Promotion and demotion contests*

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Abstract

To increase total effort, we design a two-stage lottery contest where heterogeneous agents face the prospect of promotion and the threat of demotion from one stage to the next. We develop two competing theoretical models to generate predictions about behaviour: (i) the standard economic model and (ii) a behavioural model where agents derive non-monetary utility from winning. The experimental results provide strong support for the use of promotion and demotion in contests when ability differences are small, however, they do not provide strong support for the use of promotion and demotion in contests when ability differences are large. Our experimental results are consistent with the predictions made by the behavioural model.

Keywords: Promotion, demotion, heterogeneity, contest design, experiments.

JEL Classification: C72, C92, D72, J33, M51.

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1 Introduction

Various forms of performance-based promotion and demotion are regularly implemented in organizations, education, and sports. Uber introduced "Uber Pro" in select cities around the world in 2018 (see *Gridwise* 2019). This reward scheme assigns high performing drivers to higher tiers where they receive perks such as free college tuition and 24/7 roadside assistance, while poor performing drivers are demoted to lower tiers where they no longer receive the same perks they did previously. Another example where promotions and demotions are frequently observed is in mutual fund management (see Hu et al., 2000 and Huang and Wang, 2015). Fund managers that receive high returns on their investments are assigned to larger, more lucrative funds in the future where they receive higher compensation. Whereas fund managers that perform poorly for an extended period are demoted to manage smaller mutual funds where they receive lower levels of compensation. In secondary schools high ability students are identified in 8th grade based on their performance in 7th grade and are assigned to compete with one another in future years within elite level classes.[1] Each year the student's ability is re-evaluated by their teachers based on their relative performance. In sports such as tennis and swimming, athletes get promoted (relegated) to divisions where the prize for winning the tournament is higher (lower) than it would have been previously. While individuals often experience promotion and demotion in real life, few have examined its efficacy.

Promotion can be effective in fostering effort within organizations (Baker et al., 1988). However, a major concern for managers when considering demotion as a means for incentivizing effort is the loss of motivation it may induce in individuals (Goldner, 1965). Whether the promotion and demotion of employees is effective in inducing higher effort is debatable. This paper seeks to measure the efficacy of promotion and demotion in motivating individuals to exert higher effort, especially when abilities are different. Specifically, we investigate promotion and demotion within a lottery contest framework (Tullock, 1980). By conducting laboratory experiments we can rule out unobservable variables that might affect performance and promotion/demotion decisions in the field, such as employee soft skills or supervisor favouritism (Prendergast and Topel, 1996).

The most heavily investigated contest design is the single-prize pooled contest. In some cases, single-prize pooled contests may be optimal in terms of incentivizing effort. However, in many cases these contests are suboptimal. For example, consider a situation where several agents are of high ability and the rest are of low ability. Under such circumstances one would expect the low ability agents to exert a low amount of effort as their likelihood of winning the prize would be quite low.[2] A simple way for the principal to encourage the low ability agents to exert higher levels of effort is to group agents based on ability level and create multiple sub-contests. By reducing the heterogeneity within subgroups, the principal might expect higher levels of engagement from the low ability agents. Assuming a fixed prize budget, the principal would need to reduce the prize awarded to high ability agents to increase the incentive for low ability agents to exert effort. Hence, dividing the

[1] This practice is common in Australia, New Zealand and other countries in Asia.

[2] This phenomenon is commonly referred to as the "discouragement effect", see Dechenaux et al. (2015) for more details.

prize across subgroups simply results in a more even distribution of effort across all agents, and it does not necessarily increase total effort.[3] In addition to grouping agents, the principal could allow for promotion and demotion across sub-groups to incentivize higher levels of effort than what they would generate under the pooled contest design.[4]

In this paper we theoretically and experimentally compare the performance of two contest designs. In the first contest design (the benchmark), all agents compete with one another in one "division" for a single prize in each stage of the game (henceforth "Pooled contest"). In the second contest design, some agents begin by competing for a high-value prize in Division 1 while the rest of the agents begin by competing for a low-value prize in Division 2. Agents who win in stage t of the game in Division 2 are promoted to Division 1 in stage $t+1$, and agents who lose in stage t of the game in Division 1 are demoted to Division 2 in stage $t+1$ (henceforth "P&D contest"). The objective of this study is to determine whether the P&D contest induces more effort than the Pooled contest.

We design a two-stage contest where heterogeneous agents face the prospect of promotion and the threat of demotion from one stage to the next. The game must consist of at least two stages to allow for agents to be promoted or demoted.[5] We develop two competing theoretical models to generate predictions about behaviour: (i) the standard economic model and (ii) a behavioural model where agents derive non-monetary utility from winning. The experimental results support the use of promotion and demotion in contests when ability differences are small. However, we did not find significant differences in total effort between the Pooled contest and the P&D contest when ability differences were large. Our experimental results are consistent with the predictions made by the behavioural model.

The novelty of our paper is twofold. First, we extend the theoretical examination of the P&D contest made by Jasina and Rotthoff (2012) by allowing for abilities to be heterogeneous and for agents to derive non-monetary utility from winning. Further to this, we are the first to investigate the P&D contest experimentally.

This paper contributes to the vast literature on performance-based incentives. Bull et al. (1987), Lazear (2000), Ariely et al. (2009) and Ederer and Manso (2013) investigate the impact of piece rate payments on performance. In contrast, we examine whether the P&D contest is more effective in incentivizing effort than the Pooled contest. Others such as Tullock (1980), Lazear and Rosen (1981), Schotter and Weigelt (1992), Moldovanu and Sela (2001), Moldovanu et al. (2007) and Sheremeta (2011) also study the effects of contests on effort exertion. We focus on settings where contestants make decisions dynamically, whereas those mentioned previously studied contests of a static nature.

The literature which is most relevant to this paper is on multi-stage contests. Parco et al. (2005), Amaldoss and Rapoport (2009), Sheremeta (2010a, 2010b) and Höchtl et al.

[3] A contest designer could implement an intermediate design where agents are assigned to separate divisions based on ability without the opportunity for promotion or demotion across divisions. We illustrate in Appendix D that this intermediate design is never better at incentivizing total effort than the pooled design.

[4] Note, the focus of this paper is on how different contest designs incentivize effort. We are not interested in how contests can be used to sort agents.

[5] In Levy (2020b) we explore the efficacy of the P&D contest as the number of stages approaches infinity. We find that the P&D contest becomes more effective in inducing effort as the length of the game increases. In this study we are testing the efficacy of the P&D contest under the worst circumstances.

(2011) study two-stage elimination contests. In elimination contests agents exert effort to progress to the final stage and win a prize. At the end of each stage, a specific number of agents are eliminated from participation in the subsequent stages of the contest. Once an agent has been eliminated, they are no longer in contention for the prize. By contrast, in our study agents are not eliminated from future competition but rather demoted to competing in less lucrative contests. Furthermore, prizes are awarded in each stage of competition rather than awarding a grand prize upon the final stage of competition. Jasina and Rotthoff (2012) construct a two-stage contest model where homogeneous agents get promoted and demoted, whereas we examine promotion and demotion in an environment where agents may have different abilities. This feature prevails in many real applications and enables us to contribute to the literature by illustrating how the efficacy of P&D contests in incentivizing effort depends on ability differences. Moreover, Jasina and Rotthoff (2012) do not compare the P&D contest with the Pooled contest. Hence, they were not able to theoretically illustrate the suboptimality of promotion and demotion when abilities are homogeneous.

We also contribute to the literature on endogenous group formation. Ahn et al. (2008), Brekke et al. (2011) and Aimone et al. (2013) study endogenous group formation in public-goods provision games. Carrell et al. (2013) investigate the effects of endogenous group formation on academic performance for entering freshmen at the United States Air Force Academy. We allow for groups to endogenously form within a contest framework. In our study agents are either promoted or demoted based on their performance in the previous stage of the game. Büyükboyacı (2016) investigates a static Parallel contest where agents were able to choose which division to compete in. However, in her setup there was no possibility of promotion or demotion. Her model predicts the Parallel contest should outperform the Pooled contest when ability differences are large, and her experimental results are consistent with the theory. Contrary to Büyükboyacı (2016) we demonstrate both theoretically and empirically how parallel contests with promotion and demotion are effective when ability differences are small.

Finally, our work adds to the extensive literature on the non-monetary utility of winning. The standard economic model assumes that contestants are only concerned about the monetary value of the prize. However, Schmitt et al. (2004) propose that the contestant's utility may depend on the act of winning itself. Sheremeta (2010b) tests this hypothesis experimentally and finds strong support in its favour. Other studies including Price and Sheremeta (2011, 2015), Brookins and Ryvkin (2014), Mago et al. (2016) and Cason et al. (2020) have since replicated the findings of Sheremeta (2010b) in contests.[6] We can reconcile our experimental results with the theoretical model when we introduce non-monetary utility of winning.

The rest of the paper is organized as follows. In section 2 we develop two competing theoretical models which enable us to compare the two contest designs described earlier. Section 3 outlines the experimental design, procedures, and hypotheses. Section 4 provides a summary and interpretation of the results generated from the experiment and section 5

[6]The non-monetary utility of winning has been found to influence subjects' behavior in other competitive environments, e.g., Erkal et al.(2018) in real effort tournaments and Goeree et al.(2002) in auctions.

contains concluding remarks.

2 Model

2.1 P&D contest

The game consists of two stages, where agents participate in a lottery contest in each stage. Agents are split into two divisions, Division 1 and Division 2. The model has four risk neutral agents and each division has two agents.[7] Agents placed in Division 1 in stage 1 have ability level $a_h > 0$ and agents placed in Division 2 in stage 1 have ability level $a_l > 0$, where $a_h \geq a_l$.[8] The ability level for an agent does not change from one stage to the next. Each agent's type is common knowledge. Agents compete within their respective divisions in each stage. Division 2 (Division 1) winners (losers) in stage 1 are promoted (demoted) to Division 1 (Division 2) in stage 2. In stage $t \in \{1, 2\}$ the prize for winning the contest in Division 1 is $v_{1t} > 0$ and the prize for winning the contest in Division 2 is $v_{2t} \geq 0$, where $v_{1t} > v_{2t}$ for all t. The prize for not winning a contest is 0. The effort that type $i \in \{h, l\}$ exerts when facing type $j \in \{h, l\}$, in Division $d \in \{1, 2\}$, at stage t is denoted $e^j_{idt} \geq 0$ and the cost of exerting a unit of effort is 1 for all agents.

The probability of type i winning the contest against type j, in Division d, at stage t is given by the following (Tullock based) success function:[9]

$$S^j_{idt} = \frac{a_i e^j_{idt}}{a_i e^j_{idt} + a_j e^i_{jdt}}.$$

The stage game payoff for type i against type j, in Division d, at stage t is given by the following:

$$\pi^j_{idt} = \frac{a_i e^j_{idt}}{a_i e^j_{idt} + a_j e^i_{jdt}} v_{dt} - e^j_{idt}.$$

Payoffs are additive across stages. For simplicity, we assume that there is no discounting. Since the game consists of multiple stages, our equilibrium concept is that of Subgame Perfect Equilibrium. Agents observe the effort choice of their opponent and the outcome of the contest in each stage. In theory, the effort level chosen by an agent could be history dependent. However, in the Subgame Perfect Equilibrium this will not be the case. Since efforts are unique, the Subgame Perfect Equilibrium is unique.

[7]We explore what happens as we increase the number of agents in play in Levy (2020a). When divisions consist of more than two agents the problem for the principal is more complex as they must also consider how many agents to promote and demote.

[8]Sorting agents might be difficult in practice as ability might be unobservable. However, in most cases the principal would have a proxy for ability, e.g., prior sales performance, or the score received in a standardized test. Although in this subsection we assume the principal can sort agents by ability, we relax this assumption in Appendix A.

[9]Heterogeneity in lottery contests can be introduced in several ways, e.g., through differences in players' impact on the contest success function, or differences in relative costs of effort. The theoretical propositions outlined in subsection 2.3 are robust to both approaches. We chose to introduce heterogeneity by varying players' impact on the contest success function as this approach has been adopted more frequently. For example, Fonseca (2009), Anderson and Freeborn (2010), Ridlon and Shin (2013) and Kimbrough et al. (2014) also adopt this approach.

