given level of effort will cost and what your potential output would be for a given effort level. You use the calculator by entering an amount of effort and clicking the "Calculate" button. You submit your effort choice by clicking the “Submit” button. Once you click the Submit button, YOUR EFFORT CHOICE IS BINDING AND CANNOT BE CHANGED.

Stages 2-5

In stages 2-5, you will produce output by choosing effort in exactly the same way as in stage 1. The production function, cost of effort, and distribution for the *noise* term will be exactly the same. In each of these four stages, however, the player who received the payment of 90 ECUs in stage 1 will earn $\frac{1}{3}$ of the output he/she produces in the stage. So if the player produces 180 units of output, he will receive a payment of 60 ECUs. The player who received the payment of 162 in the first stage will also receive $\frac{1}{3}$ of his/her own output in any given stage plus $\frac{1}{5}$ of the output produced by the other player in that stage. Your earnings for a period will be the sum of your earnings from the five stages.

Example 1:

Suppose you supply 1.85 units of effort in the first stage and the noise term you draw is -0.5, your output will be

$$Output = 120 \times 1.85 - 0.5 = 221.5$$

and your costs will be

$$Cost = 10 \times 1.85^2 = 34.22$$

Suppose your output is higher than that of the player with whom you are paired, your earnings will be

$$Earnings = 162 - 34.22 = 127.78$$

Suppose you supply 0.99 units of effort in the second stage and the noise term you draw is 1.4. Your output will be

$$Output = 120 \times 0.99 + 1.4 = 120.2$$

and your costs will be

$$Cost = 10 \times 0.99^2 = 9.8$$

The player you are paired with supplies 2.1 units of effort in the second stage and the noise term he draws is 0.7, his output will be

$$Output = 120 \times 2.1 + 0.7 = 252.7$$

Because your output was higher in the first stage, you will receive $\frac{1}{3}$ of your output in the second stage AND $\frac{1}{5}$ of the other player's output in the second stage, so your earnings in the second stage will be

$$Earnings = \frac{1}{3}(120.2) + \frac{1}{5}(252.7) - 9.8 = 90.61$$

Your earnings in stages 3, 4, and 5 are determined in exactly the same way as those in period 2. Note that your earnings in stages 2 through 5 depend on whether you produce more or less than your partner in stage 1.

Example 2:

Suppose you supply 1.9 units of effort in the first stage and the noise term you draw is 0.2, your output will be

$$Output = 120 \times 1.9 + 0.2 = 228.2$$

and your costs will be

$$Cost = 10 \times 1.9^2 = 39.6$$

Suppose your output is lower than that of the player with whom you are paired, your earnings will be

$$Earnings = 90 - 39.6 = 50.4$$

Suppose you supply 1.67 units of effort in the second stage and the noise term you draw is 0. Your output will be

$$Output = 120 \times 1.67 + 0 = 200.4$$

and your costs will be

$$Cost = 10 \times 1.67^2 = 27.89$$

Because your output was lower in the first stage, you will only receive $\frac{1}{3}$ of your output in the second stage, so your earnings in the second stage will be

$$Earnings = \frac{1}{3}(200.4) - 27.89 = 38.91$$

Again, your earnings in stages 3, 4, and 5 are determined in exactly the same way as those in period 2.

The Role of Colors

In most periods, the stages will proceed as explained above. However, in every period there is a 25% chance that the computer will disregard the outputs produced by you and the player you are paired with in the first stage. In these cases— on average about 7-8 of the 30 periods we will conduct today — the computer will assign the first stage payments (162 and 90 ECUs) based on colors. In every period in which it disregards first-stage outputs when determining first-stage payments, there is a 50-50 chance that the computer will assign the payment of 162 ECU to the Red player and 90 to the Blue player and a 50-50 chance that it will assign the payment of 162 ECU to the Blue player and 90 to the Red player. You will not be made aware of whether the computer has disregarded the outputs or if it has assigned the higher payment to your color until AFTER you have made your effort decision. You will pay for your first stage effort regardless of whether the computer uses your first stage output to determine payoffs.

When colors are used to assign payments in the first stage, the amounts you receive in stages 2, 3, 4 and 5 will also be determined by which payment the computer assigned you in the first stage. If you were assigned the payment of 90 ECUs in the first stage, then you will receive 1/3 of your output in each subsequent stage regardless of whether your effort choice resulted in higher or lower output in the first stage. Similarly, if you were assigned the payment of 162 ECUs, you will receive 1/3 of your output and 1/5 of the other player's output in each subsequent stage regardless of whether your effort choice resulted in higher or lower output in the first stage.

