Excessive Expenditure in Two-stage Contests:
Theory and Experimental Evidence

Wilfred Amaldoss
Duke University

Amnon Rapoport
University of Arizona

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Corresponding Author:

Wilfred Amaldoss
Duke University
Fuqua School of Business,
Dept. of Marketing, Box 90120,
Durham, NC 27708
Email Address: Wilfred.amaldoss@duke.edu

Abstract

Symmetric, budget-constrained, and financially motivated members of independent groups participated in a series of two-stage contests to win a single, commonly valued, and exogenously determined prize. We present and test an equilibrium model that, in addition to the utility of receiving the prize, incorporates 1) a non-pecuniary utility of winning each stage of the contest, and 2) allows for misperception of the probability of winning, which is determined by Tullock's contest success function. The equilibrium solution accounts for the major finding of excessive aggregate expenditures in stage 1 of the contest. We then test a Cognitive Hierarchy model that attributes individual differences in stage 1 expenditures to different levels of depth of reasoning. Although the explanatory power of this model is limited, it suggests a critical role to the non-pecuniary utility of winning in accounting for the excessive expenditures.

1. Introduction

Contests are economic or political interactive decision making situations in which agents compete with one another over monopoly rights, monetary prizes, power, or influence by expending resources like money or effort. They vary from one another on multiple dimensions including group size, number of groups, number of prizes, number of inter-related stages, symmetric vs. asymmetric agents, simultaneous vs. sequential decisions, information structure, and other rules that govern the interaction. A variety of models have been proposed for different classes of contests, many of them extending Tullock's (1967) seminal model in which contestants vie for a single prize through the expenditure of resources and their probability of winning the prize increases monotonically in their level of expenditure (see, e.g., Nitzan, 1994, for an early review). As rent-seeking behavior in the world (e.g., sport competitions, political competitions, R&D contests) is difficult to observe and document, several researchers have turned to experimental testing of the implications of these various contest models (Anderson & Stafford, 2003; Davis & Reilly, 1998; Millner & Pratt, 1989, 1991; Önçüler & Croson, 2004; Parco, Rapoport & Amaldoss, 2005; Potters, de Vries, & van Winden, 1998; Schmitt, Shupp, Swope, & Cardigan (in press); Schmitt, Shupp, & Walker, 2003; Shogren & Baik, 1991; Vogt, Weinmann, & Yang, 2002; Weimann, Yang, & Vogt, 2000).

Previous Experimental Research. A major finding of most of these studies is that aggregate rent-seeking behavior of risk-neutral contestants in the laboratory significantly exceeds the equilibrium predictions. Millner and Pratt (1991) conducted an experiment designed to test predictions derived from a model by Hillman and Katz (1994) that more risk-averse agents dissipate a larger share of the rent. In contrast to the model's predictions, they concluded that more risk-averse subjects dissipate less of the rent, although there is excessive rent-seeking. Millner and Pratt (1989) reported similar results. Davis and Reilly (1998) conducted an experiment in which they compared behavior in a variety of repeated contests and all-pay auctions. They concluded that the equilibrium solution was flawed as a guide for predictions: "Collectively, the agents tend to dissipate more rents than Nash equilibrium predictions in all auctions—an outcome that diminishes, but does not disappear with experience (1998, pp. 110-111)." Anderson and Stafford (2003) tested a model proposed by Gradstein (1995) by varying the cost heterogeneity of the subjects and entry fee. They, too, reported that rent-seeking expenditures significantly exceeded the equilibrium predictions. When the agent's probability of winning the prize was proportional to her expenditure, Potters et al. (1998) also reported over-expenditure relative to the equilibrium prediction. Schmitt et al. (2004) and Önçüler & Croson (2004) reported similar findings, the former in a two-stage game with carryover in which rent-seeking expenditures in period t increase the efficacy of rent-seeking expenditures in period t+1, and the latter in a two-stage contest under risk. None of these studies has proposed a general explanation for the excessive expenditures.

There are two studies that have failed to report excessive expenditure, one by Shogren and Baik (1991) and the other by Vogt et al. (2002). Both of these studies have unique features that differentiate them from the other studies mentioned above. The former paper only reports the results of the final ten periods. It is possible (see, e.g., Davis & Reilly, 1998, Parco, Rapoport, & Amaldoss, 2005) that excessive expenditures did occur in the early periods and behavior gradually converged to equilibrium play. The latter study by Vogt et al. used a contest success function that was highly discriminative (r=8), closer to all-pay auction, and required within each period sequential rather than simultaneous decisions as in all previous studies.

The present study builds on and extends a previous experimental study by Parco, Rapoport and Amaldoss (PRA, 2005) that investigated expenditures in two-stage contests with budget-constrained agents competing to win an exogenously determined prize. Varying the prize value in a within-subject design, they had their subjects first compete in stage 1 within their own groups by expending a portion of their budget. Winners, one from each group, were chosen probabilistically by Tullock's proportional contest success function. In stage 2, the winners competed with each other for the prize by expending additional resources from the portion of the budget remaining after stage 1. The winner of stage 2 was chosen in a similar manner. Similarly to all previous experiments cited above, PRA reported significant over-expenditure in stage 1 relative to the subgame perfect equilibrium predictions. Similarly to Davis and Reilly, they also reported that mean stage 1 expenditures decreased steadily with experience in the direction of equilibrium play.

The present study has two main purposes. The first is to extend the previous study of PRA to a larger number of groups and larger group size. Parco et al. focused on the special case of two dyads competing with each other. Therefore, at each stage of the contest a contestant had to face only a single competitor. The present study reports the results of two new experimental conditions, one with three groups of eight members each, and the other with eight groups of three members each, thereby significantly extending the experimental analyses of two-stage contests with budget constraints. The second main goal is to test a descriptive model proposed by PRA, which assumes that, in addition to the pecuniary utility associated with receiving the prize, agents derive a non-pecuniary utility from winning the competition at each stage of the contest. In addition, and in line with results from studies of individual decision making under risk, the descriptive model allows for misperception of the probability of winning either stage of the contest by postulating a non-linear weighting function (e.g., Prelec, 1998; Tversky & Kahneman, 1992; Wu & Gonzalez, 1996). Incorporating these two factors, PRA constructed a subgame perfect equilibrium solution and tested it with their data. Although the model accounted for the aggregate expenditures reasonably well, it could justifiably be criticized as being *ad-hoc* in nature. Hence, the need for testing it with other sets of game parameters.

Section 2 describes a model of two-stage contests with symmetric and budget-constrained agents, the same one proposed and studied by Stein and Rapoport, and the equilibrium solution tested previously by PRA. It then derives point predictions for the game parameters investigated in the present study. Section 3 describes the experimental method and design. The equilibrium solutions of Stein and Rapoport (SR) and of PRA are separately tested in Section 4. The PRA model outperforms the SR model and accounts for the aggregate expenditures. The results suggest that the utility of winning, rather than misperception of the probabilities of winning, is critical for the good performance of the PRA equilibrium solution. Whereas equilibrium solutions are about individual, not aggregate, behavior, previous experimental studies of contests have largely ignored individual differences. In Section 5 we attempt to account for the individual differences, admittedly with qualified success, by testing the Cognitive Hierarchy model that was recently proposed by Camerer et al. (2004), which postulates a hierarchy of subjects in terms of their depth of reasoning. Tests of this model also indicate the critical role of the non-pecuniary utility of winning in the subjects' expenditure decisions. Section 6 concludes.