2.1.1 Equilibrium in stage 2

We begin by deriving the equilibrium in stage 2. When we allow for promotion and demotion across divisions one of the high type agents in Division 1 is demoted to Division 2 in stage 2, and one of the low type agents in Division 2 is promoted to Division 1 in stage 2. Thus, in stage 2 high types compete with low types in both divisions. The problem for type i against type $-i$, in Division d, at stage 2 is as follows:

$$\max_{e_{id2}^{-i} \geq 0} \quad \frac{a_i e_{id2}^{-i}}{a_i e_{id2}^{-i} + a_{-i} e_{-id2}^{i}} v_{d2} - e_{id2}^{-i}.$$

The Nash equilibrium effort level for type i against type $-i$, in Division d, at stage 2, $\hat{e}_{id2}^{-i} \in \{\hat{e}_{h12}^{l}, \hat{e}_{l12}^{h}, \hat{e}_{h22}^{l}, \hat{e}_{l22}^{h}\}$ is as follows:

$$\hat{e}_{id2}^{-i} = \frac{a_i a_{-i} v_{d2}}{(a_i + a_{-i})^2}.$$

The equilibrium payoff for type i against type $-i$, in Division d, at stage 2, W_{id2}^{-i} is as follows:

$$W_{id2}^{-i} = \frac{a_i^2 v_{d2}}{(a_i + a_{-i})^2}.$$

2.1.2 Equilibrium in stage 1

Recall, in stage 1 high types compete with one another in Division 1 and low types compete with one another in Division 2. The problem for agent $m \in \{1, 2\}$ against agent $n \neq m \in \{1, 2\}$,[10] in Division d, at stage 1 is as follows:

$$\max_{e_{md1}^{n} \geq 0} \quad \frac{e_{md1}^{n}}{e_{md1}^{n} + e_{nd1}^{m}} \left(v_{d1} + W_{i12}^{-i}\right) + \left(1 - \frac{e_{md1}^{n}}{e_{md1}^{n} + e_{nd1}^{m}}\right) W_{i22}^{-i} - e_{md1}^{n}.$$

The Nash equilibrium effort level for type i in Division d at stage 1, $\hat{e}_{id1}^{i} \in \{\hat{e}_{h11}^{h}, \hat{e}_{l21}^{l}\}$, is the following:

$$\hat{e}_{id1}^{i} = \frac{(a_h + a_l)^2 v_{d1} + a_i^2 (v_{12} - v_{22})}{4(a_h + a_l)^2}.$$

Now that we have derived the equilibrium effort functions in each stage it is possible to calculate the total effort across both stages in the P&D contest, TE_{PD}, as follows:

$$\begin{aligned} TE_{PD} &= \underbrace{2\left(\hat{e}_{h11}^{h} + \hat{e}_{l21}^{l}\right)}_{\text{Stage 1 effort}} + \underbrace{\hat{e}_{h12}^{l} + \hat{e}_{l12}^{h} + \hat{e}_{h22}^{l} + \hat{e}_{l22}^{h}}_{\text{Stage 2 effort}} \\ &= \frac{\left(a_h^2 + a_l^2\right)(v_{11} + v_{21} + v_{12} - v_{22}) + 2a_h a_l \left(v_{11} + v_{21} + 2\left(v_{12} + v_{22}\right)\right)}{2(a_h + a_l)^2}. \end{aligned}$$

[10] We index with m and n instead of i and j as i and j relate to the agent's type rather than their identity. In stage 1, agents compete against the same type as themselves in both divisions.

2.2 Pooled contest

Suppose the principal decides to allow all four agents to compete with one another in one division over two stages, where the winner of the lottery contest in each stage of the game receives a prize $V = v_{1t} + v_{2t}$. The total prize size V represents the total budget the principal has to spend on prizes in each stage for all contest designs. The problem for type i at each stage is as follows:

$$\max_{e_i \geq 0} \quad \frac{a_i e_i}{a_h \sum_{m=1}^{2} e_m + a_l \sum_{n=3}^{4} e_n} V - e_i.$$

The Nash equilibrium effort level in each stage in the Pooled contest for type i, $\hat{e}_i^{PO} \in \{\hat{e}_h^{PO}, \hat{e}_l^{PO}\}$, is the following:

$$\hat{e}_i^{PO} = \frac{3a_{-i}\left(2a_i - a_{-i}\right)}{4(a_h + a_l)^2} V.$$

Note, the above equilibrium only holds if $a_h \leq 2a_l$. Otherwise, if $a_h > 2a_l$, then $\hat{e}_l^{PO} = 0$ and $\hat{e}_h^{PO} = \frac{V}{4}$ is the unique Nash equilibrium.

Now that we have derived the equilibrium effort functions for each stage it is possible to calculate the total effort across both stages in the Pooled contest, TE_{PO}, as follows:

$$\begin{aligned} TE_{PO} &= 2\left(2\left(\hat{e}_h^{PO} + \hat{e}_l^{PO}\right)\right) \\ &= \begin{cases} \frac{3\left(4a_h a_l - a_h^2 - a_l^2\right)}{(a_h + a_l)^2} V, & \text{if} \quad a_h \leq 2a_l, \\ \\ V, & \text{if} \quad a_h > 2a_l. \end{cases} \end{aligned}$$

2.3 Comparisons

Suppose the objective of the principal is to maximize total effort across divisions and across stages. After solving each of the two-stage games outlined earlier it is possible to derive the following.

Proposition 1: *Assume the principal is able to sort agents into divisions by ability in stage 1. In the P&D contest $(\hat{v}_{1t}, \hat{v}_{2t}) = (V, 0)$ for $t \in \{1, 2\}$, is an optimal prize allocation.*

The above result is in line with the proposition made in Moldovanu and Sela (2001), i.e. it is optimal to implement a single-prize contest. Given proposition 1 we assume $v_{1t} = V$ and $v_{2t} = 0$ for $t \in \{1, 2\}$ in the rest of the analysis. We also impose this prize allocation in our experimental design.

Proposition 2: *Assume the principal is able to sort agents into divisions by ability in stage 1. If ability differences are sufficiently small, the Pooled contest yields higher total effort than the P&D contest. If ability differences are sufficiently large, the P&D contest yields higher total effort than the Pooled contest.*

Proposition 2 can be explained intuitively. If the agents are very similar in ability, it is better to pool agents as you get higher effort when you have more agents engaged in competition. If abilities are quite different, agents with low ability will be discouraged from exerting effort. Hence, it is suboptimal to pool agents as you essentially only have two out of the four agents fully engaged in competition for the prize. Under such circumstances it would be better to sort agents into divisions by ability while allowing for promotion and demotion as you can generate higher levels of engagement from all four agents.

For proofs of all propositions see Appendix B.

Figure 1 illustrates the dissipation rate across the two types of contests.

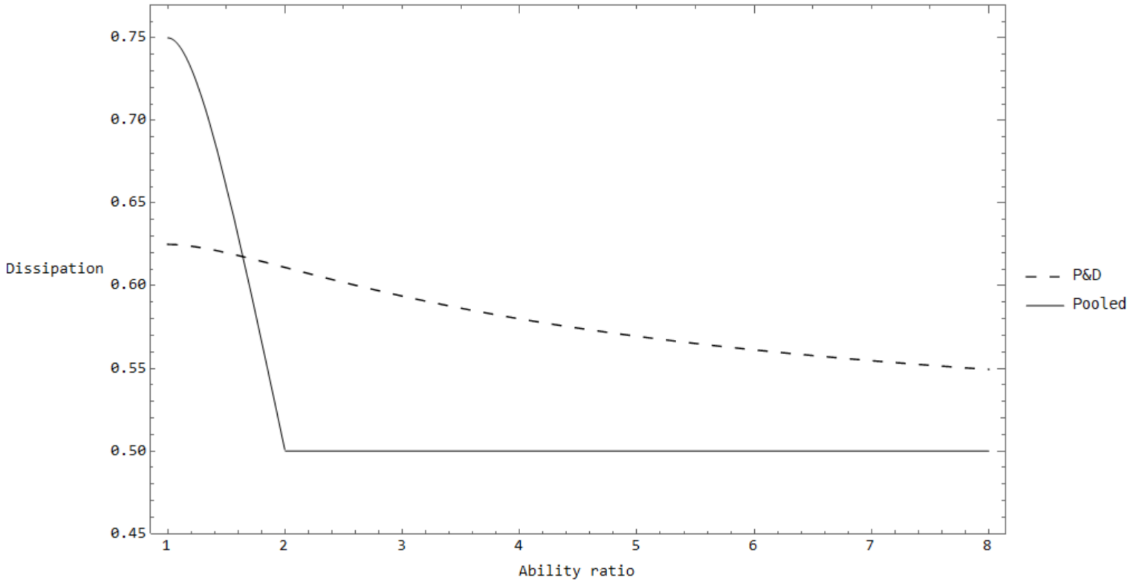

Figure 1: Dissipation rate comparison

The dissipation rate is simply the total effort divided by the total prize value across both stages, i.e., total effort divided by $2V$. Recall, the total prize value is equal across the two types of contests. Hence, the dissipation rate is essentially a proxy for total effort. The horizontal axis represents the ability ratio, which is simply a_h/a_l. As the ability ratio changes, we keep a_l constant. In line with proposition 2, we can see that total effort is lower (higher) in the Pooled contest than in the P&D contest when the ability ratio is sufficiently large (small).

2.4 Effect of joy of winning on effort

The theoretical analyses so far are based on the assumption that agents care only about the monetary value of the prizes. However, as discussed in the literature section, accumulated experimental evidence has suggested that individuals derive non-monetary utilities from winning in competitive environments such as contests, tournaments, and auctions. In this subsection we adopt an alternative specification to the standard economic model. This specification is similar in nature to what was examined in Goeree et al. (2002) and Sheremeta (2010b).[11] Suppose agents receive $v_{dt} + \omega_m$ in Division d at stage t when they win in the P&D contest and $V + \omega_m$ when they win in stage t in the Pooled contest, where

[11]This specification where monetary and non-monetary incentives are additively separable is also used in Frey and Oberholzer-Gee (1997) and DellaVigna and Pope (2018). See Bowles and Polanía-Reyes (2012) for an alternative, non-separable formulation.

ω_m is the joy of winning for agent m. The joy from winning that m receives in either contest depends on m's ability and the ability of m's strongest rival such that for $m \neq n$, the joy of winning is calculated as follows:

$$\omega_m = \frac{\max_{a_n \in a_{-m}} a_n}{a_m} w,$$

where $w > 0$ is a parameter for the joy of winning.[12] This specification indicates that agents receive a higher (lower) joy of winning when their strongest rival is of higher (lower) ability than themselves. Using the above expression for the joy of winning we can specify the joy of winning in each contest. In the P&D contest the joy of winning for type i in each division at stage t is the following:

$$\omega_i = \begin{cases} w, & \text{if} \quad t = 1, \\ \frac{a_{-i}}{a_i} w, & \text{if} \quad t = 2. \end{cases}$$

In the Pooled contest the joy of winning for type i in each stage is the following:

$$\omega_i = \frac{a_h}{a_i} w.$$

By substituting this alternative payoff structure into the utility functions outlined in subsections 2.1 and 2.2 we can derive the equilibrium total effort functions for both the P&D contest, TE^w_{PD}, and the Pooled contest, TE^w_{PO}. For an explicit derivation of these equilibrium total effort functions see Appendix E. For comparisons between the two contests when we allow for non-monetary utility of winning see hypotheses 1b and 2b in section 3.

3 Experimental design and procedures

The experiment implemented the lottery contests described in the previous section. For the treatments corresponding to the P&D contest, four participants competed across two divisions in a two-stage lottery contest. Two high ability participants were assigned to Division 1 and the remaining two low ability participants were assigned to Division 2 at the beginning of the game.[13] Participants in Division 1 competed for a prize of 100 Points, and participants in Division 2 competed for a prize of 0 Points, where 10 Points was equal to 1 AUD.[14] Effort provision was implemented in terms of investments in a lottery. Participants were told that they could buy a discrete number of lottery tickets in each stage. The lottery tickets purchased by the subjects as well as those purchased by their respective opponents in each stage were then said to be placed in the same "urn", of which one ticket was randomly drawn. The participant who purchased the ticket that

[12] We chose this relatively simple specification as it minimizes the number of parameters that need to be introduced. We have explored more general specifications, but we do not gain greater insights in our setup.

[13] This point does not apply to the treatment where abilities were homogeneous.

[14] Note, the incentive to exert effort for those placed in Division 2 was the prospect of being placed in Division 1 in stage 2 where they would be able to compete for a prize of significant value. The main reason we chose to implement this prize allocation was because it was optimal. However, we also wanted to remove any desire for participants to voluntarily demote themselves.

was randomly drawn received a prize equal to 100 Points if they were in Division 1, or 0 Points if they were in Division 2. Participants were informed of the ability level of the other participants who they competed with in each stage prior to making their decision. To capture ability differences in the experiment we used the following approach. Suppose the ability levels for low types and high types was $(a_l, a_h) = (1, 2)$. The low types would have been told that each Point they invest bought them 10 lottery tickets and the high types would have been told that each Point they invest bought them 20 lottery tickets. This was also made common knowledge among participants.