Example 3:

Suppose your color is Red and you supply 1.85 units of effort in the first stage and the noise term you draw is -0.5, your output will be

$$Output = 120 \cdot 1.85 - 0.5 = 221.5$$

and your costs will be

$$Cost = 10 \cdot 1.85^2 = 34.22$$

Suppose the other (Blue) player's output is 200.01. Your output is higher, but the computer disregards your outputs and assigns the Blue player the payment of 162. You are the Red player, so your earnings will be

$$Earnings = 90 - 34.22 = 55.78$$

Suppose you supply 0.99 units of effort in the second stage and the noise term you draw is 1.4. Your output will be

$$Output = 120 \cdot 0.99 + 1.4 = 120.2$$

and your costs will be

$$Cost = 10 \times 0.99^2 = 9.8$$

Even though your output was higher in the first round, because of the computer's decision, you will only receive $\frac{1}{3}$ of your output in the second stage WHILE the other player will receive $\frac{1}{5}$ of your output in the second stage as well as $\frac{1}{3}$ of his own output, so your earnings in the second stage will be

$$Earnings = \frac{1}{3}(120.2) - 9.8 = 30.27$$

Again, your earnings in stages 3, 4, and 5 are determined in exactly the same way as those in period 2.

We will play 30 periods. You will be paid for 2 randomly selected periods out of the 30 and you will not learn which periods have been selected until all 30 periods have been completed. Following the completion of all 30 periods, you will be asked to answer a short questionnaire, part of which you will be paid for, before being paid your total earnings and dismissed. In addition to your earnings from the experiment, all subjects will receive a $5 show-up fee. Are there any questions?