2. A Class of Two-Stage Contest with Budget Constraints

The Model

N symmetric agents are assumed to compete with one another in a two-stage contest for an exogenously determined and commonly known prize. The N agents are assumed to be risk-neutral; they assign the same valuation r to the prize. Initially, the N players are divided into k equal-size groups of m members each (thus, $mk=N$). Agents begin stage 1 of the contest with a fixed, positive, and commonly known budget denoted by e_0. Without loss of generality assume that $e_0=1$. In stage 1, the m members of each group compete with one another to choose a winner from their group by expending resources subject to the budget constraint e_0. Each group chooses and then sends a single winner (finalist) to stage 2 of the contest. The k finalists—one from each group—then compete with one another in the second and final stage for the prize r. They do so under the constraint that their expenditures in stage 2 do not exceed what remains from the initial budget e_0 after subtracting their individual expenditures in stage 1. The individual expenditures in stages 1 or 2 are not recoverable. The major focus of this model is on the allocation of resources between the two stages of the contest when the budget constraint is either binding or not.

Consider a designated agent h (h=1, 2,…, m) of group j (j=1,2,…,k) who expends a_h on stage 1 ($0 \leq a_h \leq e_0$). Assume that the probability that player h wins the stage 1 competition in her group depends on her expenditure *relative* to the total expenditures of the m members of her group. Following Tullock (1967, 1980) and the vast literature on contests, this probability is computed from the ratio $a_h^{\alpha} / \sum_{i=1}^{m} a_i^{\alpha}$.

Consider next the k finalists, one from each group, and denote the expenditure of finalist j in stage 2 by b_j ($0 \leq b_j \leq (e_0 - a_h)$). Invoking again Tullock's logit-form contest rule, the probability that finalist j wins the competition on stage 2 (and receives the prize r) is *relative* to her expenditure in stage 2: $b_j^{\beta} / \sum_{i=1}^{k} b_i^{\beta}$. Tullock (1980) and subsequently Nitzan (1994) interpreted the parameters α (α>0) and β (β>0) as the "marginal returns to lobbying outlays," whereas Hirshleifer (1995) interpreted them as "decisiveness parameters." They could best be viewed as institutional parameters set by the designer of the contest for its preliminary and final stages. When α and β tend to zero, the probabilities that player h wins the contest on stage 1 and player j wins the contest on stage 2 tend to $1/m$ and $1/k$, respectively. When α and β tend to infinity, the contests on both stages become fully discriminatory in the sense that the contestant expending the most on either stage wins the contest on this stage with certainty. And when they are equal to 1, as they are in the present study, the probability of winning is proportional to the expenditure level. Introducing two parameters (α and β), one for each stage, rather than the same parameter for both stages, increases the generality of the model by allowing the institutional parameters to vary from stage to stage, as they often are in real multi-stage contests.

Utility of Winning. The prize *r* can only be won by an agent who proceeds to stage 2 of the contest. Moreover, in our model the choice of the winner at stage 1 is determined probabilistically without any guarantee that a player who expends more than any of the other *m*-1 members of her group will be the winner. The same is true about choosing the ultimate winner in stage 2. Given this uncertainty, which is characteristic of many multi-stage tournaments (e.g., Poker, Backgammon), PRA have argued that agents derive additional intrinsic utility from winning the competition at each stage of the contest (all *N* agents in stage 1 and only the *k* finalists in stage 2). Both experienced and inexperienced Poker players report a high degree of satisfaction from winning the game even when it is played for very low stakes. This may particularly be the case when the agents are inexperienced, as subjects are in our experiment, and therefore consider winning as a reward by itself. Parco et al. further conjectured that the non-pecuniary utility of winning stage 1, denoted by ω_1, increases in the number of contestants in stage 1 (*m*) and in the size of the reward (*r*). They also assumed that the number of competing groups (*k*) dampens the excitement of winning stage 1. To capture these effects without adding new parameters, they assumed the functional form $\omega_1 = \frac{m}{k}\sqrt{r}$. In stage 2 of the contest, the finalist is assumed to derive a non-pecuniary utility, ω_2, in addition to the utility of winning the prize. This utility is conjectured to increase in the number of contestants in stage 2 (*k*) and size of the reward (r), but decrease in the number of competitors in stage 1 (m). Specifically, PRA assume the functional form $\omega_2 = \frac{k}{m}\sqrt{r}$.

Misperception of Probabilities. Studies of individual decision behavior provide ample evidence that inexperienced subjects misperceive probabilities in a systematic way. Alternative probability weighting functions have been proposed to account for these systematic deviations (e.g., Prelec, 1998, Wu & Gonzales 1996). Following Tversky and Kahneman (1992), PRA chose a one-parameter probability weighting function, namely, $w(P) = \frac{P^\gamma}{\left(P^\gamma + (1-P)^\gamma\right)^{\frac{1}{\gamma}}}$ where $0<\gamma<1$. This function over-weights low probabilities and under-weights high probabilities. Specifically, it is regressive and *S*-shaped. Across several studies, the fixed point at which $w(P)=P$ has been found to be approximately $^1/_e$ (see Prelec, 1998, for a brief review). The fixed point for Tversky and Kahneman's (1992) probability weighting function is 0.34 for gains (see Prelec, 1998). This implies that $\gamma \approx 0.61$.

Recall that the utility of winning is endogenous to the model parameters. PRA suggested that by setting $\gamma = 0.61$ their model could account for the misperception of probabilities without the inclusion of additional parameters. In summary, they incorporate two different and independent psychological factors in their two-stage contest model without adding any free parameters.

Equilibrium

The expected utility of a risk-neutral player h for the two stages of the contest is given by

$$E_1(a_h, b_j) = (e_0 - a_h) + w(P_{1h})[(r + \omega_2)\times w(P_{2j}) - b_j + \omega_1], \quad (1)$$

where we define $P_{1h}=a_h^\alpha / \sum_{i=1}^{m} a_i^\alpha$ and $P_{2j}=b_j^{\beta} / \sum_{i=1}^{k} b_i^\beta$. Because the N players are symmetric, we only need to solve for the equilibrium strategy for any one player.

The budget constraint is not binding if $0<a_h+b_j<1$. It is binding if $a_h+b_j=1$. Stein and Rapoport have shown that there is a critical prize value, denoted here by $r(\omega_1,\omega_2)$, that separates between these two cases. We treat these two cases separately.

<u>Case 1:</u> $0<r<r(\omega_1,\omega_2)$ (budget constraint is not binding).