For the treatments where we implemented the P&D contest, the process in stage 2 was very similar to that in stage 1, except the participants who changed division after stage 1 would compete for a different prize in stage 2. Moreover, in stage 2 of the heterogeneous ability treatment participants would compete against participants with different ability levels. In all treatments participants received an endowment of 100 Points in each stage which they could use to purchase lottery tickets. Note, it was not possible for participants to transfer the remainder of their endowment from one stage to another stage.

For the treatments corresponding to the Pooled contest, all four participants (comprising of two high and two low types) were placed in the same division where they competed with each other in two identical lottery contests, each with a prize of 100 Points.

To summarize, the experiment followed a between subject design with 4 treatments in total. The two dimensions that varied were the following:

1. The contest design: P&D, Pooled
2. The ability difference: $(a_l, a_h) \in \{(1, 1), (1, 2)\}$[15]

Table 1 provides a summary of the treatments.

Table 1: Summary of treatments and sessions

Contest	(a_l, a_h)	**Number of Sessions**	**Total Participants**	**Number of Periods**
P&D	$(1, 1)$	5	72	20
Pooled	$(1, 1)$	5	76	20
P&D	$(1, 2)$	5	76	20
Pooled	$(1, 2)$	5	80	20

Each participant's ability level was fixed, and they played the same two-stage game 20 times. This enabled us to determine whether participants converged towards the Nash predictions over time. Participants were randomly assigned to four person groups for every two-stage game. After each stage, participants in all treatments received feedback about their own decision, the decision of the other three members of their group and their own payoff. To avoid wealth effects, the participants were told that one period (out of 20) would be chosen randomly and paid out at the end of the experiment. To avoid framing effects the instructions were written in neutral language. For example, instead of saying

[15] In real terms, the homogeneous treatments simulate settings where productivity varies minimally. This is the case for menial jobs, e.g., sending invoices out to customers or ticket collection at movie theatres.

that we will **demote** a **high type** participant from **Division 1** to **Division 2** we would say that we will **move** a **type A** participant from the **Blue division** to the **Red division**.

The procedures in every experimental session were as follows. First, the participants received some general information about the experimental session. Then, participants were asked to read the instructions for one of the two-stage contests with four players as described above. After each participant confirmed that they understood the instructions, they answered a set of control questions to ensure that they had fully understood the instructions (which are available in Appendix F). Furthermore, participants had one practice period of play. Only after participants had completed all the preliminary steps did the first real decision period start. Upon completion of the 20 real periods of play participants were informed about their payoff for this part of the experiment.

The main part of the experiment was followed by three tasks where subjects' risk aversion, loss aversion and ambiguity aversion were elicited using list methods. During each task, subjects were presented with a list of 21 choices between a lottery and a sure amount of money, constructed in such a way that a subject preferring more money to less would have a unique point at which they were willing to switch from the draw to the sure amount. In the risk task, the lottery $(\$0, \$2.00; 0.5, 0.5)$, and the sure amounts of money increased from \$0 to \$2.00, in 10 cent increments. In the loss task, the lotteries were $(-\$x, \$2.00; 0.5, 0.5)$, where x changed from \$0 to \$2.00 in 10 cent increments, and the sure amount of money was always \$0. Finally, in the ambiguity task the lottery was $(\$0, \$2.00; p, 1-p)$, where, unbeknownst to subjects, p was randomly drawn from the uniform distribution on [0,1], and the sure amounts were the same as in the risk task. The three tasks were presented to subjects in a random order, without feedback, and one of them was randomly selected for actual payment.

Participants were also asked to complete a short demographic survey. At the end of each session participants were informed about their overall payoff in the experiment. A total of 304 subjects participated across the 20 computerized sessions using the oTree software package (Chen et al. 2016). All 304 participants were students from the University of Technology Sydney (UTS). The experiment was conducted online using Zoom (a video conferencing service). Participants were recruited via ORSEE (Greiner 2015). Each session lasted between 1 to 1.5 hours, and participants earned on average 26.58 AUD (including the 8 AUD show-up fee).

3.1 Predictions

Given $(v_{1t}, v_{2t}) = (100, 0)$, $(a_l, a_h) \in \{(1, 1), (1, 2)\}$ we have the following equilibrium predictions across treatments.

Table 2: Equilibrium total effort across treatments

<table>
<tr><td rowspan="3"></td><td colspan="4">Standard economic model, $w = 0$</td><td colspan="4">Behavioural model, $w \in [46, 121]$</td></tr>
<tr><td colspan="2">$(a_l, a_h) = (1, 1)$</td><td colspan="2">$(a_l, a_h) = (1, 2)$</td><td colspan="2">$(a_l, a_h) = (1, 1)$</td><td colspan="2">$(a_l, a_h) = (1, 2)$</td></tr>
<tr><td>P&D</td><td>Pooled</td><td>P&D</td><td>Pooled</td><td>P&D</td><td>Pooled</td><td>P&D</td><td>Pooled</td></tr>
<tr><td>Total effort stage 1</td><td>75</td><td>75</td><td>78</td><td>50</td><td>[121, 196]</td><td>[110, 166]</td><td>[112, 178]</td><td>[103, 189]</td></tr>
<tr><td>Total effort stage 2</td><td>50</td><td>75</td><td>44</td><td>50</td><td>[96, 171]</td><td>[110, 166]</td><td>[103, 193]</td><td>[103, 189]</td></tr>
<tr><td>Total effort across all stages</td><td>125</td><td>150</td><td>122</td><td>100</td><td>[217, 367]</td><td>[219, 332]</td><td>[215, 371]</td><td>[207, 378]</td></tr>
</table>

Note: The values left of the comma correspond to $w = 46$ and the values right of the comma correspond to $w = 121$ in the above table.

When $(a_l, a_h) = (1, 2)$ and $w = 0$ the total effort exerted across both stages in the Nash equilibrium is 100 in the Pooled contest. This is 22% less effort than the principal could yield at no extra cost by employing the P&D contest.

From Table 2 we can obtain the following hypotheses.

Hypothesis 1a: If $(a_l, a_h) = (1, 1)$ and $w = 0$, the Pooled contest yields higher total effort than the P&D contest.

Hypothesis 2a: If $(a_l, a_h) = (1, 2)$ and $w = 0$, the P&D contest yields higher total effort than the Pooled contest.

Hypotheses 1a and 2a were derived using the standard economic model, i.e., $w = 0$. However, evidence from several studies suggests that $w > 0$. The following table provides an overview of estimates for the joy of winning parameter, w, from studies where data was obtainable.

Table 3: Overview of estimates for the joy of winning parameter (w)

Paper	**Estimated joy of winning parameter (w)**	**Endowment (E)**	**w/E**
Sheremeta (2010b)	62.9	120	0.52
Price and Sheremeta (2015)	48.53	40	1.21
Mago et al. (2016)	$[36.8, 57.6]$	80	$[0.46, 0.72]$
Cason et al. (2020)	$[59.72, 85.96]$	100	$[0.60, 0.86]$

Note: In Mago et al. (2016) and Cason et al. (2020) we were only able to obtain boundary estimates.

The studies listed in the above table have estimated the joy of winning to be between 46% and 121% of the endowment.[16] By allowing for the value of w to be between these bounds, we can derive the following alternative hypotheses.

Hypothesis 1b: If $(a_l, a_h) = (1, 1)$ and $w > 50$, the P&D contest yields higher total effort than the Pooled contest.

Hypothesis 2b: If $(a_l, a_h) = (1, 2)$ and $w \geq 82.8$, the P&D contest does not yield higher total effort than the Pooled contest.

[16] The endowment varied in each of the studies listed in Table 3. Participants may bid more aggressively if they have more funds available to spend. We developed a normalized value for the joy of winning parameter, w, by dividing it by the endowment, E.

4 Results

4.1 Total effort

In this subsection we investigate the differences in total effort across all experimental treatments. The following figures illustrate the total effort level for each contest design when abilities were homogeneous, i.e., $(a_l, a_h) = (1, 1)$ and heterogeneous, i.e., $(a_l, a_h) = (1, 2)$. The left side of each figure indicates the predicted and actual average total effort level across all 20 periods for each treatment. The right side of each figure shows how total effort varied from period to period. The error bars represent 95% confidence intervals.

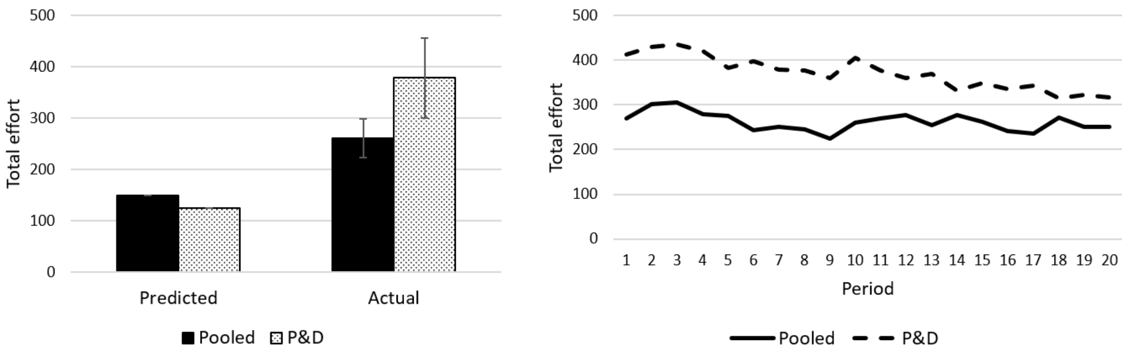

Figure 2: Total effort – Homogeneous

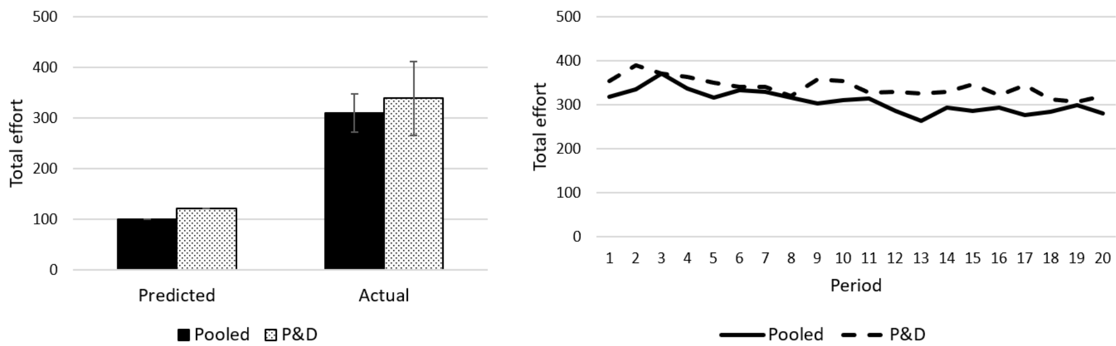

Figure 3: Total effort – Heterogeneous

Each session we ran counts as an independent observation, so we have 5 independent observations relating to total effort per treatment. We examine the theoretical predictions by conducting non-parametric tests. See Table 4 for a comparison of total effort across treatments.

Table 4: Treatment comparison – Total effort

	Homogeneous		**Heterogeneous**	
	Pooled	P&D	Pooled	P&D
Mean	261.14	378.33	310.46	339.35
Std. Err.	13.75	28.08	13.75	26.33
No. of Sessions	5	5	5	5

Result 1: *Total effort was significantly higher in the P&D contest than the Pooled contest*

when abilities were homogeneous.

Support: When participants were homogeneous, total effort in the P&D contest was 378.33, approximately 45% higher than total effort in the Pooled contest which was 261.14 (see Table 4). A two-sided Mann-Whitney U test indicates significantly higher total effort in the P&D contest than in the Pooled contest when participants were homogeneous (Mann-Whitney U test: p-value = 0.0163). A sample size calculation confirms that the number of independent observations we have per treatment ($n = 5$) is sufficient to obtain 80% power with a standard 0.05 alpha error probability.

Result 2: *There was no significant difference in total effort between the two contests when abilities were heterogeneous.*

Support: When participants were heterogeneous, total effort in the P&D contest was 339.35, approximately 9% higher than total effort in the Pooled contest which was 310.46 (see Table 4). A two-sided Mann-Whitney U test indicates no significant difference in total effort between the P&D contest and the Pooled contest when participants were heterogeneous (Mann-Whitney U test: p-value = 0.4647).

Results 1 and 2 are at odds with hypotheses 1a and 2a and are consistent with hypotheses 1b and 2b. Recall, in subsection 2.4 we allowed for agents to receive non-monetary utility from winning. If we let the joy of winning parameter w be equal to 82.8, we can generate the following predictions with respect to total effort in each treatment.