Appendix: Screen Shots of User Interface

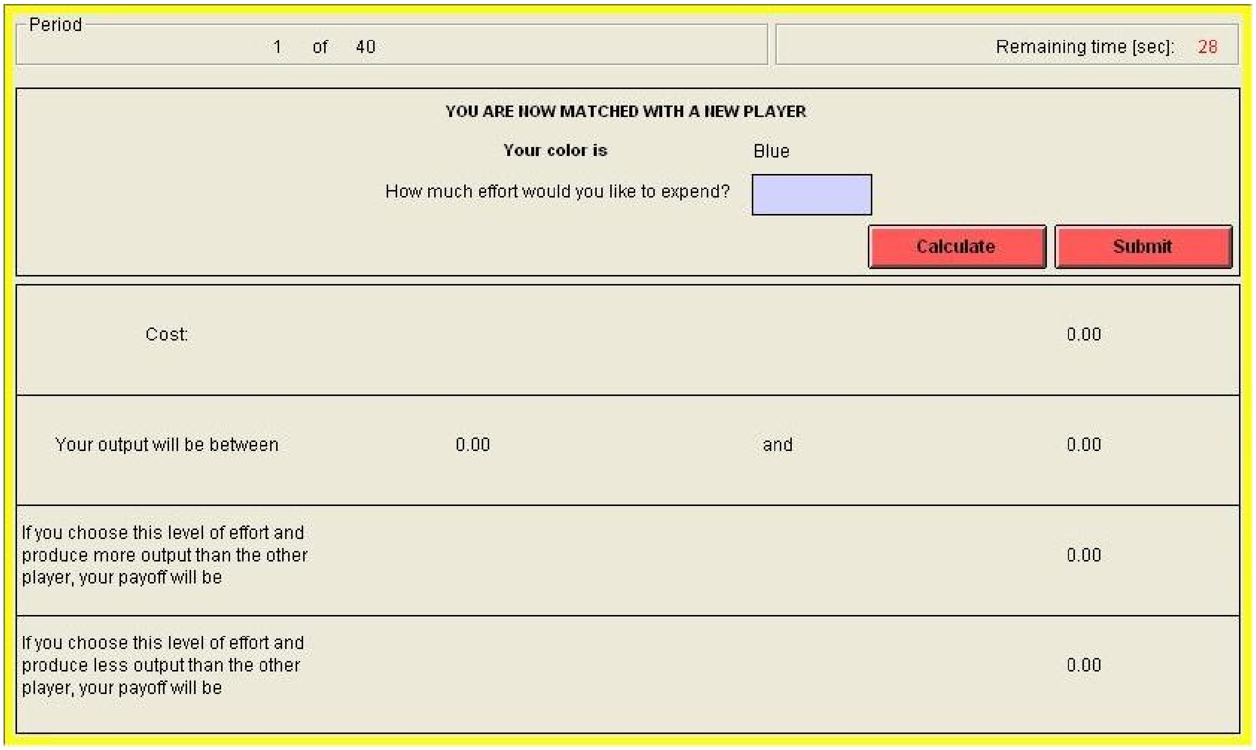


Figure A1 Tournament Interface

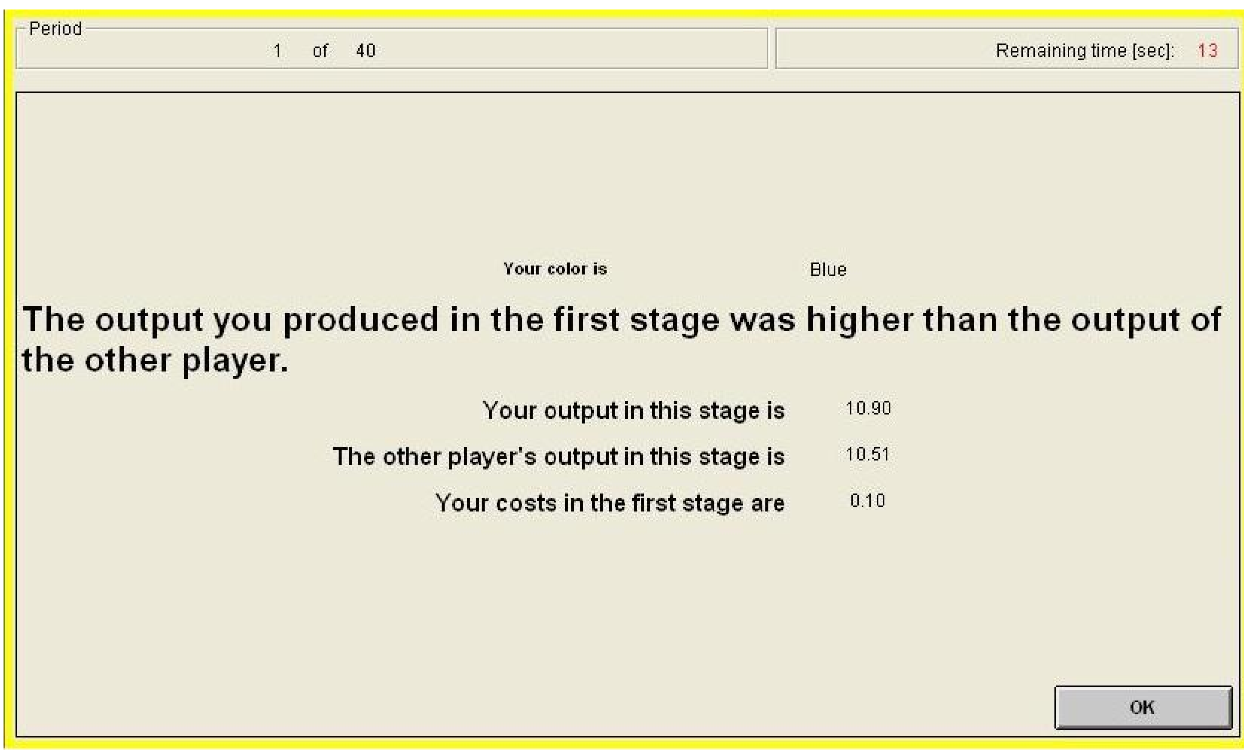


Figure A2 Post-Tournament Feedback

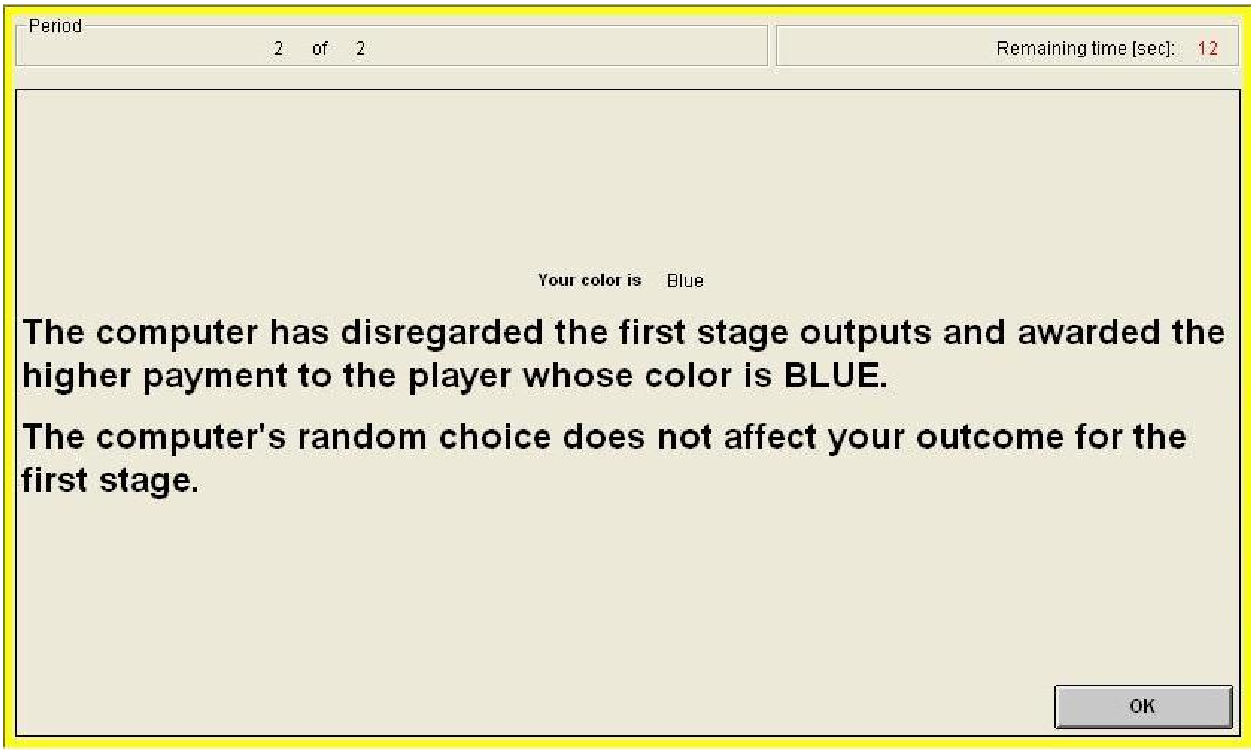


Figure A3 Random Period Feedback When Allocation is Unaffected

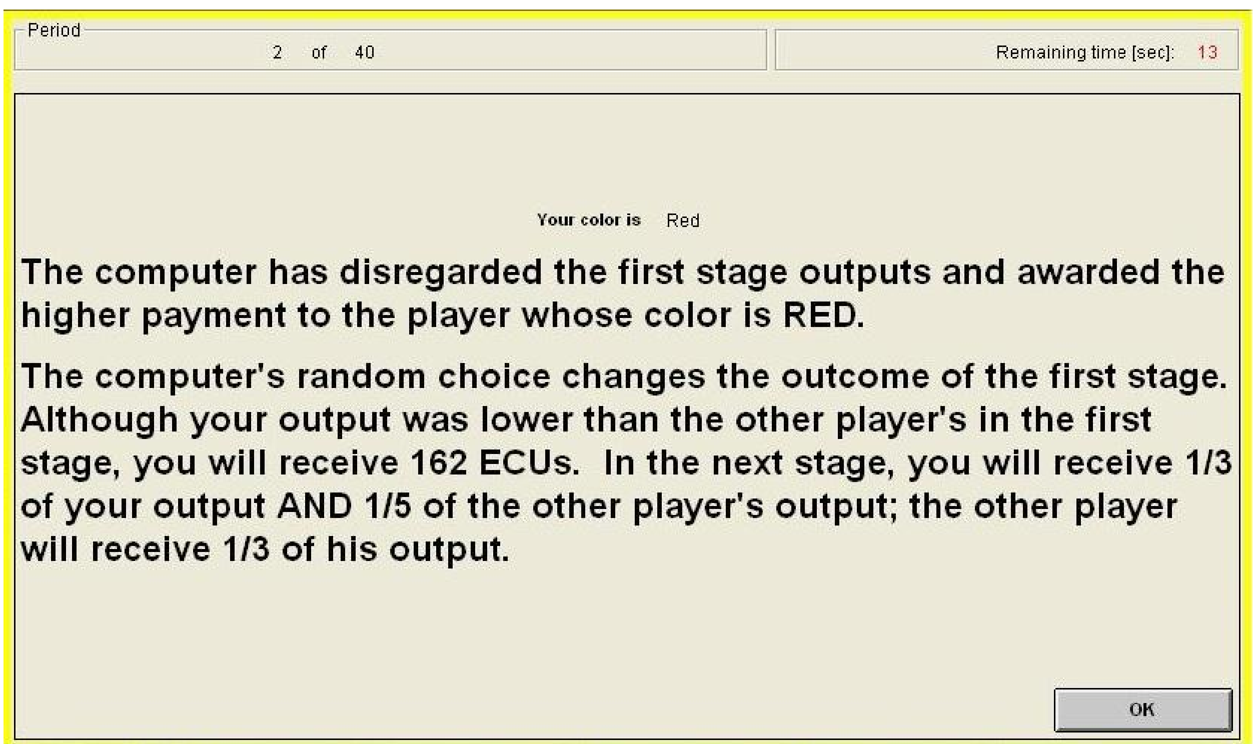


Figure A4 Feedback Screen When a Subject Wins Due to Randomness

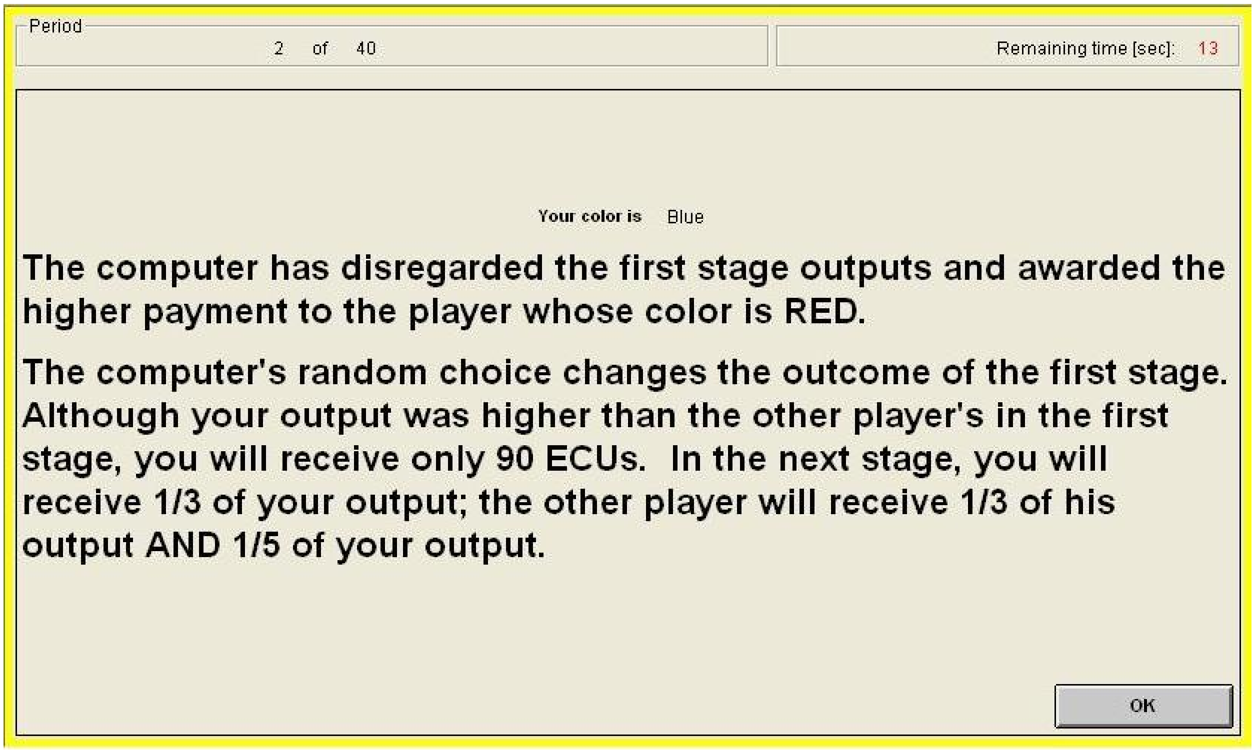


Figure A5 Feedback When a Subject Loses Due to Randomness