PRA constructed the following equilibrium expenditures for stages 1 and 2, if the budget constraint is not binding:

$$a_h = \frac{1}{km}(\left(\left(\frac{1}{k}\right)^{\gamma}+\left(\frac{k-1}{k}\right)^{\gamma}\right)^{-\frac{1+\gamma}{\gamma}}\left(\left(\frac{1}{m}\right)^{\gamma}+\left(\frac{m-1}{m}\right)^{\gamma}\right)^{-\frac{1+\gamma}{\gamma}}\times$$
$$\left(\left(\frac{m-1}{m^2}\right)^{\gamma}+\left(\frac{1}{m}\right)^{2\gamma}-\left(\frac{1}{m}\right)^{2\gamma-1}+\left(\left(\frac{m-1}{m^2}\right)^{\gamma}+\left(\frac{1}{m}\right)^{2\gamma}\right)(m-1)\gamma\right)\times$$
$$(\left(\left(\frac{1}{k}\right)^{\gamma}+\left(\frac{k-1}{k}\right)^{\gamma}\right)^{\frac{1+\gamma}{\gamma}}k\omega_1 - \tag{2}$$
$$\left(\left(\frac{k-1}{k^2}\right)^{\gamma}+\left(\frac{1}{k}\right)^{2\gamma}-2\left(\frac{1}{k}\right)^{2\gamma-1}+\left(\frac{k-1}{k^2}\right)^{\gamma}k(\gamma-1)-\left(\left(\frac{k-1}{k^2}\right)^{\gamma}+\left(\frac{1}{k}\right)^{2\gamma}-\left(\frac{1}{k}\right)^{2\gamma-1}\right)\gamma\right)\omega_2-$$
$$r\left(\left(\frac{k-1}{k^2}\right)^{\gamma}+\left(\frac{1}{k}\right)^{2\gamma}-2\left(\frac{1}{k}\right)^{2\gamma-1}-\left(\frac{k-1}{k^2}\right)^{\gamma}k(1-\gamma)-\gamma\left(\left(\frac{k-1}{k^2}\right)+\left(\frac{1}{k}\right)^{2\gamma}-\left(\frac{1}{k}\right)^{2\gamma-1}\right)\right))$$

and

$$b_j = \frac{\left(\left(\frac{k-1}{k^2}\right)^{\gamma}+\left(\frac{1}{k}\right)^{2\gamma}-\left(\frac{1}{k}\right)^{2\gamma-1}+\left(\left(\frac{k-1}{k^2}\right)^{\gamma}+\left(\frac{1}{k}\right)^{2\gamma}\right)(k-1)\gamma\right)(r+\omega_2)\left(\left(\frac{1}{k}\right)^{\gamma}+\left(\frac{k-1}{k}\right)^{\gamma}\right)^{-\frac{1+\gamma}{\gamma}}}{k}. \tag{3}$$

If the probability weighting function is the identity function ($\gamma=1$), then Equations (2) and (3) reduce to

$$a_h = \frac{(m-1)[r+\omega_1 k^2+\omega_2]}{k^2m^2} \tag{4}$$

and

$$b_j = \frac{(k-1)\left(r+\omega_2\right)}{k^2}. \tag{5}$$

Further, if no additional utility is gained from winning either stage of the contest ($\omega_1 = \omega_2 = 0$) and the probabilities in the contest success function are perceived correctly ($\gamma = 1$), then Equations (4) and (5) are reduced to those reported by Stein and Rapoport by setting $\alpha = \beta = 1$.

The equilibrium solution (Equations 4 and 5) only holds if $0<a_h+b_j<1$, a condition that occurs for only certain values of *r*. Expenditures in each stage of the contest are seen to increase in the prize value *r*. To determine the range of the feasible values of *r*, we must add a_h and b_j and require the sum to be smaller than 1. We then obtain $0 < r < r_c(\omega_1, \omega_2)$. If $\gamma = 1$, then $r(\omega_1,\omega_2)$ is given by the following implicit function:

$$\frac{k^2(m^2 - \omega_1(m-1)) - \omega_2(m^2(k-1)+m-1)}{(m-1)+m^2(k-1)} - r = 0, \tag{6}$$

and the expected utility in equilibrium is:

$$E_1\left(a_h, b_j\right) = 1 + \frac{r+\omega_2}{m^2k^2} + \frac{\omega_1}{m^2}. \tag{7}$$

It can be verified that the equilibrium is subgame perfect. The proof is similar to that in Stein and Rapoport and is, therefore, omitted.

<u>Case 2:</u> $r \geq r_c(\omega_1, \omega_2)$ (budget constraint is binding).

If $a_h+b_j=1$, then the solution occurs on the boundary. This requires that $r \geq r_c(\omega_1, \omega_2)$. We use the equality $a_h+b_j=1$ to eliminate a_h, and then solve for b_j. If $\gamma = 1$, then after some algebra we obtain a quadratic equation in b_j:

$$a(b_j)^2+b(b_j)+c=0,$$

where the coefficients of the quadratic equation reduce to

$$a = (m-1)^2k^2$$

$$b = kr(m-1) + mr(k-1) - k^2m(m-1) + k^2(m-1)\omega_1 + [k(m-1) + m(k-1)]\omega_2$$

$$c = mr(k-1) + m(k-1)\omega_2.$$

The solution of this quadratic equation is given by

$$b_j = \begin{cases} \dfrac{-b+\sqrt{b^2-4ac}}{2a}, & if\,\alpha \neq m \\ -c/b, & if\,\alpha = m \end{cases}. \quad (8)$$

Once the value of b_j is computed from Equation (8), then the equilibrium expenditure for stage 1 is determined from $a_h+b_j=1$. The expected utility of the game in equilibrium is:

$$E_1(a_h, b_j) = 1 + (r + \omega_2)/(m^2k^2) + \omega_l/m^2.$$

Following Stein and Rapoport, it can again be shown that the equilibrium solution for case 2 is subgame perfect.

Parco et al. reported the results of an experimental study of the two-stage contest model in the special case of m=k=2, and showed that the PRA equilibrium solution could account for the mean expenditures in stages 1 and 2 for five different values of the prize r. Changes in mean stage 1 expenditures over iterations of the stage game could also be accounted for under the assumption that the utility of winning ω_1 decreases with experience across iterations. The experiment by PRA only considered the special case of m=k=2. Also, the equilibrium solution was motivated by the experimental results (over-expenditure in stage 1) and was, therefore, *ad-hoc* in nature. A major purpose of the present study is to test this model with a new set of data gathered in two-stage contests with symmetric players that differs from one another in the number of groups (k) and number of members of each group (m).

3. Experimental Method and Design

The present study was designed to test the equilibrium solution in the case where the probability of winning each stage of the contest is directly proportional to the expenditure: α=β=1. The parameter values in our experiment are r={6, 45} and m={3, 8}. To keep the total number of subjects participating in each experimental session fixed at N=24, we set k=3 when m=8 and k=8 when m=3.

Experimental Design. The experiment employed a 2×2 factorial design. The stage 1 group size m={3, 8} was a between-subject factor, while the prize value r={6, 45} was a within-subject factor. Thus, the four conditions (treatments) studied in the present study are *m3r6*, *m3r45*, *m8r6*, and *m8r45* where $k=N/m$. Data were collected from two groups for each level of m.

Subjects. Ninety-six undergraduate students of business administration participated in four separate experimental sessions each including 24 subjects. The subjects were recruited by advertisements posted on bulletin boards and class announcements promising monetary reward contingent on performance in a group decision-making experiment. Both male and female students responded in nearly equal proportions. Each session lasted about 2 hours. The mean payoff per subject was $22.70. In addition, all the subjects received a $5.00 show-up bonus for their participation.

Procedure. At the beginning of each session, the subjects drew poker chips from a bag containing chips numbered 1 through 24 to randomly determine their seat assignment in the laboratory. Subjects were then seated in their designated cubicles and received written instructions (Appendix). They proceeded to read the instructions at their own pace. When all the subjects completed reading the instructions, the supervisor entertained questions from individual subjects. Very few questions were actually asked.