Table 5: Predicted total effort across treatments when $w = 82.8$

	Homogeneous	**Heterogeneous**
P&D	290.60	291.30
Pooled	274.20	291.30

Note, $w = 82.8$ is within the bounds outlined in Table 2, (i.e., 46 and 121). This parametrization yields predictions which are consistent with both results 1 and 2. In other words, it enables us to simultaneously explain why we observed higher total effort in the P&D contest than in the Pooled contest when abilities were homogeneous, and no difference in total effort across the two contests when abilities were heterogeneous.

4.2 Individual effort

4.2.1 Effect of being promoted or demoted on individual effort

To observe the impact of being promoted (demoted), we compare effort in stage 2 for those in Division 1 (Division 2).[17] The key variable of interest is whether participants were in Division 1 in stage 1 (Div11 in Table 6). With this approach we avoid self-selection bias as both players must win (lose) in stage 1 to play in Division 1 (Division 2) in stage 2. We are comparing effort for players within the same division so the prize they are competing for is the same. One could argue that participants who won in Division 1 in stage 1 may be less

[17] In this subsection we look at individual effort in the P&D contest in stage 2 in both the homogeneous and heterogeneous treatments. The standard economic model predicts no difference in effort exertion between high and low ability participants in either division in stage 2. Hence, introducing ability differences does not influence our null hypothesis.

willing to compete in stage 2 simply because they have already accumulated a significant amount of money. To control for this wealth heterogeneity, we include the participant's payoff in stage 1 (Payoff1 in Table 6) as an independent variable in the estimation. We have also included covariates relating to age, gender, ethnicity and major in the estimation that follows. We ran a Tobit regression, clustering errors at the session level. See Table 6 for the results from the estimation process.

Table 6: Stage 2 individual effort

	Homogeneous		**Heterogeneous**	
Variable	Division 1	Division 2	Division 1	Division 2
Div11	49.209***	7.311	50.948***	-2.870
	(12.563)	(4.996)	(5.556)	(5.072)
Payoff1	-0.666***	-0.755***	-0.610***	-0.473***
	(0.096)	(0.041)	(0.079)	(0.095)
Age	-0.249	1.866***	-0.093	0.342
	(0.404)	(0.663)	(0.234)	(0.595)
Female	-1.328	14.988*	6.859*	5.638
	(3.585)	(8.055)	(3.766)	(5.665)
Asian	-0.361	-0.314	-3.058	-7.914**
	(0.802)	(6.927)	(4.209)	(3.641)
Econ or Fin Major	7.409	5.273	9.956***	-5.894
	(7.431)	(8.571)	(3.199)	(5.693)
Constant	106.184***	17.430	86.955***	47.647***
	(9.777)	(13.773)	(9.526)	(16.243)
No. of observations	720	720	760	760

Note: Dependent variable is individual effort in either Division 1 or Division 2 at stage 2 in the P&D contest. Tobit regression where the lower limits and upper limits on the dependent variables are 0 and 100 respectively. Errors are clustered at the session level. *** $p < 0.01$, * $p < 0.05$, * $p < 0.1$. Robust standard errors in parentheses.

Result 3: *Promotion had a negative effect on individual effort, while demotion had no effect on individual effort.*

Support: In the above estimation Div11 is equal to 1 if the participant was in Division 1 in stage 1, otherwise, it equals 0. The coefficients of Div11 in columns 2 and 4 of Table 6 are positive and statistically significant at the 1% level. This suggests that participants who were already in Division 1 chose a significantly higher effort level than individuals who were promoted from Division 2 to Division 1. The coefficients of Div11 in columns 3 and 5 of Table 6 are not statistically significant. This suggests that participants who were demoted from Division 1 to Division 2 did not choose a significantly different effort level to individuals who were already in Division 2. Note, result 3 does not change when we control for risk and ambiguity preferences, nor if we include time fixed effects.

The predictions from the standard economic model suggest that individual effort should not be affected by promotion or demotion in both the homogeneous and heterogeneous treatments. Hence, the fact that the observed effect of promotion was negative comes as a surprise. Those who began in Division 2 were potentially more complacent than those who began in Division 1. Promoted participants might have been satisfied with their achievement and in turn chose less effort than those who were in Division 1 to begin with. Contrary to popular belief, demotion did not discourage effort exertion.

4.2.2 Determinants of individual effort

In this subsection we again focus on effort at the individual level within the treatments pertaining to the P&D contest. For more details about how participants behaved relative to the equilibrium predictions in all treatments refer to the tables in Appendix C. We investigate the determinants of individual level effort in the P&D contest by running a Tobit regression, clustering errors at the session level. We study whether the division participants were in and whether a participant was a high type explain effort choices. We have also included covariates relating to age, gender, ethnicity, major, measures of risk aversion (in both the gain and loss domains) and ambiguity aversion in the estimation that follows. See Table 7 for the results from the estimation process.

Table 7: Factors influencing individual effort across stages

	Homogeneous		**Heterogeneous**	
Variable	Stage 1	Stage 2	Stage 1	Stage 2
Division 1	21.647***	41.666***	26.880***	36.410***
	(3.434)	(7.242)	(6.853)	(4.067)
High ability				9.481*
				(4.941)
Division 1 × High ability				-6.680
				(4.836)
Age	-0.091	0.469	-0.140	0.105
	(0.622)	(0.689)	(0.471)	(0.568)
Female	12.678**	10.984	4.609	7.169
	(6.331)	(7.562)	(4.630)	(4.454)
Asian	-8.381	-2.980	-6.716	-9.117**
	(6.559)	(5.110)	(6.112)	(4.262)
Econ or Fin Major	13.057	11.696	5.344	4.206
	(10.778)	(11.771)	(7.003)	(4.130)
Gain	0.709	0.296	0.990	0.125
	(0.924)	(0.886)	(1.040)	(0.998)
Loss	0.396	0.825	0.322**	0.261
	(0.438)	(0.510)	(0.159)	(0.251)
Ambiguity	0.177	0.247	-0.286	0.028
	(0.446)	(0.558)	(0.544)	(0.532)
Constant	17.235	-12.722	22.293	10.331
	(20.626)	(20.725)	(14.327)	(16.461)
No. of observations	1440	1440	1520	1520

Note: Dependent variable is individual effort in either stage 1 or stage 2 in the P&D contest. Tobit regression where the lower limits and upper limits on the dependent variables are 0 and 100 respectively. Errors are clustered at the session level. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. Robust standard errors in parentheses.

Result 4: *Participants chose significantly higher effort levels in Division 1 than in Division*

2.

Support: The coefficient estimates for Division 1 in Table 7 are positive and statistically significant at the 1% level. This result is in line with the theoretical predictions.

According to the standard economic model, a participant's effort choice in stage 2 should not be affected by their own ability. Although we do observe an effect of a participant's own ability on effort in stage 2, it is a weak effect, i.e., the coefficient estimate for effort in stage 2 is positive and statistically significant at the 10% level.

Result 5: *Participants chose a positive level of effort in Division 2 at stage 2.*

Support: The average level of effort chosen in Division 2 at stage 2 across both P&D treatments was 25.99. We estimated a simple panel regression for each treatment, where the dependent variable was effort in Division 2 at stage 2 and the independent variables were a constant and session dummy-variables. The model included a random effects error structure, clustering standard errors at the session level. We found that for both treatments with promotion and demotion the constant estimates were significantly higher than 0 (p-value < 0.05).

Result 5 suggests that participants in Division 2 at stage 2 chose positive effort even though they had no chance of being promoted and they were competing for a prize with no monetary value. This result supports the notion that individuals derive non-monetary utility from winning, as highlighted in Sheremeta (2010b). In the P&D treatment with homogeneous players, the average level of effort chosen in Division 2 at stage 2 was 26.63 (see Table C.1). This implies a joy of winning parameter value of approximately 106.52 (i.e., $\tilde{e}_{22} = w/4 \Rightarrow w/4 = 26.63 \Rightarrow w = 106.52$).

In both the homogeneous and heterogeneous treatments age, major, risk preferences over the gain domain and ambiguity preferences did not affect individual effort in the P&D contest. However, females chose significantly higher effort than males in stage 1 in the P&D contest when abilities were homogeneous. Furthermore, Asians chose significantly lower effort in stage 2 and participants who exhibited lower levels of risk aversion over the loss domain chose significantly higher effort in stage 1 in the P&D contest when abilities were heterogeneous.

5 Conclusion

Performance-based promotion and demotion prevails in a variety of settings, such as organizations, education, and sports. Prior to conducting this research, the efficacy of promotion and demotion in incentivizing effort was unclear. On the one hand, promotion is generally perceived to be effective in fostering effort within organizations. On the other hand, managers may avoid demoting subordinates as it may demotivate performances in the future.

This paper investigated promotion and demotion within a two-stage lottery contest framework. We developed two competing theoretical models to generate predictions about behaviour: (i) the standard economic model and (ii) a behavioural model where agents derive non-monetary utility from winning. In our experiment the P&D contest outperformed the Pooled contest when abilities were homogeneous. However, the P&D contest did not outperform the Pooled contest when abilities were heterogeneous. We can reconcile our empirical results with the predictions made by the behavioural model.

Our findings have direct policy implications for management practices in settings where contests are already used to incentivize effort, for example organizations that implement the "Employee of the Month" award. To elicit higher effort among agents, we recommend that the principal subdivides agents and implement some form of promotion and demotion, if they observe a sufficiently low level of heterogeneity in abilities. Furthermore, the experimental results suggest that demotion does not affect effort exertion. Hence, the recommendation for managers to refrain from demoting employees as it reduces their motivation might have no empirical basis.

The theoretical model developed in this paper can be extended in several ways. For instance, the game consists of two stages, although, in many situations the duration of the game may be longer or indefinite. It would be worthwhile studying how varying the number of stages in the game determines the efficacy of promotion and demotion in contests. In this paper the principal assigns agents to one of two divisions based on their ability. In reality the principal may choose to allocate agents across more than two divisions. Developing a theoretical framework where the principal can select the number of divisions could be an interesting direction for future research.

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A P&D contest without initial sorting of abilities

In this section we assume the principal is unable to sort agents into divisions by ability. Instead, they randomly assign agents to divisions in stage 1. All other aspects of the model are the same as in subsection 2.1.

A.1 Equilibrium in stage 2

In stage 2 there are three possible pairings across the two divisions. We could have both high types in Division 1, both low types in Division 1 or a high and a low type in both divisions. The problem for type i against type j, in Division d, at stage 2 is as follows:

$$\max_{e^j_{id2} \geq 0} \quad \frac{a_i e^j_{id2}}{a_i e^j_{id2} + a_j e^i_{jd2}} v_{d2} - e^j_{id2}.$$

The Nash equilibrium effort level for type i against type j, in Division d, at stage 2, $\hat{e}^j_{id2} \in \{\hat{e}^h_{h12}, \hat{e}^l_{h12}, \hat{e}^h_{l12}, \hat{e}^l_{l12}, \hat{e}^h_{h22}, \hat{e}^l_{h22}, \hat{e}^h_{l22}, \hat{e}^l_{l22}\}$ is as follows:

$$\hat{e}^j_{id2} = \frac{a_i a_j v_{d2}}{(a_i + a_j)^2}.$$

The equilibrium payoff for type i against type j, in Division d, at stage 2, W^j_{id2} is as follows:

$$W^j_{id2} = \frac{a_i^2 v_{d2}}{(a_i + a_j)^2}.$$

A.2 Equilibrium in stage 1

When the principal randomly assigns agents to divisions at the beginning of the game there are three possible assignments. We could have (i) both high types in Division 1, (ii) both low types in Division 1 or (iii) a high and a low type in both divisions. The total effort for cases (i) and (ii) is equivalent to what we calculated in subsection 2.1. Consequently, we will focus on deriving the equilibrium for case (iii) where both high types and low types are assigned to each division. The problem for type i against type $-i$, in Division d, at stage 1 is as follows:

$$\max_{e^{-i}_{id1} \geq 0} \quad \frac{a_i e^{-i}_{id1}}{a_i e^{-i}_{id1} + a_{-i} e^i_{-id1}} \left(v_{d1} + P^{-i}_{i12}\right) + \left(1 - \frac{a_i e^{-i}_{id1}}{a_i e^{-i}_{id1} + a_{-i} e^i_{-id1}}\right) P^{-i}_{i22} - e^{-i}_{id1},$$

where,

$$P^{-i}_{i12} = \frac{a_i e^{-i}_{i-d1}}{a_i e^{-i}_{i-d1} + a_{-i} e^i_{-i-d1}} \frac{v_{12}}{4} + \left(1 - \frac{a_i e^{-i}_{i-d1}}{a_i e^{-i}_{i-d1} + a_{-i} e^i_{-i-d1}}\right) \frac{a_i^2 v_{12}}{(a_i + a_{-i})^2},$$

and,

$$P^{-i}_{i22} = \frac{a_i e^{-i}_{i-d1}}{a_i e^{-i}_{i-d1} + a_{-i} e^i_{-i-d1}} \frac{a_i^2 v_{22}}{(a_i + a_{-i})^2} + \left(1 - \frac{a_i e^{-i}_{i-d1}}{a_i e^{-i}_{i-d1} + a_{-i} e^i_{-i-d1}}\right) \frac{v_{22}}{4}.$$

Note, the first part of P_{i12}^{-i} represents the expected payoff that type i receives in stage 2 if the type i agent in the other division, $-d$, wins the contest in stage 1. The second part of P_{i12}^{-i} represents the expected payoff that type i receives in stage 2 if the type i agent in the other division, $-d$, does not win the contest in stage 1. These descriptions can also be applied to the expressions which constitute P_{i22}^{-i}.