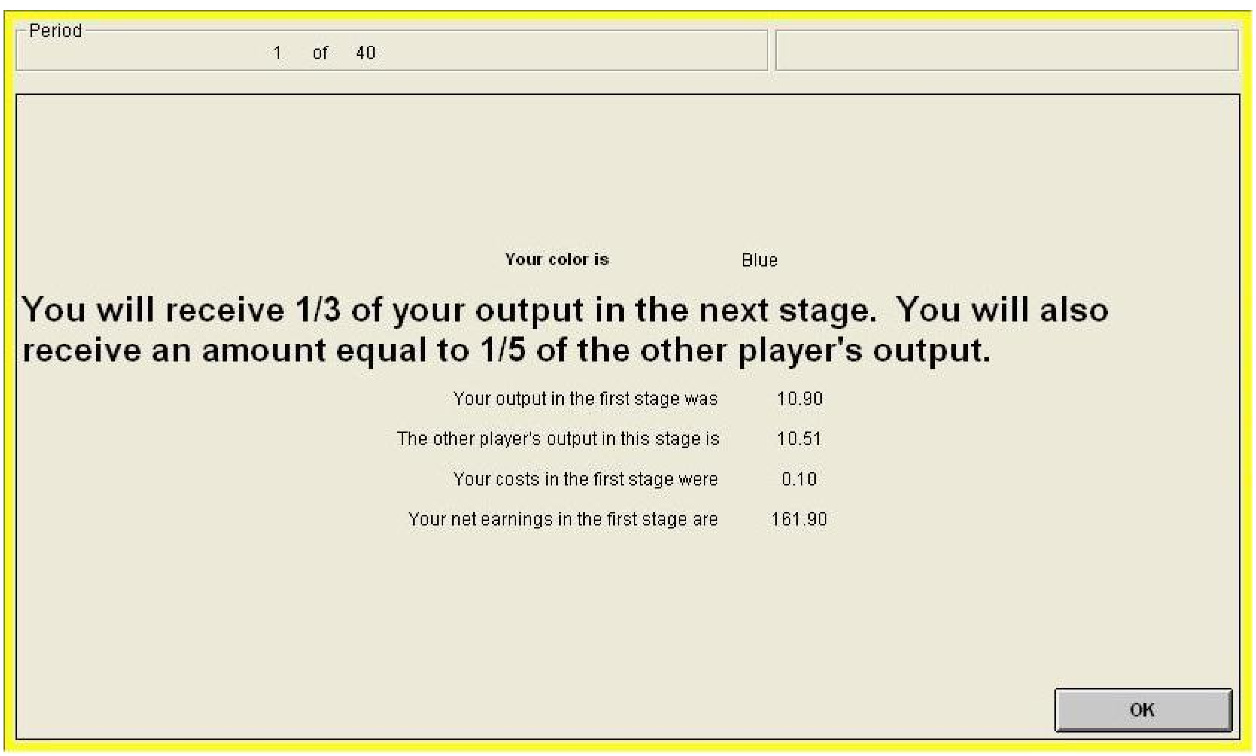


Figure A6 Payment Scheme Reminder Screen

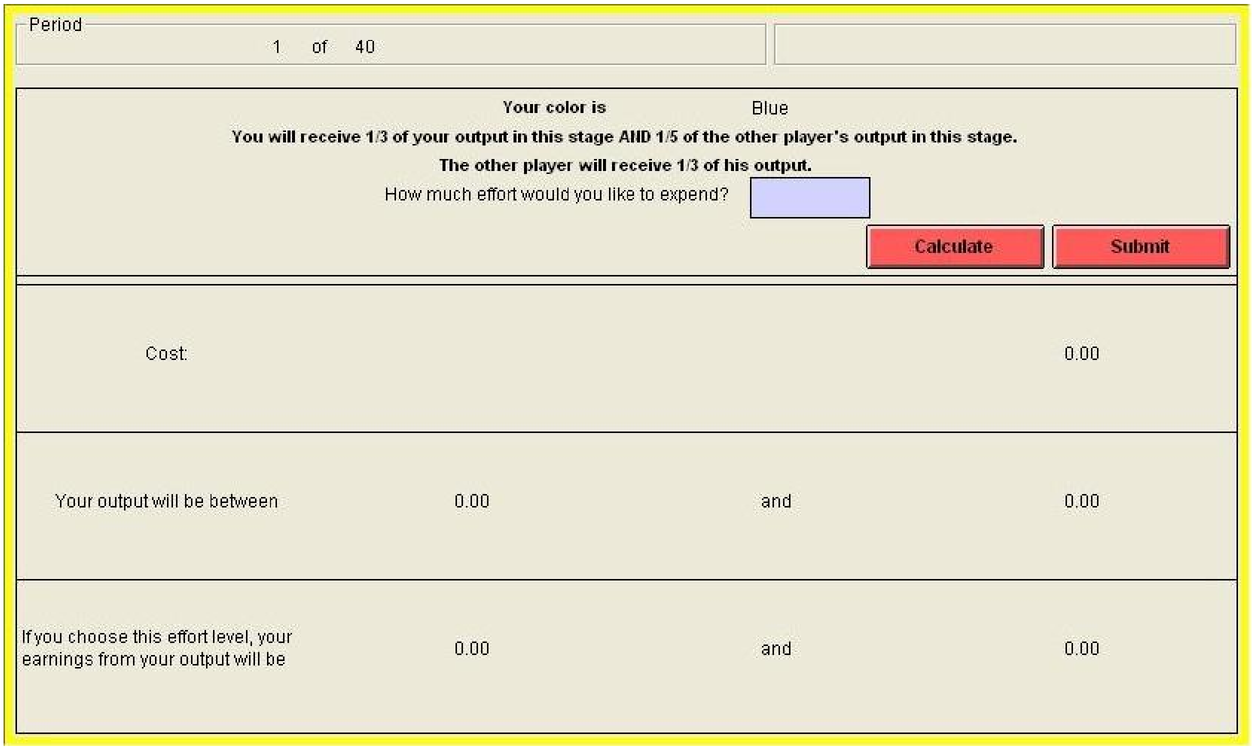


Figure A7 Production Stage Interface

Figure A8 Post-Production Feedback

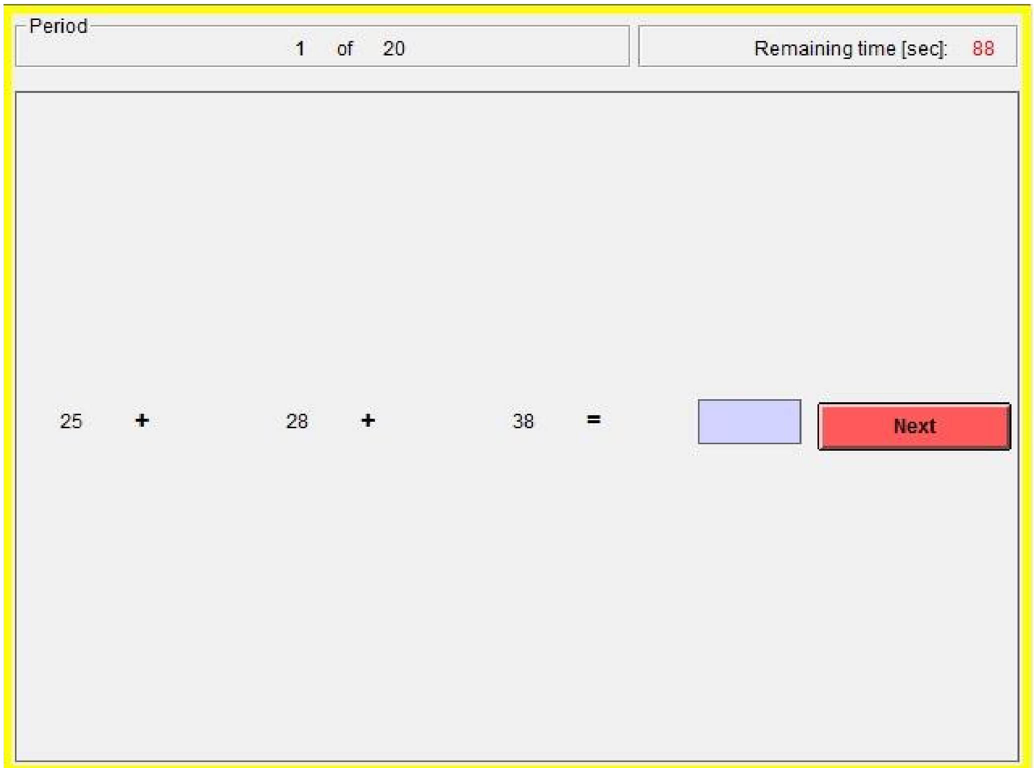


Figure A9 Real Effort Task

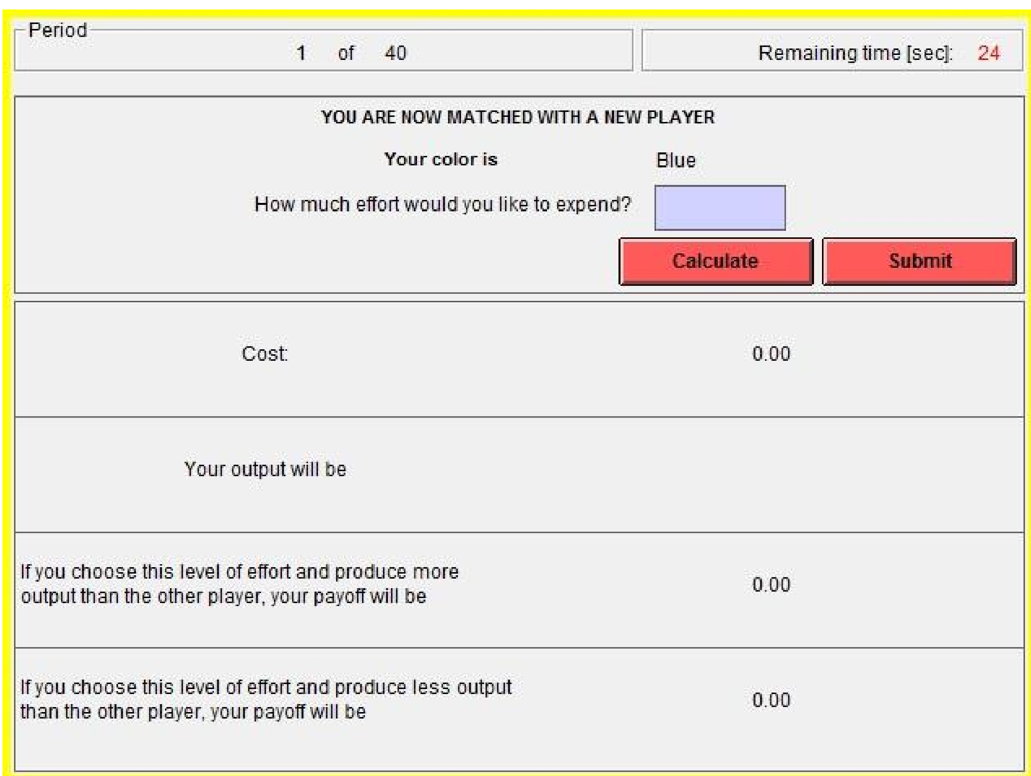


Figure A10 No Noise Screen

Appendix: Scales

Abbreviated 4-item Rotter Internal-External Locus of Control Scale
A. What happens to me is my own doing.
B. Sometimes I feel that I don't have enough control over the direction my life is taking.