We ran two groups of subjects for each value of m. The subjects in each session participated in sixty trials. The two reward values were counter-balanced, with r=6 in trials 1-30 and r=45 in trials 31-60 in the first group, and with r=45 in trials 1-30 and r=6 in trials 31-60 in the second group. At the beginning of each trial, subjects were randomly assigned to one of the k groups, each including m players each. Random assignment on each trial was intended to prevent reputation building effects. At the beginning of each trial, the subjects were only informed of the trial number (1-60), the initial budget for the trial (same for all players), and the prize value. To allow subjects using integers rather than fractions, the initial budget was set at e_0=$1.00 (experimental dollar), and the prize values were accordingly set at r=6 and r=45.

The contest was framed as a two-stage tournament. On the first stage (called "semi-finals" in the instructions), each of the m cohort members was asked to specify privately his or her expenditure for this stage. The winner of each group was chosen randomly by the computer that implemented Tullock's contest rule. The rule was explained and exemplified in detail (see Appendix). Once the k winners of stage 1—one from each group—were thus chosen, a computer screen informed the winners of this fact and privately displayed their remaining budget for stage 2 (called the "finals" stage). The m-1 players who did not advance to stage 2 received no information until the end of the trial. The k finalists were asked to specify their expenditures for stage 2 (without exceeding their remaining budget), and then the proportional contest rule was implemented a second time to determine the ultimate winner.

At the end of stage 2, the computer displayed the decisions of all the N members at each stage of the contest and the outcomes of each stage. This information was displayed as a game tree (see Outcome Screen in the Appendix). Thus, whether or not they proceeded to stage 2, all the N subjects in a session received the same outcome information at the end of each trial. Once all the subjects completed reviewing the Outcome Screen, they pressed a "continue" button. When all the 24 players in the session pressed the "continue" button, the experiment proceeded to the next trial.

The instructions explained in detail the structure of the contest with a special emphasis on the probabilistic choice of a winner at the end of each stage. The trade-off between the expenditure decisions in the two stages was explicitly stated: "Once the prize value is known, your primary consideration is to determine how much to spend in each stage of the tournament. The more you spend in the semi-finals, the greater your chances of winning this stage of the competition. However, the more you spend during the semi-finals, the less money you have to spend in the finals and the less money you have if you receive the prize."

At any time during the trial the subjects could review their own results from previous trials by clicking on a button labeled "Review Previous Trials." At the end of the experiment, 10 of the 60 trials were chosen randomly for payment. The subjects were paid their cumulative earnings for these payoff trials and dismissed.

4. Test of the Equilibrium Solutions

In this section we summarize the observed expenditures of the subjects, highlight some empirical regularities, and then report how well two different equilibrium solutions account for the behavior of our subjects.

--Insert Table 1 about here—

Table 1 presents the aggregate mean expenditures in stages 1 and 2 of the contests for each group separately. Column 2 displays the prize value *r* and columns 3-5 the mean stage 1 expenditures of Group 1, Group 2, and the overall mean. Similarly, Columns 6-8 show the mean stage 2 expenditures observed in Group 1, Group 2, and the overall mean. We conducted an ANOVA with *m* as a between-subject factor and *r* as a within-subject factor. The null hypothesis that the group size *m* has no effect on stage 1 mean expenditures was soundly rejected ($F_{(1, 92)}=150.22$, $p<0.001$). For $m=3$, the observed stage 1 expenditures were 0.368 and 0.418 if $r=6$ and $r=45$, respectively. The actual expenditures are higher when $m=8$, with the mean expenditures equal to 0.610 and 0.664 in conditions *m8r6* and *m8r45*, respectively. The second null hypothesis that the prize value has no effect on stage 1 mean expenditures was also soundly rejected ($F_{(1,92)}=19.6$, $p<0.001$).

--Insert Table 1 about here--

In our game the players are symmetric, and therefore both winners and losers in each stage of the contest should expend the same amount. Table 2 reports the observed mean expenditures of both winners and losers by stage, condition, and prize value. Consistent with the results presented in Table 1, the mean expenditures of winners and losers in stage 1 increase with the prize value. On comparing the expenditures for *m=3* with those for *m=8*, we find that the mean stage 1 expenditures of winners and losers increase with *m*. However, the mean expenditures of winners and losers are not the same. The winners of stage 1 consistently expended more than the losers ($p<0.01$). Winners in conditions *m3r6*, *m3r45*, *m8r6*, and *m8r45* expended, on average, 26%, 16%, 11% and 8% over the losers, respectively. Even in the second stage of the game winners in conditions *m3r6*, *m8r6*, *m8r45* expended more than the losers ($p<0.01$). The difference in mean expenditures between winners and losers, however, is not significant in condition *m3r45* ($p>0.2$).

Next, we compare the mean expenditures to the equilibrium predictions of two different models. We begin by testing the SR equilibrium, where players are assumed to be risk-neutral, non-pecuniary utility of winning is set at zero, and the probabilities of winning are perceived correctly. Then, we test the equilibrium predictions of the PRA model where players are allowed to misperceive probabilities and derive additional utility from winning.

--Insert Table 2 about here—

Stein and Rapoport Model. The equilibrium stage 1 and stage 2 expenditures under the SR model are presented in Columns 4 and 9 of Table 3. Although the observed behavior is in qualitative agreement with the equilibrium predictions, the actual expenditures are considerably higher than the point predictions of the SR solution. When m=3, the equilibrium predictions are

0.021 and 0.347 for *r*=6 and *r*=45, respectively. The actual mean expenditures in conditions *m3r6* and *m3r45* are significantly higher (*r*=6: observed mean = 0.368, t=10.67, p<0.001; *r*=45: observed mean = 0.418, t=2.28, p<0.03). Similarly, the corresponding equilibrium stage 1 predictions when *m*=8 are 0.115 and 0.482 for *r*=6 and *r*=45, but the actual expenditures in conditions *m8r6* and *m8r45* are significantly higher (*r*=6: observed mean = 0.610, t=12.04, p<0.001; *r*=45: observed mean = 0.664, t=4.99, p<0.001). To visually appreciate the discrepancy between observed and predicted stage 1 expenditures, Fig. 1 plots the deviations. The figure shows that the deviations increase with *m* and decrease with *r*.

--Insert Table 3 about here--

Given the systematic and significant deviations from equilibrium play in stage 1, a comparison between observed and predicted expenditures in stage 2 is clearly meaningless. The only observation worth making is that even in condition *m*3*r*6, where in equilibrium players should expend only about 68% (2.1% plus 65.6%) of their budget across both stages, in actuality the budget constraint is practically binding. This, of course, is due to the considerable over-expending of resources by subjects in stage 1.

<u>PRA model.</u> Table 3 also presents the predictions of the PRA model. The actual stage 1 mean expenditures are quite closely aligned with the model prediction except in condition *m3r6*. (As is shown below, the discrepancy in this case is due to a single session.) Subjects in condition *m3r6* should spend 0.301 in stage 1 of the contest, but the actual expenditure is significantly higher (observed mean = 0.368, t=3.58, p<0.01). On average, subjects in condition *m3r45* were predicted to spend 0.437 in stage 1, and we cannot reject the null hypothesis that the actual and predicted expenditures are the same (observed mean = 0.418, t=0.78, p>0.2). In equilibrium, subjects in conditions *m8r6* and *m8r45* should expend 0.612 and 0.680, respectively, in stage 1

of the game. The actual expenditures in these two conditions are not statistically different from the model predictions (r=6: observed mean = 0.610, t=0.07, p>0.2; r=45: observed mean = 0.664, t=0.55, p>0.2).