Without loss of generality normalize $a_l = 1$. For simplicity assume the prize in Division 2 in both stages is 0 and the prize in Division 1 in both stages is V. For the case where high and low types are assigned to both divisions in stage 1, the Nash equilibrium effort level for type i against type $-i$, in Division d, at stage 1, $\hat{e}_{id1}^{-i} \in \{\hat{e}_{h11}^{l}, \hat{e}_{l11}^{h}, \hat{e}_{h21}^{l}, \hat{e}_{l21}^{h}\}$ is the following:

$$\begin{aligned}\hat{e}_{h11}^{l} = &\frac{1}{50(a_h-1)(a_h+1)^4(3a_h^2+2a_h+3)^3}\Big(1375a_h^{10}+4275a_h^9+8027a_h^8+12692a_h^7\\&+9934a_h^6+2154a_h^5+454a_h^4-668a_h^3-253a_h^2+235a_h+175-X(5a_h^6-89a_h^5+43a_h^4\\&+232a_h^3+173a_h^2+81a_h+35)\Big)V,\end{aligned}$$

$$\begin{aligned}\hat{e}_{l11}^{h} = &-\frac{1}{50(a_h-1)(a_h+1)^4(3a_h^2+2a_h+3)^3}(175a_h^{11}+235a_h^{10}-253a_h^9-668a_h^8+454a_h^7\\&+2154a_h^6+9934a_h^5+12692a_h^4+8027a_h^3+4275a_h^2+1375a_h-X\Big(35a_h^7+81a_h^6\\&+173a_h^5+232a_h^4+43a_h^3-89a_h^2+5a_h)\Big)V,\end{aligned}$$

$$\begin{aligned}\hat{e}_{h21}^{l} = &\frac{1}{10(a_h-1)(a_h+1)^7(3a_h^2+2a_h+3)^3}\Big(-80a_h^{13}-1237a_h^{12}-7441a_h^{11}-23705a_h^{10}\\&-48503a_h^9-77932a_h^8-102570a_h^7-101794a_h^6-75742a_h^5-45341a_h^4-20789a_h^3\\&-5941a_h^2-875a_h-50+X(16a_h^9+175a_h^8+669a_h^7+1217a_h^6+1361ah^5+1275a_h^4\\&+1031a_h^3+523a_h^2+123a_h+10)\Big)V,\end{aligned}$$

$$\begin{aligned}\hat{e}_{l21}^{h} = &\frac{1}{10(a_h-1)(a_h+1)^4(3a_h^2+2a_h+3)^3}\Big(50a_h^{11}+725a_h^{10}+3616a_h^9+7716a_h^8+10620a_h^7\\&+17118a_h^6+10864a_h^5+8004a_h^4+4210a_h^3+997a_h^2+80a_h-X(10a_h^7+93a_h^6+214a_h^5\\&+100a_h^4+240a_h^3+127a_h^2+16a_h)\Big)V,\end{aligned}$$

where,

$$X = \sqrt{25a_h^8+260a_h^7+804a_h^6+1084a_h^5+2054a_h^4+1084a_h^3+804a_h^2+260a_h+25}\ .$$

A.3 Calculating total effort without initial sorting of abilities

Now that we have expressions for equilibrium effort in stage 1, we can calculate total effort across divisions and stages in the P&D contest when the principal assigns high and low types to both divisions in stage 1, TE^{hl}_{PD}, as follows:

$$
\begin{aligned}
TE^{hl}_{PD} = &\frac{1}{50(a_h+1)^4(3a_h^2+2a_h+3)^3}\Big(1800a_h^{10} + 15610a_h^9 + 50328a_h^8 + 104728a_h^7 + 158816a_h^6 \\
&+ 207836a_h^5 + 158816a_h^4 + 104728a_h^3 + 50328a_h^2 + 15610a_h + 1800 - X(225a_h^6 + 764a_h^5 \\
&+ 1087a_h^4 + 328a_h^3 + 1087a_h^2 + 764a_h + 225)\Big)V.
\end{aligned}
$$

The game consists of two high and two low ability agents, of which two are randomly assigned to Division 1 in stage 1. The probability that both high ability agents are assigned to Division 1 in stage 1 is $1/6$, which is equal to the probability that both low ability agents are assigned to Division 1 in stage 1. Therefore, total effort in the P&D contest when the principal is unable to sort agents into divisions by ability in stage 1, TE^{r}_{PD}, is as follows:

$$TE^{r}_{PD} = \frac{1}{6}TE^{hh}_{PD} + \frac{1}{6}TE^{ll}_{PD} + \frac{2}{3}TE^{hl}_{PD},$$

where TE^{hh}_{PD} represents total effort when both high types are assigned to Division 1 in stage 1 and TE^{ll}_{PD} represents total effort when both low types are assigned to Division 1 in stage 1. Since TE^{hh}_{PD} and TE^{ll}_{PD} are equal to our calculation of total effort in subsection 2.1, TE^{r}_{PD} can be expressed as follows:

$$TE^{r}_{PD} = \frac{1}{3}TE_{PD} + \frac{2}{3}TE^{hl}_{PD}.$$

Hence, equilibrium total effort for the case where the principal is unable to sort agents into divisions by ability in stage 1, TE^{r}_{PD}, as follows:

$$
\begin{aligned}
TE^{r}_{PD} = &\frac{1}{3}TE_{PD} + \frac{2}{3}TE^{hl}_{PD} \\
= &\frac{1}{75(a_h+1)^4(3a_h^2+2a_h+3)^3}\Big(2475a_h^{10} + 20335a_h^9 + 65403a_h^8 + 136428a_h^7 + 207066a_h^6 \\
&+ 262986a_h^5 + 207066a_h^4 + 136428a_h^3 + 65403a_h^2 + 20335a_h + 2475 - X(225a_h^6 + 764a_h^5 \\
&+ 1087a_h^4 + 328a_h^3 + 1087a_h^2 + 764a_h + 225)\Big)V,
\end{aligned}
$$

where,

$$X = \sqrt{25a_h^8 + 260a_h^7 + 804a_h^6 + 1084a_h^5 + 2054a_h^4 + 1084a_h^3 + 804a_h^2 + 260a_h + 25}\ .$$

Proposition 3: *Assume the principal is not able to sort agents into divisions by ability in stage 1. If ability differences are sufficiently large but not too large, the P&D contest yields higher total effort than the Pooled contest. Otherwise, the Pooled contest yields higher total effort than the P&D contest.*

Unlike in proposition 2, our third proposition states that the Pooled contest yields higher total effort than the P&D contest when ability differences are very large. When the principal cannot sort agents into divisions by ability, there is a high probability that the principal assigns one high and one low ability agent to Division 1 in stage 1. Consequently, two agents with very different abilities will compete for the prize in the P&D contest in stage 1 and possibly stage 2 as well. Whereas in the Pooled contest, you will have two agents with the same ability competing for the prize in both stages, thus, competition will be fiercer in the Pooled contest. This is because the “encouragement effect” of having promotion and demotion across stages is outweighed by the “discouragement effect” of having asymmetric competition for the prize in Division 1 when ability differences are very large. This “discouragement effect” can be reduced considerably when the principal is able to sort agents into divisions by ability in stage 1.

B Proofs

Proof of proposition 1. Recall, the principal's primary concern is to maximize total effort across divisions and stages. After adding the equilibrium effort functions for each stage of play, we derive the following equilibrium total effort function for the P&D contest when the principal can sort agents into divisions by ability in stage 1:

$$TE_{PD} = \frac{\left(a_h^2 + a_l^2\right)\left(v_{11} + v_{21} + v_{12} - v_{22}\right) + 2a_h a_l \left(v_{11} + v_{21} + 2\left(v_{12} + v_{22}\right)\right)}{2(a_h + a_l)^2}.$$

Let V be the total prize budget available to the principal in each stage of the game. The principal's objective is to maximize total effort; hence, they face the following problem:

$$\begin{aligned}
\max_{v_{11}, v_{21}, v_{12}, v_{22}} \quad & \frac{\left(a_h^2 + a_l^2\right)\left(v_{11} + v_{21} + v_{12} - v_{22}\right) + 2a_h a_l \left(v_{11} + v_{21} + 2\left(v_{12} + v_{22}\right)\right)}{2(a_h + a_l)^2} \\
\text{s.t.} \quad & v_{11} + v_{21} = V \\
& v_{12} + v_{22} = V \\
& v_{11}, v_{21}, v_{12}, v_{22} \geq 0.
\end{aligned}$$

Without loss of generality normalize $V = 1$ and $a_l = 1$. After substituting our constraints into the objective function the principal solves the following:

$$\begin{aligned}
\max_{v_{12}} \quad & \frac{3a_h}{(a_h + 1)^2} + \frac{a_h^2 + 1}{(a_h + 1)^2} v_{12} \\
\text{s.t.} \quad & v_{12} \geq 0.
\end{aligned}$$

Clearly the principal maximizes the above objective by setting $(v_{12}, v_{22}) = (V, 0)$. Any allocation of v_{11} and v_{21} such that $v_{11} + v_{21} = V$ is optimal. Therefore, allocating the total prize budget to Division 1 in each stage is an optimal prize allocation in the P&D contest.

□

Proof of proposition 2. Without loss of generality normalize $a_l = 1$. Assume the prize in Division 2 in both stages is 0 and the prize in Division 1 in both stages is V. We showed this prize allocation was optimal in the proof of proposition 1.

The equilibrium total effort functions for the Pooled contest, TE_{PO}, and P&D contest when the principal can sort agents by ability, TE_{PD}, are as follows:

$$TE_{PO} = \begin{cases} \frac{3\left(4a_h - a_h^2 - 1\right)}{(a_h+1)^2} V, & \text{if } \ a_h \leq 2, \\ V, & \text{if } \ a_h > 2, \end{cases} \qquad \text{and} \qquad TE_{PD} = \frac{a_h^2 + 3a_h + 1}{(a_h + 1)^2} V.$$

Case 1: Let $a_h \in [1,2]$.

Subtracting TE_{PO} from TE_{PD} we get the following:

$$TE_{PD} - TE_{PO} = \frac{4a_h^2 - 9a_h + 4}{(a_h+1)^2} V > 0 \quad \text{if} \quad a_h > 1.64.$$

Therefore, total effort is higher in the P&D contest when $a_h > 1.64a_l$.

Case 2: Let $a_h > 2$.

Subtracting TE_{PO} from TE_{PD} we get the following:

$$TE_{PD} - TE_{PO} = \frac{a_h}{(a_h+1)^2} V > 0 \quad \text{for all} \quad a_h > 0.$$

Therefore, when the principal can sort agents by ability, total effort is higher in the P&D contest if $a_h > 1.64a_l$. Otherwise, total effort is higher in the Pooled contest.

□

Proof of proposition 3. Without loss of generality normalize $a_l = 1$. Assume the prize in Division 2 in both stages is 0 and the prize in Division 1 in both stages is V.

The equilibrium total effort functions for the Pooled contest, TE_{PO}, and P&D contest when the principal is unable to sort agents by ability, TE^r_{PD}, are as follows:

$$TE_{PO} = \begin{cases} \frac{3\left(4a_h - a_h^2 - 1\right)}{(a_h+1)^2} V, & \text{if} \quad a_h \leq 2, \\ V, & \text{if} \quad a_h > 2, \end{cases}$$

$$\begin{aligned} TE^r_{PD} = \frac{1}{75(a_h+1)^4(3a_h^2+2a_h+3)^3} \Big(& 2475a_h^{10} + 20335a_h^9 + 65403a_h^8 + 136428a_h^7 + 207066a_h^6 \\ & + 262986a_h^5 + 207066a_h^4 + 136428a_h^3 + 65403a_h^2 + 20335a_h + 2475 - X(225a_h^6 + 764a_h^5 \\ & + 1087a_h^4 + 328a_h^3 + 1087a_h^2 + 764a_h + 225) \Big) V, \end{aligned}$$

where,

$$X = \sqrt{25a_h^8 + 260a_h^7 + 804a_h^6 + 1084a_h^5 + 2054a_h^4 + 1084a_h^3 + 804a_h^2 + 260a_h + 25}\ .$$

Case 1: Let $a_h \in [1,2]$.