A. When I make plans, I am almost certain that I can make them work.
B. It is not always wise to plan too far ahead because many things turn out to be a matter of good or bad fortune.

A. In my case getting what I want has little or nothing to do with luck.
B. Many times we might just as well decide what to do by flipping a coin.

A. Many times I feel that I have little influence over the things that happen to me.
B. It is impossible for me to believe that chance or luck plays an important role in my life.

HRS/NLSY79 Risk Preference
A. Now I have another kind of question. Suppose that you are the only income earner in the family, and you have a good job guaranteed to give you your current (family) income every year for life. You are given the opportunity to take a new and equally good job, with a 50-50 chance that it will double your (family) income and a 50-50 chance that it will cut your (family) income by a third. Would you take the new job?
Yes (go to B)
No (go to C)

B. Suppose the chances were 50-50 that it would double your (family) income and 50-50 that it would cut it in half. Would you still take the new job?
Yes (go to end)
No (go to end)

C. Suppose the chances were 50-50 that it would double your (family) income and 50-50 that it would cut it by 20 percent. Would you take the new job?
Yes (go to end)
No (go to end)

GSOEP Risk Preference
Are you generally a person who is fully prepared to take risks or do you try to avoid taking risks? Rate yourself from 0 to 10, where 0 means "unwilling to take any risks" and 10 means "fully prepared to take risks."