These results prompted us to delve further into what is driving the PRA model to outperform the SR model by considering two nested models. Recall that the PRA model allows for both misperception of probability and non-pecuniary utility of winning. First, consider the case where players are not assumed to derive additional utility from winning ($\omega_1 = \omega_2 = 0$). The corresponding equilibrium predictions for stage 1 expenditures are presented in Column 6 of Table 3. We note that the equilibrium predictions of this nested model are substantially lower than the actual expenditures (p<0.01). Misperception of probability by itself cannot help the PRA model to account for the excessive expenditures in stage 1. Next, consider the other case where players are restricted to accurately perceive probabilities. The equilibrium predictions corresponding to this nested model are presented in Column 7. We cannot reject the null hypothesis that actual and predicted expenditures are the same in conditions *m3r45*, *m8r6* and *m8r45* (p>0.18). This finding implies that the utility from winning is the key force in the PRA model.

Parco et al. claimed that both factors are necessary to account for the mean expenditures. In their experiment, the utility of winning remained constant in both stages of the game as m=k. In contrast, in our experiment, where $m \neq k$, the incremental utility from winning systematically changes in each stage of the contest and helps to better account for the data even when we set $\gamma = 1$. Subjects in our experiments played the same game for the first thirty trials and then played another game in the next thirty trials. However, in the study conducted by PRA the prize value randomly changed from trial to trial, and this added complexity might possibly have rendered it more difficult for the subjects to accurately perceive the two probabilities of winning.

---Insert Fig 1 about here ---

Trends in Expenditure. The analyses reported above examined the mean expenditures. In an attempt to detect trends in the expenditure pattern of the subjects, we divided the 30 trials into 3 blocks of 10 trials each and conducted an ANOVA to test for block effects. Examination of the block means (Table 4) does not indicate a clear trend in the expenditure pattern. In fact, we cannot reject the null hypothesis of equality of the three block means ($F_{(2,184)}=0.38$, $p>0.68$). However, this result is qualified by a significant block by prize value interaction effect ($F_{(2,184)}=12.59$, $p<0.001$), as well as a significant interaction effect of prize value and group size ($F_{(2,184)}=5.8$, $p<0.006$), implying that the trends differ among the conditions.

--Insert Table 4 about here--

Individual Differences. Further analyses show considerable individual differences. Figure 2 exhibits the frequency distributions of the mean stage 1 expenditures of the subjects for each of the four conditions. Each expenditure class in the figure accounts for 10% of the total budget. The observed empirical distributions of subjects by their mean expenditure are unimodal in all the four conditions. The mean expenditures of individual subjects in condition *m*8*r*6 ranges from 0.24 to 0.86 with a modal frequency in the expenditure class of 0.6-0.7. Similarly, individual expenditures in condition *m*8*r*45 range from 0.36 to 0.89 with the mode at 0.7-0.8. Likewise, the stage 1 expenditures of subjects in condition *m3r6* vary from 0.11 to 0.61, and the stage 1 expenditures of the subjects in condition *m3r45* range all the way from 0.1 to the highest expenditure class.

--Insert Fig. 2 about here--

Since we used a within-subject design, we could explore whether there is any systematic pattern in the behavior of individual subjects across the two prize values, namely, *r=6* and *r=45*. Figure 3 exhibits the mean stage 1 expenditures of individual subjects simultaneously for the two prize values. It shows that subjects who spent more when *r=6* also spent more when *r=45*. Table 5 summarizes this relationship by reporting the correlation coefficients that range from 0.30 to 0.81 across the four conditions. Thus, the pattern of individual differences among subjects persists in both the prize values and both group sizes. A possible explanation of these systematic individual differences is that subjects differ from one another in their depth of reasoning; they are boundedly rational to varying levels and form beliefs that are not mutually consistent. We explore this explanation in the next section.

--Insert Fig. 3 and Table 5 about here--

5. Cognitive Hierarchy Model.

Our intent in this section is to examine whether the expenditure pattern of our subjects can be accounted for by differences in their depth of thinking. We use the single-parameter Cognitive Hierarchy (CH) model recently proposed by Camerer et al. (2004) to accomplish this goal. It is not our intention here to compare the CH model with other models of iterative thinking (e.g., Costa-Gomes & Crawford, 2004; Costa-Gomes, Crawford, & Broseta, 2001; Ho, Camerer, & Weigelt, 1998; Kuber & Weizsacker, 2004; Nagel, 1995; Stahl & Wilson, 1995).

The CH model assumes that players engage in iterative step-by-step reasoning. The iterative process starts with zero-step thinkers who make random choices. The one-step thinkers best respond to zero-step thinkers. In general, *k*-step thinkers assume that their opponents are distributed over zero to *k*-1 steps. So the *k*-step players fail to see the possibility that others could think as many steps as they do, if not more.

Let the strategy of player h spending a_h units in stage 1 of the game be s_h^a. Also let each expenditure class equal to 10% of the total budget. Zero-step thinkers are equally likely to choose any of the expenditure classes. Denote by $f(k)$ the frequency distribution of the k-step thinkers. Denote a k-step player's beliefs about the proportion of z-step thinkers by $g_k(z)$. As the k-step players only consider the possibility that opponents can consider $0 \le z \le k-1$ steps, the corresponding beliefs about competitors is given by $g_k(z) = f(z) / \sum_{l=0}^{k-1} f(l), \forall z < k.$ It is useful to note that as k increases the deviation between actual frequencies $f(k)$ and beliefs $g_k(z)$ reduces.

Consistent with Camerer et al. (2004), we assume that subjects choose their stage-1 expenditure level, namely s_h^a, such that it maximizes their payoff given their beliefs $g_k(z)$ about their competitors. Further, the frequency distribution of k-step thinkers is given by a Poisson density function $f(k) = e^{-\tau}\tau^k / k!$, where the parameter τ is the mean and variance of the distribution. Assuming that subjects derive additional utility from winning each stage of the game and that they do not correctly perceive probabilities as in PRA model, we estimate the value of τ for each of the four conditions by minimizing the mean root squared deviation between the observed mean expenditure and the CH model prediction.

We find that the mean predicted expenditures of the CH model are, in general, very closely aligned with the mean observed expenditures. The mean predicted stage 1 expenditures in conditions *m3r6*, *m3r45*, *m8r6*, *m8r45* are 0.368, 0.451, 0.610, and 0.644 respectively. In actuality, the corresponding expenditures are 0.368, 0.418, 0.610, and 0.664, respectively. We cannot reject the null hypothesis that the actual and predicted mean expenditures are the same in conditions *m3r6*, *m8r6*, and *m8r45* (p>0.2), but can in condition *m3r45* (p<0.05). The estimated values of τ in conditions *m3r6*, *m3r45*, *m8r6*, and *m8r45* were 0.75, 4.0, 1.32, and 3.387, respectively, implying that the majority of the subjects were thinking more than a single step. These estimates of τ are within the range of values reported in Camerer et al. for a wide variety of games (2004, p.878).