Subtracting TE_{PO} from TE^r_{PD} we get the following:

$$\begin{aligned} TE^r_{PD} - TE_{PO} = \frac{1}{75(a_h+1)^4(3a_h^2+2a_h+3)^3} \Big(& 8550a_h^{10} + 20335a_h^9 + 30978a_h^8 + 24828a_h^7 \\ & + 5016a_h^6 + 25386a_h^5 + 5016a_h^4 + 24828a_h^3 + 30978a_h^2 + 20335a_h + 8550 \\ & - X(225a_h^6 + 764a_h^5 + 1087a_h^4 + 328a_h^3 + 1087a_h^2 \\ & + 764a_h + 225)\Big)V > 0 \quad \text{if} \quad a_h > 1.76. \end{aligned}$$

Therefore, total effort is higher in the P&D contest when $a_h > 1.76a_l$.

Case 2: Let $a_h > 2$.

Subtracting TE_{PO} from TE^r_{PD} we get the following:

$$\begin{aligned} TE^r_{PD} - TE_{PO} = \frac{1}{75(a_h+1)^4(3a_h^2+2a_h+3)^3} \Big(& 450a_h^{10} + 8185a_h^9 + 28278a_h^8 + 60228a_h^7 \\ & + 92616a_h^6 + 132486a_h^5 + 92616a_h^4 + 60228a_h^3 + 28278a_h^2 + 8185a_h + 450 \\ & - X(225a_h^6 + 764a_h^5 + 1087a_h^4 + 328a_h^3 + 1087a_h^2 \\ & + 764a_h + 225)\Big)V > 0 \quad \text{if} \quad a_h < 3.01. \end{aligned}$$

Therefore, when the principal is unable to sort agents by ability, total effort is higher in the P&D contest if $a_h \in (1.76a_l, 3.01a_l)$. Otherwise, total effort is higher in the Pooled contest. $\square$

C Predicted vs Actual effort choice

For $(a_l, a_h) = (1, 1)$, $v_1 = V = 100$ and $w = 0$ we have the following.

Table C.1: Predicted vs Actual effort choice – Homogeneous

	Theoretical prediction			**Actual effort choice**		
	P&D		Pooled	P&D		Pooled
Division	1	2	–	1	2	–
e_1	31.25	6.25	18.75	57.27	38.92	33.45
e_2	25.00	0.00	18.75	62.63	26.63	32.12
Total effort stage 1	75.00		75.00	192.37		133.80
Total effort stage 2	50.00		75.00	178.52		128.49
Total effort across all stages	125.00		150.00	370.89		262.29

For $(a_l, a_h) = (1, 2)$, $v_1 = V = 100$ and $w = 0$ we have the following.

Table C.2: Predicted vs Actual effort choice – Heterogeneous

	Theoretical prediction			**Actual effort choice**		
	P&D		Pooled	P&D		Pooled
Division	1	2	–	1	2	–
e_{l1}	–	2.78	0.00	–	32.89	38.73
e_{h1}	36.11	–	25.00	57.24	–	39.31
e_{l2}	22.22	0.00	0.00	53.54	21.76	36.43
e_{h2}	22.22	0.00	25.00	56.16	28.99	39.36
Total effort stage 1	77.78		50.00	180.27		156.08
Total effort stage 2	44.44		50.00	160.45		151.57
Total effort across all stages	122.22		100.00	340.72		307.65

Note, the total effort values in the above tables differ slightly from the values in Table 4. To calculate the values in Table 4 we calculated the average total effort for each session, then calculated average total effort over all sessions for each treatment. The total effort values in the above tables were calculated by taking the average total effort over the treatment. Since some sessions contained more participants in them than others the values across these two calculations are different.

D Parallel contest without promotion and demotion

Unlike in the P&D contest, now suppose high ability agents compete in Division 1 and low ability agents compete in Division 2 in every stage (henceforth "Parallel contest"). The problem for agent m against agent n in Division d, at stage t is as follows:

$$\max_{e_{mdt} \geq 0} \quad \frac{e_{mdt}}{e_{mdt} + e_{ndt}} v_{dt} - e_{mdt}.$$

The Nash equilibrium effort level in each stage in the Parallel contest for agents in Division d at stage t, $\hat{e}_{dt}^{PA}$ is the following:

$$\hat{e}_{dt}^{PA} = \frac{v_{dt}}{4}.$$

Now that we have derived the equilibrium effort functions for each stage it is possible to calculate the total effort across both stages in the Parallel contest, TE_{PA}, as follows:

$$TE_{PA} = \frac{2(v_{11} + v_{21} + v_{12} + v_{22})}{4} = \frac{v_{11} + v_{21} + v_{12} + v_{22}}{2}.$$

We chose to exclude the Parallel contest design from the main part of this paper as it is less effective than the Pooled contest design in incentivizing total effort. Now we will illustrate how total effort is never higher in the Parallel contest than in the Pooled contest. Without loss of generality normalize $a_l = 1$ and let the prize in Division 2 in both stages be 0 and the prize in Division 1 in both stages be V.

<u>Case 1</u>: Let $a_h \in [1, 2]$.

The equilibrium total effort functions for the Pooled contest, TE_{PO} and Parallel contest, TE_{PA} are as follows:

$$TE_{PO} = \frac{3\left(4a_h - a_h^2 - 1\right)}{(a_h + 1)^2} V \quad \text{and} \quad TE_{PA} = V.$$

Subtracting TE_{PA} from TE_{PO} we get the following:

$$TE_{PO} - TE_{PA} = \frac{2(2 - a_h)(2a_h - 1)}{(a_h + 1)^2} V > 0 \quad \text{for} \quad a_h \in [1, 2].$$

Therefore, total effort is higher in the Pooled contest than in the Parallel contest when $a_h \in [a_l, 2a_l]$.

<u>Case 2</u>: Let $a_h > 2$.

The equilibrium total effort functions for the Pooled contest, TE_{PO} and Parallel contest are as follows:

$$TE_{PO} = V \quad \text{and} \quad TE_{PA} = V.$$

Subtracting TE_{PA} from TE_{PO} we get the following:

$$TE_{PO} - TE_{PA} = 0.$$

Hence, total effort is never higher in the Parallel contest than in the Pooled contest.

E Joy of winning

In this section we explicitly derive the equilibrium total effort functions mentioned in subsection 2.4.

E.1 P&D contest

E.1.1 Equilibrium in stage 2

Recall, in stage 2 high types compete with low types in both divisions. The problem for type i against type $-i$, in Division d, at stage 2 is as follows:

$$\max_{e_{id2}^{-i}\geq 0} \quad \frac{a_i e_{id2}^{-i}}{a_i e_{id2}^{-i} + a_{-i} e_{-id2}^{i}} \left(v_{d2} + \frac{a_{-i}}{a_i} w \right) - e_{id2}^{-i}.$$

The Nash equilibrium effort level for type i against type $-i$, in Division d, at stage 2, $\tilde{e}_{id2}^{-i} \in \{\tilde{e}_{h12}^{l}, \tilde{e}_{l12}^{h}, \tilde{e}_{h22}^{l}, \tilde{e}_{l22}^{h}\}$ is as follows:

$$\tilde{e}_{id2}^{-i} = \frac{(a_l v_{d2} + a_h w)^{(1+\mathbb{1}(i=l))} (a_h v_{d2} + a_l w)^{(1+\mathbb{1}(i=h))}}{a_i (a_h + a_l)^2 (v_{d2} + w)^2}.$$

The equilibrium payoff for type i against type $-i$, in Division d, at stage 2, W_{id2}^{-i} is as follows:

$$\begin{aligned} W_{id2}^{-i} = & \frac{a_{-i}^3 w^3 + a_i w^2 \left(3a_{-i}^2 v_{d2} + (a_h + a_l)^2\right) + a_i v_{d2}^2 \left((a_h + a_l)^2 + a_i^2 v_{d2}\right)}{a_i (a_h + a_l)^2 (v_{d2} + w)^2} \\ & + \frac{a_i v_{d2} w \left(3 a_h a_l v_{d2} + 2(a_h + a_l)^2\right)}{a_i (a_h + a_l)^2 (v_{d2} + w)^2}. \end{aligned}$$

E.1.2 Equilibrium in stage 1

Recall, in stage 1 high types compete with one another in Division 1 and low types compete with one another in Division 2. The problem for agent $m \in \{1,2\}$ against agent $n \neq m \in \{1,2\}$, in Division d, at stage 1 is as follows:

$$\max_{e_{md1}^{n}\geq 0} \quad \frac{e_{md1}^{n}}{e_{md1}^{n} + e_{nd1}^{m}} \left(v_{d1} + w + W_{i12}^{-i}\right) + \left(1 - \frac{e_{md1}^{n}}{e_{md1}^{n} + e_{nd1}^{m}}\right) W_{i22}^{-i} - e_{md1}^{n}.$$

The Nash equilibrium effort level for type i in Division d at stage 1, $\tilde{e}_{id1}^{i} \in \{\tilde{e}_{h11}^{h}, \tilde{e}_{l21}^{l}\}$, is the following:

$$\tilde{e}_{id1}^{i} = \frac{\mathbb{1}(i=h)\gamma + \mathbb{1}(i=l)\lambda}{4a_i (a_h + a_l)^2 (v_{22} + w)^2 (v_{12} + w)^2},$$

where,

$$\begin{aligned}\gamma &= a_h^3(v_{22}^3(-(v_{12}+w)^2) + v_{22}^2(v_{12}^3 + v_{12}^2 w + 2v_{12}w^2 + v_{11}(v_{12}+w)^2 + w^3)\\
&\quad + 2v_{22}w(v_{12}^3 + v_{12}^2 w + 2v_{12}w^2 + v_{11}(v_{12}+w)^2 + w^3) + w^2(v_{12}^3 + v_{12}^2 w + 2v_{12}w^2\\
&\quad + v_{11}(v_{12}+w)^2 + w^3)) + a_h^2 a_l(w(w^2(-v_{22}^2 + 8v_{22}v_{12} + 5v_{12}^2) + 2v_{22}^2 v_{12}^2 + 4w^3(v_{22}+v_{12})\\
&\quad - 2v_{22}v_{12}w(v_{22} - 5v_{12}) + 2w^4) + 2v_{11}(v_{22}+w)^2(v_{12}+w)^2) + a_h a_l^2(w(v_{22}^2(v_{12}^2 + 5v_{12}w + w^2)\\
&\quad - v_{22}w(v_{12}^2 - 4v_{12}w + w^2) + w^2(v_{12}^2 + 5v_{12}w + w^2)) + v_{11}(v_{22}+w)^2(v_{12}+w)^2)\\
&\quad + a_l^3 w^3(v_{22} - v_{12})(v_{22} + v_{12} + 2w),\end{aligned}$$

and,

$$\begin{aligned}\lambda &= a_h^3 w^3(v_{22} - v_{12})(v_{22} + v_{12} + 2w) + a_h^2 a_l(w(v_{22}^2(v_{12}^2 + 5v_{12}w + w^2) - v_{22}w(v_{12}^2 - 4v_{12}w + w^2)\\
&\quad + w^2(v_{12}^2 + 5v_{12}w + w^2)) + v_{21}(v_{22}+w)^2(v_{12}+w)^2) + a_h a_l^2(w(w^2(-v_{22}^2 + 8v_{22}v_{12} + 5v_{12}^2)\\
&\quad + 2v_{22}^2 v_{12}^2 + 4w^3(v_{22}+v_{12}) - 2v_{22}v_{12}w(v_{22} - 5v_{12}) + 2w^4) + 2v_{21}(v_{22}+w)^2(v_{12}+w)^2)\\
&\quad + a_l^3(v_{22}^3(-(v_{12}+w)^2) + v_{22}^2(v_{12}^3 + v_{12}^2 w + 2v_{12}w^2 + v_{21}(v_{12}+w)^2 + w^3)\\
&\quad + 2v_{22}w(v_{12}^3 + v_{12}^2 w + 2v_{12}w^2 + v_{21}(v_{12}+w)^2 + w^3) + w^2(v_{12}^3 + v_{12}^2 w + 2v_{12}w^2\\
&\quad + v_{21}(v_{12}+w)^2 + w^3)).\end{aligned}$$