Holt-Laury Low Stakes Risk Preference

In the questions that follow, you are going to be asked to make ten decisions. Each decision will be between Option A and Option B. Please enter your decisions below and on the corresponding sheet that was handed out to you. Only one of the ten choices you make will be used to determine your earnings for this part of the experiment. After you answer all 10 questions you will be shown the "decision selected" and "outcome" which will be used to calculate your earnings. Be sure to write these down. Each decision is a paired choice between "Option A" and "Option B." You will make ten choices. Before you start making your ten choices, let me explain what these choices mean. Imagine a ten-sided die that will be used to determine payoffs; the faces are numbered from 1 to 10. After you have made all of your choices, the die would be thrown twice, once to select one of the ten decisions to be used, and a second time to determine what your payoff is for the option you chose, A or B, for the particular decision selected. Given this, you should make the choice that you would prefer if we were throwing the die for real. Now, please look at Decision 1 at the top. Option A pays 200 pennies if the throw of the ten sided die is 1, and it pays 160 pennies if the throw is 2-10. Option B yields 385 pennies if the throw of the die is 1, and it pays 10 pennies if the throw is 2-10. The other Decisions are similar, except that as you move down the table, the chances of the higher payoff for each option increase. In fact, for Decision 10 in the bottom row, the die will not be needed since each option pays the highest payoff for sure, so your choice here is between 200 pennies or 385 pennies.

To summarize, you will make ten choices: for each decision row you will have to choose between Option A and Option B. You may choose A for some decision rows and B for other rows, and you may change your decisions and make them in any order.

	Option A	Option B	Your Choice
1.	**1/10 of \$2.00 9/10 of \$1.60**	**1/10 of \$3.85 9/10 of \$0.10**	**A / B**
2.	**2/10 of \$2.00 8/10 of \$1.60**	**2/10 of \$3.85 8/10 of \$0.10**	**A / B**
3.	**3/10 of \$2.00 7/10 of \$1.60**	**3/10 of \$3.85 7/10 of \$0.10**	**A / B**
4.	**4/10 of \$2.00 6/10 of \$1.60**	**4/10 of \$3.85 6/10 of \$0.10**	**A / B**
5.	**5/10 of \$2.00 5/10 of \$1.60**	**5/10 of \$3.85 5/10 of \$0.10**	**A / B**
6.	**6/10 of \$2.00 4/10 of \$1.60**	**6/10 of \$3.85 4/10 of \$0.10**	**A / B**
7.	**7/10 of \$2.00 3/10 of \$1.60**	**7/10 of \$3.85 3/10 of \$0.10**	**A / B**
8.	**8/10 of \$2.00 2/10 of \$1.60**	**8/10 of \$3.85 2/10 of \$0.10**	**A / B**
9.	**9/10 of \$2.00 1/10 of \$1.60**	**9/10 of \$3.85 1/10 of \$0.10**	**A / B**

10.	**10/10 of $2.00 0/10 of $1.60**	**10/10 of $3.85 0/10 of $0.10**	**A / B**

LOT-R Optimism-Pessimism

Using the response scale provided, let us know how much you agree or disagree with each of the following statements.

A = I agree a lot
B = I agree a little
C = I neither agree nor disagree
D = I disagree a little
E = I disagree a lot

In uncertain times, I usually expect the best.
If something can go wrong for me, it will.
I'm always optimistic about my future.
I hardly ever expect things to go my way.
I rarely count on good things happening to me.
Overall, I expect more good things to happen to me than bad.

Preference for Merit Scale

Please indicate the extent to which you agree or disagree with each of the following statements by selecting the appropriate response from the scale below.

A = Strongly Agree
B = Moderately Agree
C = Slightly Agree
D = Neither Agree nor Disagree
E = Slightly Disagree
F = Moderately Disagree
G = Strongly Disagree

In work organizations, each employee ought to be named employee of the month at least once, even if he or she is not deserving.

In organizations, people who do their job well ought to rise to the top.

It is wrong for an employee to give a job to someone they know without advertising the job to other candidates.

In life, people ought to get what they deserve.

The effort a worker puts into a job ought to be reflected in the size of a raise he or she receives.

When students are working on a group project, each member of the group ought to receive the same grade regardless of the amount of effort each team member puts in.

Promotion decisions ought to take into account the effort workers put into their job.

Members of a work team ought to receive different pay depending on the amount each person contributed.

Sometimes it is appropriate to give a raise to the worker who most needs it, even if he or she is not the most hard working.

Qualifications ought to be given more weight than seniority when making promotion decisions.

Between two equally smart students applying for the same job, the one who is the harder worker ought to always get the job.

When a bonus is given to a work team for good performance, the money ought to always be divided equally among the group members.

It is never appropriate to choose which student to hire by how much the student needs the job.

People ought to be able to get away with poor quality work under some circumstances.

If every person in an office has the same abilities, the promotion ought to always be given to the person who puts in the most effort.