Given that the CH model is surprisingly successful in accounting for the mean observed expenditures in each of the four treatments, we submit it to an even more stringent test. Now we compare the actual *distribution* of expenditures reported in Fig. 3 against the predicted expenditures in each of the expenditures classes. Figure 4 displays a scatter plot of the actual and predicted frequencies across all the four conditions. Now it is easy to see that CH model systematically over-predicts the high frequency events. For example, 46% of the subjects in condition *m3r45* spent 0.4-0.5 units, while the corresponding CH model prediction is 98%. Thus the CH model is successful in predicting the mean expenditures, not the entire distributions.

--Insert Fig. 4 about here--

A related question is whether the CH model can track the observed mean expenditures in the absence of utility for winning? If the non-pecuniary utility for winning is zero ($\omega_1 = \omega_2 = 0$), then the estimated value of τ systematically reduces in conditions *m3r6* and *m8r45* so that the predicted mean expenditures move upward toward 0.5 (random choice prediction) and thereby better account for the high expenditure levels observed in these two conditions. For example, the estimated values of τ drop to 0.35 and 0.79 in conditions *m3r6* and *m8r45*, respectively. Recall that the mean actual expenditures in conditions *m8r6* and *m8r45* are 0.610 and 0.664, respectively. Even if τ=0 (random choice), the CH model cannot account for the excessive expenditures observed in these two conditions, as random choice leads to a mean expenditure of only 0.5. This analysis clarifies that the limited reasoning in itself cannot fully account for the excessive expenditures in conditions *m8r6* and *m8r45*.

Consistent with the analysis reported in Section 4, we note that misperception of probabilities is less important in our experiments. Allowing for accurate perception of probabilities ($\gamma = 1$) increases the estimated value of τ but does not hurt the predictive accuracy of CH model.

In summary, the excessive expenditures in stage 1 of the game cannot be accounted for by merely invoking poor reasoning on the part of our subjects. Further, the non-pecuniary utility of winning, not misperception of probabilities, plays a key role in the decisions of our subjects.

6. Conclusions

We report behavioral regularities in two-stage contests involving large number of groups and large group sizes and then explore whether the observed expenditure pattern can be accounted for by psychological factors such non-pecuniary utility for winning and misperception of probabilities. Consistent with earlier experimental research on single-stage contests and two-stage contests with small groups, we observe that subjects tend to spend more than the equilibrium prediction in the first stage of the contest.

The excessive expenditures, though, cannot be explained by SR model, but can better be accounted by the model proposed by PRA. The key reason for the superior performance of the PRA model is that it allows for non-pecuniary utility for winning. The PRA model, however, cannot account for individual differences. We studied whether the individual differences can be accounted for by differences in the depth of reasoning. On fitting the Cognitive Hierarchy model to the data, we find that the model accounts quite well for the mean expenditure across subjects but not for the distributions of mean individual expenditures.

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Table 1: Observed Stage 1 and Stage 2 Expenditures

Condition	Prize	Stage 1 Expenditure (a_h)			Stage 2 Expenditure (b_j)		
		Group 1	Group 2	Mean over Groups	Group 1	Group 2	Mean over Groups
m=3, *k*=8	*r*=6	0.393	0.342	0.368	0.521	0.561	0.541
	r=45	0.419	0.417	0.418	0.538	0.497	0.517
m=8, *k*=3	*r*=6	0.705	0.514	0.610	0.256	0.388	0.322
	r=45	0.727	0.601	0.664	0.213	0.341	0.277

Table 2: Stage 1 and Stage 2 Expenditures by Winners and Losers

Condition	Prize	Stage 1 Expenditure (a_h)				Stage 2 Expenditure (b_j)			
		Group 1		Group 2		Group 1		Group 2	
		Winner	Loser	Winner	Loser	Winner	Loser	Winner	Loser
m=3, *k*=8	*r*=6	0.451	0.366	0.402	0.312	0.565	0.515	0.587	0.557
	r=45	0.438	0.409	0.483	0.384	0.531	0.539	0.507	0.495
m=8, *k*=3	*r*=6	0.744	0.699	0.589	0.504	0.312	0.229	0.443	0.361
	r=45	0.773	0.721	0.652	0.594	0.232	0.204	0.406	0.308

Table 3: Model Comparison

Condition	Prize	Stage 1 Expenditure (a_h)					Stage 2 Expenditure (b_j)				
		Mean over groups	SR Model	PRA Model			Mean over groups	SR Model	PRA Model		
				Full Model	Restricted Models				Full Model	Restricted Models	
					No Utility of Winning	No Misperception of Probability				No Utility of Winning	No Misperception of Probability
m=3, *k*=8	*r*=6	0.368	0.021	0.275	0.083	0.301	0.541	0.656	0.725	0.530	0.699
	r=45	0.418	0.347	0.437	0.365	0.451	0.517	0.653	0.563	0.347	0.635
m=8, *k*=3	*r*=6	0.610	0.115	0.612	0.117	0.651	0.322	0.885	0.388	0.694	0.349
	r=45	0.664	0.482	0.680	0.461	0.698	0.277	0.518	0.320	0.539	0.302

Table 4: Trends in Stage 1 Expenditures

Condition	Reward	Group	Stage 1 Expenditure (a_h)		
			Block 1	**Block 2**	**Block 3**
m=3, k=8	r=6	Group 1	0.399	0.399	0.383
		Group 2	0.371	0.343	0.313
	r=45	Group 1	0.422	0.409	0.424
		Group 2	0.364	0.423	0.465
m=8, k=3	r=6	Group 1	0.716	0.705	0.693
		Group 2	0.528	0.519	0.497
	r=45	Group 1	0.667	0.764	0.752
		Group 2	0.620	0.574	0.609

Table 5: Correlations between Mean Individual Expenditures in Stage 1 for the Two Prizes

Condition	Group	Correlation between Stage 1 Expenditures in the Two Prize Conditions
m=3, k=8	Group 1	0.82
	Group 2	0.46
	Overall	0.61
m=8, k=3	Group 1	0.30
	Group 2	0.64
	Overall	0.65