Now that we have derived the equilibrium effort functions in each stage it is possible to calculate the total effort across both stages in the P&D contest, TE_{PD}^w, as follows:

$$\begin{aligned}TE_{PD}^w &= \underbrace{2\left(\tilde{e}_{h11}^h + \tilde{e}_{l21}^l\right)}_{\text{Stage 1 effort}} + \underbrace{\tilde{e}_{h12}^l + \tilde{e}_{l12}^h + \tilde{e}_{h22}^l + \tilde{e}_{l22}^h}_{\text{Stage 2 effort}}\\
&= \frac{f}{2a_h a_l(a_h + a_l)^2(v_{22}+w)^2(v_{12}+w)^2},\end{aligned}$$

where,

$$
\begin{aligned}
f = {} & a_h^4 w^2 (w(v_{22}^2 + 8v_{22}v_{12} - v_{12}^2) + 2v_{22}v_{12}(v_{22} + v_{12}) + 4v_{22}w^2) \\
& + a_h^3 a_l (v_{22}^3(-(v_{12} + w)^2) + v_{22}^2(v_{12}^3 + v_{12}^2(14w + v_{11} + v_{21}) + v_{12}w(19w + 2(v_{11} + v_{21})) \\
& + w^2(10w + v_{11} + v_{21})) + v_{22}w(2v_{12}^3 + v_{12}^2(13w + 2(v_{11} + v_{21})) + 4v_{12}w(2w + v_{11} + v_{21}) \\
& + w^2(5w + 2(v_{11} + v_{21}))) + w^2(v_{12}^3 + v_{12}^2(10w + v_{11} + v_{21}) + v_{12}w(11w + 2(v_{11} + v_{21})) \\
& + w^2(6w + v_{11} + v_{21}))) + 2a_h^2 a_l^2 (2v_{22}^3(v_{12} + w)^2 + v_{22}^2(2v_{12}^3 + v_{12}^2(2w + v_{11} + v_{21}) \\
& + 2v_{12}w(w + v_{11} + v_{21}) + w^2(-w + v_{11} + v_{21})) + 2v_{22}w(2v_{12}^3 + v_{12}^2(7w + v_{11} + v_{21}) \\
& + 2v_{12}w(6w + v_{11} + v_{21}) + w^2(4w + v_{11} + v_{21})) + w^2(2v_{12}^3 + v_{12}^2(5w + v_{11} + v_{21}) \\
& + 2v_{12}w(4w + v_{11} + v_{21}) + w^2(2w + v_{11} + v_{21}))) + a_h a_l^3 (v_{22}^3(-(v_{12} + w)^2) \\
& + v_{22}^2(v_{12}^3 + v_{12}^2(14w + v_{11} + v_{21}) + v_{12}w(19w + 2(v_{11} + v_{21})) + w^2(10w + v_{11} + v_{21})) \\
& + v_{22}w(2v_{12}^3 + v_{12}^2(13w + 2(v_{11} + v_{21})) + 4v_{12}w(2w + v_{11} + v_{21}) + \\
& + w^2(5w + 2(v_{11} + v_{21}))) + w^2(v_{12}^3 + v_{12}^2(10w + v_{11} + v_{21}) + v_{12}w(11w + 2(v_{11}v_{21})) \\
& + w^2(6w + v_{11} + v_{21}))) + a_l^4 w^2 (w(v_{22}^2 + 8v_{22}v_{12} - v_{12}^2) + 2v_{22}v_{12}(v_{22} + v_{12}) + 4v_{22}w^2).
\end{aligned}
$$

E.2 Pooled contest

The problem for type i at each stage is as follows:

$$
\max_{e_i \geq 0} \quad \frac{a_i e_i}{a_h \sum_{m=1}^{2} e_m + a_l \sum_{n=3}^{4} e_n} \left(V + \frac{a_h}{a_i} w \right) - e_i,
$$

The Nash equilibrium effort levels in each stage in the Pooled contest for high types, $\tilde{e}_h^{PO}$, and low types, $\tilde{e}_l^{PO}$, is the following:

$$
\tilde{e}_h^{PO} = \frac{3(V + w)(a_h w + a_l V)(a_h(2V + w) - a_l V)}{4(V(a_h + a_l) + 2a_h w)^2},
$$

and,

$$
\tilde{e}_l^{PO} = \frac{3a_h(V + w)(2a_l V - a_h(V - w))(a_h w + a_l V)}{4a_l(V(a_h + a_l) + 2a_h w)^2}.
$$

Note, the above equilibrium only holds if $w \geq V$ or if $w < V$ and $a_h \in [a_l, \frac{2Va_l}{V-w}]$. Otherwise, $\tilde{e}_l^{PO} = 0$ and $\tilde{e}_h^{PO} = \frac{V+w}{4}$ is the unique Nash equilibrium.

Now that we have derived the equilibrium effort functions for each stage it is possible to calculate the total effort across both stages in the Pooled contest, TE_{PO}^w, as follows:

$$
TE_{PO}^w = \begin{cases}
\frac{3(V+w)(a_h w + a_l V)(a_h w(a_h + a_l) - V(a_h^2 - 4a_h a_l + a_l^2))}{a_l(V(a_h + a_l) + 2a_h w)^2}, & \text{if} \quad w \geq V, \\[2ex]
\frac{3(V+w)(a_h w + a_l V)(a_h w(a_h + a_l) - V(a_h^2 - 4a_h a_l + a_l^2))}{a_l(V(a_h + a_l) + 2a_h w)^2}, & \text{if} \quad w < V \quad \text{and} \quad a_h \in \left[a_l, \frac{2Va_l}{V-w}\right], \\[2ex]
V + w, & \text{otherwise.}
\end{cases}
$$

F Instructions

The following instructions were used for the heterogeneous ability treatments. The instructions for the homogeneous ability treatments are very similar.

Pooled contest

General Instructions

This is an experiment in the economics of strategic decision-making. If you follow the instructions closely and make appropriate decisions, you can earn a considerable amount of money. You will be required to make a series of economic choices, which determine your total earnings. The currency used in the experiment is Points. Points will be converted to AUD at a rate of **10 Points to 1 AUD**. Earnings are private. You will also receive a $8.00 participation fee. You will be asked to submit your PayID at the end of the experiment to receive the online transfer of your earnings. **4** participants are in today's experiment.

If you have a question, please type it in the Zoom chatbox and send it to the experimenter who will answer it.

Your Decision

The next part of the experiment consists of 21 decision-making periods (including 1 trial period and 20 real periods) and each period consists of two stages. First, the computer will randomly determine whether you are going to be **type A** or **type B**. Once your type has been determined you will remain that type for the duration of the experiment. At the beginning of **each** period, you will be randomly and anonymously placed into a group of **four** participants. Each group will consist of two **type A** and two **type B** participants. Participants who have been grouped together will play against one another in each stage of the game.

In each stage, participants will be given **an initial endowment of 100 Points**. This endowment is not transferable across stages. You will use this endowment to purchase lottery tickets for a chance of receiving a reward in each stage. **The reward is equal to 100 Points**. In both stages of the game **type A** participants receive **20 tickets** for every Point they spend, and **type B** participants receive **10 tickets** for every Point they spend. Participants may spend any number of Points between 0 and 100 (including 0.5 decimal points).

An example of the decision screen in stage 1 is as follows:

Stage 1

You are **type A**, and you will receive **20 tickets** for every point you spend.
You are randomly placed into a group of 4. You are Player 4 in this group.
The types of other players are as follows:

Player	Type	Tickets per point
1	A	20
2	B	10
3	B	10
4 (Your ID)	A	20

You are endowed with 100 points.
The reward is worth 100 points.

You may spend any multiple of 0.5 points between 0 and 100 to purchase tickets.

How many points would you like to spend?

Figure F.1: Sample "Stage 1" screen

After you have played the game in stage 1 you will play the same game with the same participants in stage 2.

Your Earnings

Your earnings depending on whether you received the reward are as follows:

- If you **did** receive the reward: Earnings = Endowment (100) + Reward (100) – Points you spent in that stage **(formula 1)**
- If you **did not** receive the reward: Earnings = Endowment (100) – Points you spent in that stage **(formula 2)**

The more you spend on lottery tickets, the more likely you are to receive the reward. The more the other participants spend on lottery tickets, the less likely you are to receive the reward. At the end of a stage the computer **randomly draws** one ticket among all the tickets purchased by you and the other participants in your group. The owner of the ticket drawn receives a reward in that stage. Thus, your chance of receiving the reward is given by the number of lottery tickets you purchased divided by the total number of lottery tickets you and the other participants in your group purchased.

$$\text{Prob. of reward} = \frac{\text{Number of tickets you purchased}}{\text{Total number of tickets purchased in your group}} \times 100\% \qquad \textbf{formula 3}$$

In case all participants within a group purchase zero lottery tickets in a stage, the computer randomly chooses one participant to receive the reward in that stage.

Example of random draw

This is a hypothetical example of how the computer makes a random draw. Suppose in stage 1, we have the following:

Outcome of Stage 1

Player	Type	No. of points spent	No. of tickets	Total no. of tickets in group	Prob. of reward
1 (Your ID)	A	15	300	480	62.50%
2	A	5	100	480	20.83%
3	B	4	40	480	8.33%
4	B	4	40	480	8.33%

The computer randomly draws a number between 1 and 480 to determine the winner.

- If the number is between 1 and 300, Player 1 wins
- If the number is between 301 and 400, Player 2 wins
- If the number is between 401 and 440, Player 3 wins
- If the number is between 441 and 480, Player 4 wins

Click to get the random number

The random number is 267,
Therefore, you are the winner and will get the reward.

Your Stage 1 earnings = Endowment (100) + Reward (100)– Points spent (15.0) = **185.0 points.**

Figure F.2: Sample "Stage 1 Outcome" screen

The computer randomly draws **one lottery ticket out of 480** (300 lottery tickets for player 1, 100 lottery tickets for player 2, 40 lottery tickets for player 3 and 40 lottery tickets for player 4). As you can see, player 1 has a higher chance of receiving the reward: 62.50% = (300/480) × 100%. Player 2 has a 20.83% = (100/480) × 100% chance of receiving the reward. Player 3 and player 4's chance of receiving the reward is 8.33% = (40/480) × 100%.

At the end of each stage, your expenditure on lottery tickets, the other participants' expenditure on lottery tickets, whether you received the reward or not, and the earnings for the stage are reported on the outcome screen.

After you have completed both stages of the game the computer will calculate and report your total earnings for the period on your screen. Your total earnings for a period are equal to the sum of your earnings across stages 1 and 2.

Important Notes

You will not be told which of the participants in this room are assigned to which group. At the beginning of each period you will be randomly re-grouped with 3 other participants to form a four-person group. You can never guarantee yourself the reward. However, by increasing your expenditure on lottery tickets, you can increase your chance of receiving the reward in each stage. At the end of the experiment we will randomly choose **1 of the 20 real periods** for actual payment. Your earnings will be converted and paid out in AUD.

If you have any questions at this time, please message one of the experimenters using the chat function in Zoom. If there are no questions, please go ahead and complete a quiz.

Note that the instructions will remain on your screen for future reference.

P&D contest

General Instructions

This is an experiment in the economics of strategic decision-making. If you follow the instructions closely and make appropriate decisions, you can earn a considerable amount of money. You will be required to make a series of economic choices, which determine your total earnings. The currency used in the experiment is Points. Points will be converted to AUD at a rate of **10 Points to 1 AUD**. Earnings are private. You will also receive a $8.00 participation fee. You will be asked to submit your PayID at the end of the experiment to receive the online transfer of your earnings. **4** participants are in today's experiment.

If you have a question, please type it in the Zoom chatbox and send it to the experimenter who will answer it.