Fig.1: Deviation from Stage 1 Equilibrium Expenditure when $\omega = 0$

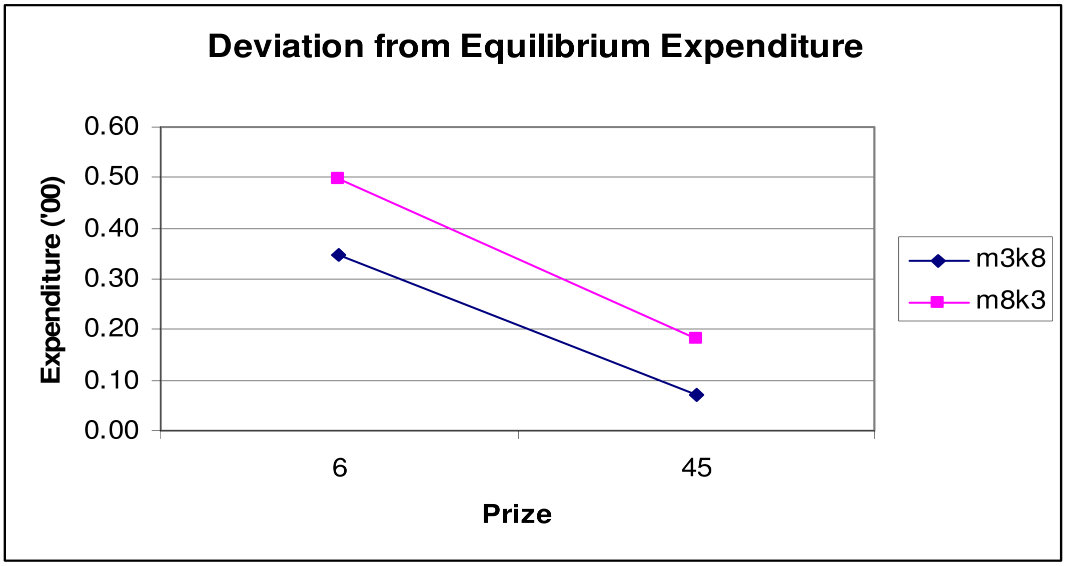


Fig.2: Distribution of Mean Expenditures of Individual Subjects

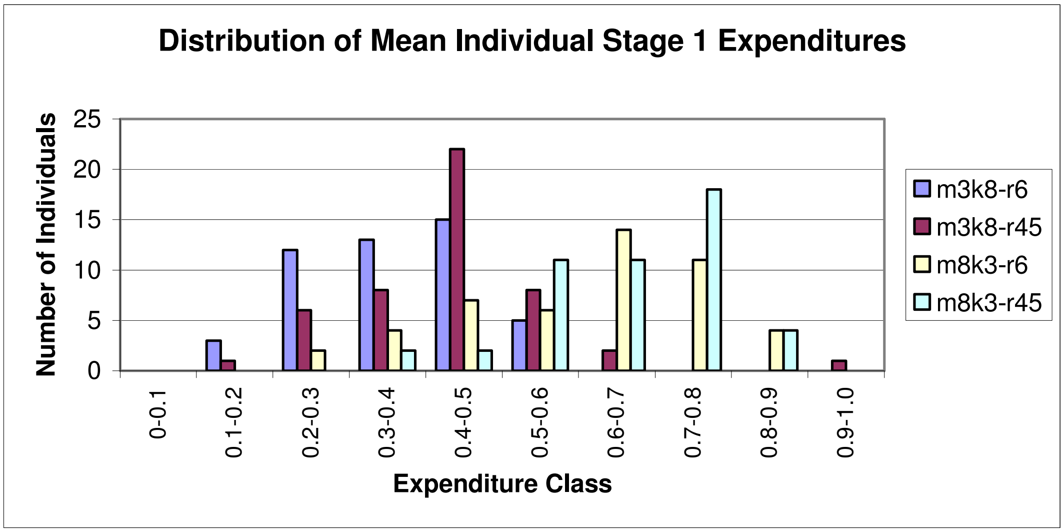


Fig.3: Relationship between Stage 1 Expenditures under the two Prize Conditions

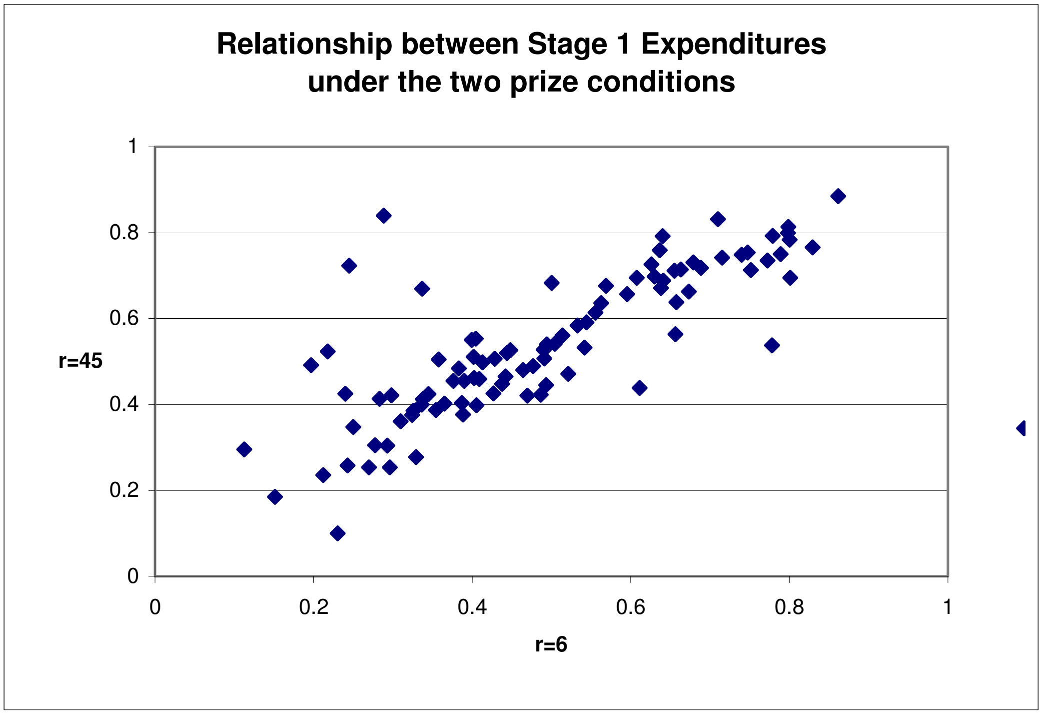
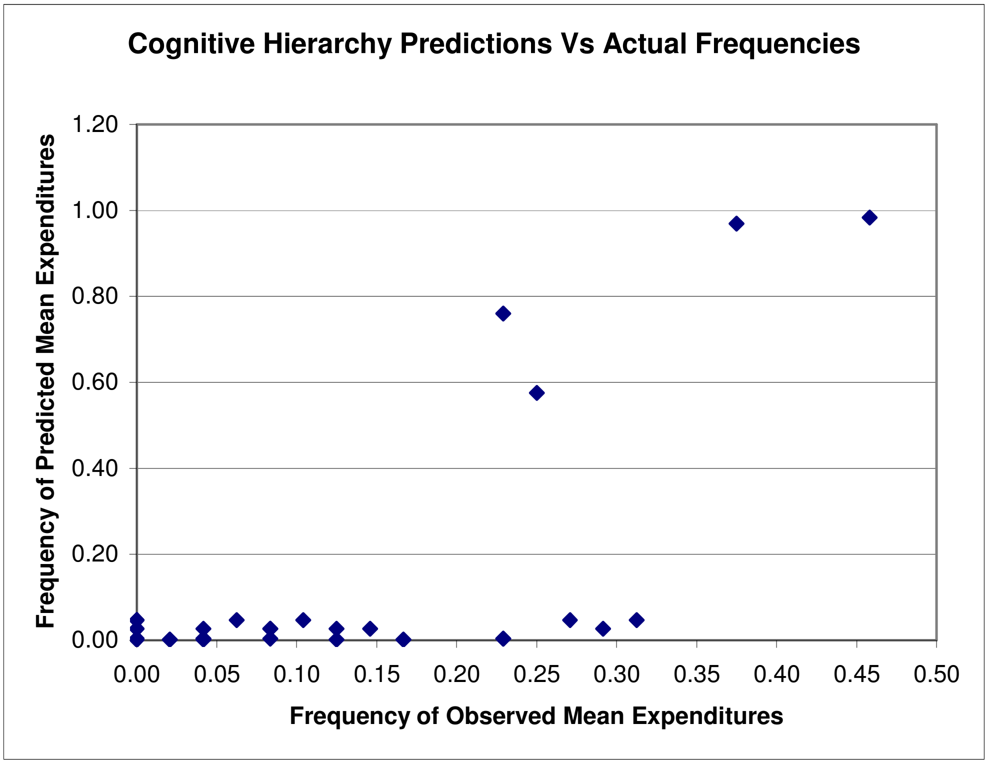


Fig.4: Relationship between Cognitive Hierarchy Model Predictions and the Actual Distribution of Mean Investments of Subjects in the Four Conditions



APPENDIX

Here we provide the instructions for the case where *m=3* and *r={6,45}*.