Your Decision

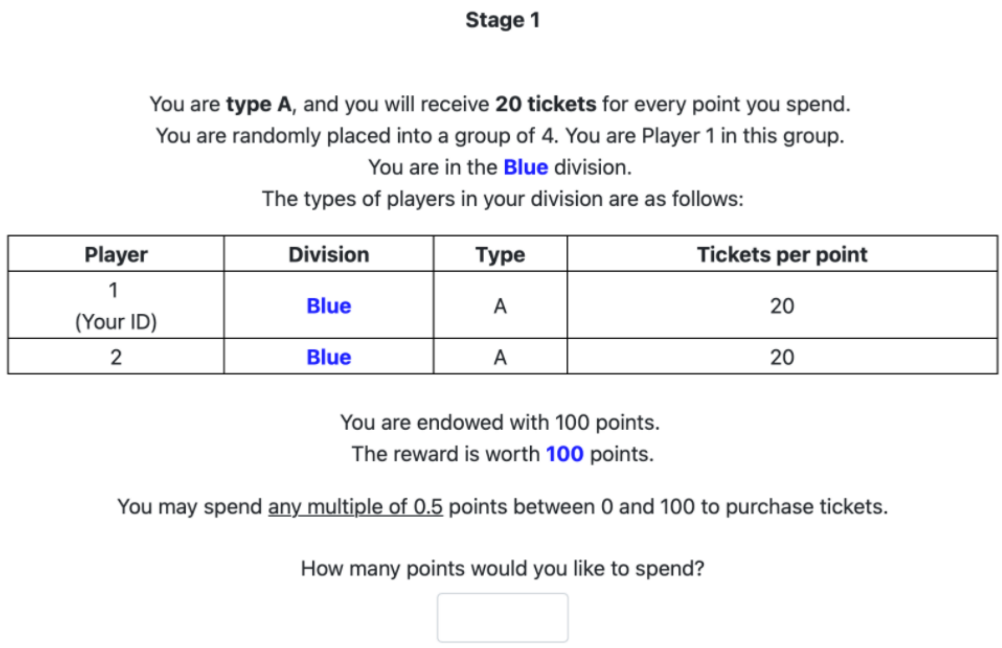
The next part of the experiment consists of 21 decision-making periods (including 1 trial period and 20 real periods) and each period consists of two stages. First, the computer will randomly determine whether you are going to be **type A** or **type B**. Once your type has been determined you will remain that type for the duration of the experiment. At the beginning of **each** period, you will be randomly and anonymously placed into a group of **four** participants. Each group will consist of two **type A** and two **type B** participants. In **stage 1** type A participants will be placed in the **Blue division** and type B participants will be placed in the **Red division**. Participants who have been grouped together will play with one another within each division in each stage of the game.

In each stage, participants will be given **an initial endowment of 100 Points**. This endowment is not transferable across stages. You will use this endowment to purchase lottery tickets for a chance of receiving a reward in each stage. The reward in the **Blue division** is equal to **100 Points** and the reward in the **Red division** is equal to **0 Points**. We will explain the consequence of receiving the reward in the Red division later.

In both stages of the game **type A** participants receive **20 tickets** for every Point they spend, and **type B** participants receive **10 tickets** for every Point they spend. Participants may spend any number of Points between 0 and 100 (including 0.5 decimal points).

Stage 1

An example of the decision screen for participants placed in the **Blue division in Stage 1** is as follows:



Stage 1

You are **type A**, and you will receive **20 tickets** for every point you spend.
You are randomly placed into a group of 4. You are Player 1 in this group.
You are in the **Blue** division.
The types of players in your division are as follows:

Player	Division	Type	Tickets per point
1 (Your ID)	**Blue**	A	20
2	**Blue**	A	20

You are endowed with 100 points.
The reward is worth **100** points.

You may spend any multiple of 0.5 points between 0 and 100 to purchase tickets.

How many points would you like to spend?

Figure F.3: Sample "Stage 1" screen (Blue division)

Your Earnings in Stage 1

Your earnings depending on whether you received the reward are as follows:

- If you were in the **Blue division** and you **did** receive the reward: Earnings = Endowment (100) + Reward (**100**) – Points you spent in that stage (**formula 1**)
- If you were in the **Red division** and you **did** receive the reward: Earnings = Endowment (100) + Reward (**0**) – Points you spent in that stage (**formula 2**)
- If you **did not** receive the reward: Earnings = Endowment (100) – Points you spent in that stage (**formula 3**)

The more you spend on lottery tickets, the more likely you are to receive the reward. The more the other participant in your division spends on lottery tickets, the less likely you are to receive the reward. At the end of a stage the computer **randomly draws** one ticket among the tickets purchased by **you and the other participant in your division**. The owners of the tickets drawn in each division receive a reward in that stage. Thus, your chance of receiving the reward is given by the number of lottery tickets you purchased divided by the total number of lottery tickets you and the other participant in your division purchased.

$$\text{Prob. of reward} = \frac{\text{Number of tickets you purchased}}{\text{Total number of tickets purchased in your division}} \times 100\% \qquad \textbf{formula 4}$$

In case all participants within a division purchase zero lottery tickets in a stage, the computer randomly chooses one participant in each division to receive the reward in that stage.

Stage 2

The decision you face in stage 2 is very similar to that of stage 1, however, this time participants will move across divisions to play for different rewards depending on the outcome of the Stage 1 game.

Moving across divisions

The participants who receive the reward in either the Blue or Red division in stage 1 will be placed in the Blue division in stage 2. The participants who do not receive the reward in either the Blue or Red division in stage 1 will be placed in the Red division in stage 2 as shown in the diagram below.

	Blue division (Reward: 100 points)	Red division (Reward: 0 points)
Stage 1	**A A***	**B B***
Stage 2	**A* B***	**A B**

A*, B* are reward recipients in each division in Stage 1. They play in the Blue division in Stage 2. A, B did not receive rewards in Stage 1. They play in the Red division in Stage 2.

Note, everyone gets to play with a different type in stage 2.

This is a hypothetical example of how the computer makes a random draw to decide who gets the reward in Stage 1. Suppose in stage 1, we have the following:

Outcome of Stage 1

Player	Type	Division	No. of points spent	No. of tickets	Total no. of tickets in division	Prob. of reward
1 (Your ID)	A	**Blue**	15	300	**400**	**75.00%**
2	A	**Blue**	5	100	**400**	**25.00%**
3	B	**Red**	4	40	**80**	**50.00%**
4	B	**Red**	4	40	**80**	**50.00%**

You are in the **Blue** division.
The computer randomly draws a number between 1 and 400 to determine the winner in your division.

- If the number is between 1 and 300, Player 1 wins
- If the number is between 301 and 400, Player 2 wins

Click to get the random number

The random number is 333,
Therefore, you are not the winner and will not get the reward.

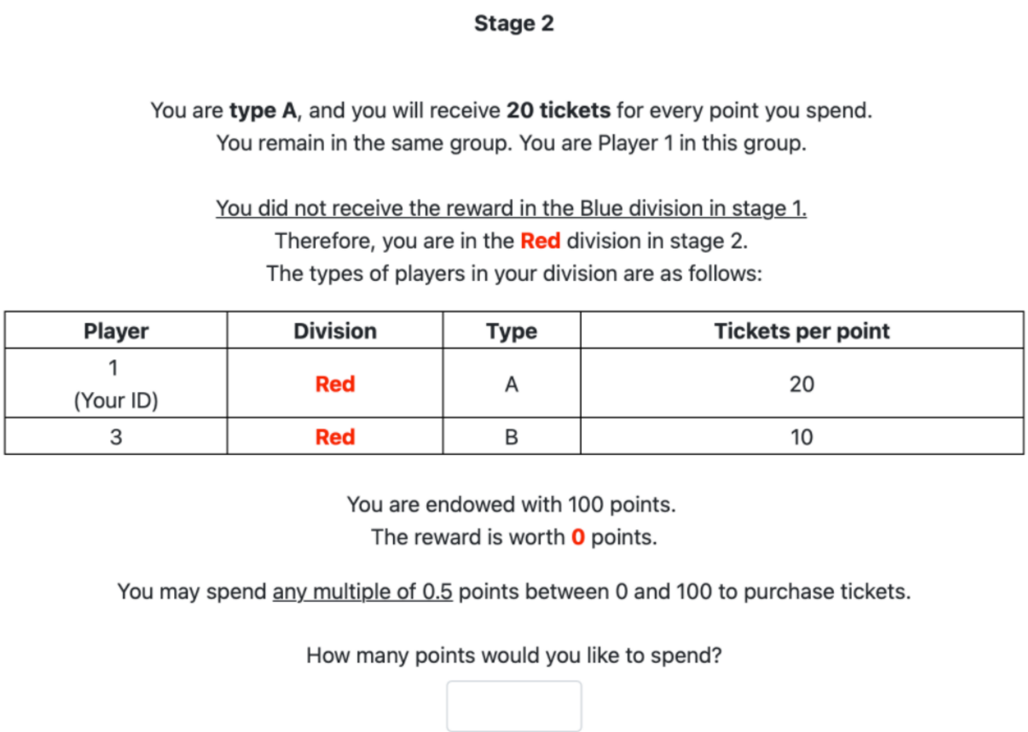
Your Stage 1 earnings = Endowment (100) – Points spent (15.0) = **85.0 points.**

Figure F.4: Sample "Stage 1 Outcome" screen

For the Blue division, the computer randomly draws **one lottery ticket out of 400** (300 lottery tickets for player 1 and 100 lottery tickets for player 2). As you can see, player 1 has a **higher chance** of receiving the reward: $75.00\% = (300/400) \times 100\%$. Whereas player 2 has a 25.00% = (100/400) × 100% chance of receiving the reward. Suppose player 2's ticket was drawn and, as a result, they received the reward of 100 points, hence, they will remain in the Blue division in stage 2 and player 1 will be moved to the Red division in stage 2.

For the Red division, the computer randomly draws **one lottery ticket out of 80** (40 lottery tickets for both players 3 and 4). Hence, both player 3 and player 4 have a 50.00% = (40/80) × 100% chance of receiving the reward. Suppose player 4's ticket was drawn and, as a result, they received the reward of 0 points in the Red division in stage 1. Hence, player 4 will be moved to the Blue division in stage 2 and player 3 will remain in the Red division in stage 2.

As a result, player 1 and player 3 will play against each other in the Red division whereas player 2 and player 4 will play against each other in the Blue division in Stage 2. The decision screen of player 1 in stage 2 will look like this:


Stage 2

You are **type A**, and you will receive **20 tickets** for every point you spend.
You remain in the same group. You are Player 1 in this group.

You did not receive the reward in the Blue division in stage 1.
Therefore, you are in the **Red** division in stage 2.
The types of players in your division are as follows:

Player	Division	Type	Tickets per point
1 (Your ID)	Red	A	20
3	Red	B	10

You are endowed with 100 points.
The reward is worth **0** points.

You may spend any multiple of 0.5 points between 0 and 100 to purchase tickets.

How many points would you like to spend?

Figure F.5: Sample "Stage 2" screen

Notice that player 1 can purchase 20 tickets/Point they spend while player 3 can only purchase 10 tickets/Point spent.

At the end of each stage, your expenditure on lottery tickets, the other participants' expenditure on lottery tickets, whether you received the reward or not, and the earnings for the stage are reported on the outcome screen.

After you have completed both stages of the game the computer will calculate and report your total earnings for the period on your screen. Your total earnings for a period are equal to the sum of your earnings across stages 1 and 2.

Important Notes

You will not be told which of the participants in this room are assigned to which group. At the beginning of each period you will be randomly re-grouped with 3 other participants to form a four-person group. You can never guarantee yourself the reward. However, by increasing your expenditure on lottery tickets, you can increase your chance of receiving the reward in each stage. After stage 1 has been completed the reward recipients in each division will be placed in the Blue division in stage 2, while the participants who do not receive the reward in either division will be placed in the Red division in stage 2.

At the end of the experiment we will randomly choose **1 of the 20 real periods** for actual payment. Your earnings will be converted and paid out in AUD.

If you have any questions at this time, please message one of the experimenters using the chat function in Zoom. If there are no questions, please go ahead and complete a quiz.

Note that the instructions will remain on your screen for future reference.

Risk and ambiguity preference elicitation tasks

Additional Decisions

In this part, you will be asked to make three decisions. One of these three decisions will be chosen at the end of the experiment and that decision will be used to calculate your actual earnings for this part.

The environments for the three decisions are similar. In each case, you will see a list of 21 choices between lotteries and sure amounts of money. Lotteries will always be on the left, and sure amounts of money on the right. The lists will be ordered so that you will prefer the lottery to the sure amount of money in the choice at the top of the list. As you go down the list, the strength of your preference will decrease. That is, you will like the lotteries less and less as compared to the sure amounts. At some point, you will be willing to switch from preferring a lottery to preferring the corresponding sure amount of money. At the point where you are willing to switch, please click on the **SWITCH HERE** button.

When you click on a **SWITCH HERE** button, lotteries will be your choice everywhere above that line, and sure amounts of money will be your choice everywhere below that line. All the 21 choices that you generate will be highlighted. If you want to change your decision, simply click on another **SWITCH HERE** button. When you are ready to finalize your decision, click **SUBMIT**.

After you have made your decision, one of the 21 choices will be selected randomly and played.

If your preference in the choice that turns out to be actually played is a lottery, your earnings will depend on your guess and a random draw. If your preference in the choice that turns out to be actually played is a sure amount of money, you will earn that amount of money.

You will be informed about your earnings from this part of the experiment at the very end of the session today, after you have completed all parts of the experiment.