SUBJECT INSTRUCTIONS

This experiment has been designed to study how people allocate their budget in a two-stage tournament. The instructions for this experiment are quite simple. If you follow them carefully and make good decisions, you may earn a considerable amount of money. Therefore, it is important that you try to do your best. A research foundation has contributed the funds to support this research.

General Description of the Tournament

Main features of the game. You are one of **24** players who volunteered to compete in a two-stage tournament with payoffs contingent on performance. Each tournament has the same structure. At the beginning of each tournament, players are randomly placed into **EIGHT** groups containing **THREE** players each. During the first stage, the three players within each group will compete against one another to determine a group winner. Each group winner (finalist) will then compete in the final match against the other seven group finalists. The winner of the final match will be awarded a prize. There will be two different prize values, one for trials 1-30 and the other for trials 31-60. The prize value will be publicly announced prior to each tournament.

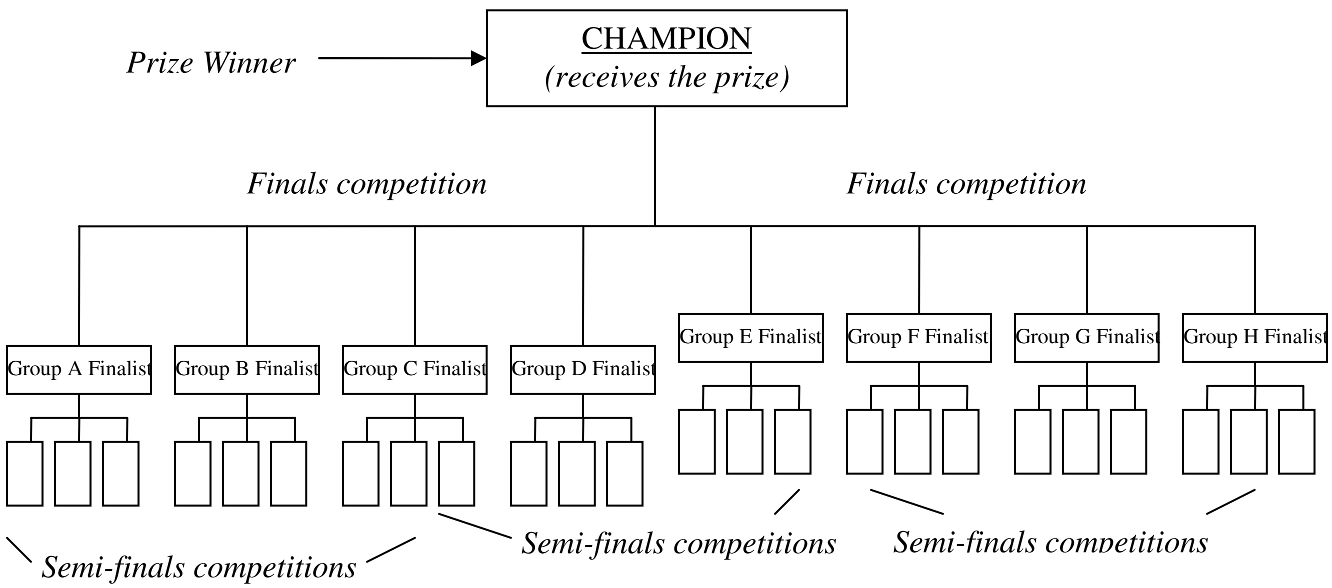
The tournament consists of two stages:

- Stage 1 – "The Semi-finals". During stage 1 of the tournament, each player is given an initial budget of $1.00. Each player will be asked privately and independently to decide how much of her budget they wish to spend. Players can spend any amount between $0.00 and $1.00. The more a player spends, the greater her chances of winning the first stage. Once all three players within the group have decided how much to spend, the computer will determine the winner of that group. Simultaneously, the other twenty-one players assigned to the other seven groups will be competing against each other in a similar fashion. The rule used by the computer for choosing a winner in each of the **eight** semi-finals will be explained below.

- Stage 2 – "The Finals." After the computer determines the **eight** finalists (one winner from each group), they will compete against each other in a final match. The other sixteen players—two from each group—who did not win during the semi-finals--will no longer participate in this game. Just like in the semi-finals, each player in the finals will be asked to decide how much she wishes to spend to compete against the other seven players. No player can spend more than the amount remaining from the initial budget. Once all eight finalists have made their decisions in stage 2 of the contest, the computer will determine the Champion.

The Champion will receive a predetermined prize. The other twenty-three players will receive no prize at all. Regardless of whether or not a player receives the prize, each of the twenty-four players will keep whatever portion remains of her initial budget of $1.00 that was not spent during the tournament.

The diagram below depicts the basic structure of the game.



<u>Calculating the "chances of winning</u>" Each player's chances of winning the competition during either stage of the game are determined by how much she spends ***in comparison to*** how much all the players in her group spend. As long as a player spends something, then he will have some chance of winning. If a player spends nothing, then she "forfeits" the competition defaulting to the other players.

Once all three players of a group have made their decisions, the computer will calculate each player's chances of winning using the following formula:

$$\textbf{A player's chances of winning} = \frac{\textbf{Amount spent by Player}}{\textbf{(Amount spent by ALL the players in his/her group)}}$$

<u>Example</u>
Suppose that each of the three players in a group spends the following:

Player 1: $0.10
Player 2: $0.57 — Total amount spent: $1.42
Player 3: $0.75

Player 1 of Group A spends $0.10 (of his initial $1.00 budget) in the semi-finals. His/her chances of winning are given by:

$$\textbf{Player 1's chances of winning} = \frac{\$0.10}{\$1.42} = 0.071$$

So Player 1 has a 7.1% chance of winning the semi-final competition. The chances of winning of Player 2 are calculated in a similar way resulting in a 40.1% chance of winning. On dividing each player's expenditure by the total group expenditures ($1.42), we have each player's chances of winning:

Player 1's chances of winning = $0.10 / $1.42 = 0.071 → 7.1% chance of winning

Player 2's chances of winning = $0.57 / $1.42 = 0.401 → 40.1% chance of winning

Player 3's chances of winning = $0.75 / $1.42 = 0.528 → 52.8% chance of winning

<u>Determining the winner</u>. Once the computer has calculated the chances of winning based on the amounts spent, it will assign "lottery ticket" numbers to each of the players in proportion to the total expenditures. The tickets are numbered from 1 to 1000. For example, if Player 1 has a 0.071 chance of winning, Player 2 has a 0.401 chance of winning, and Player 3 has a 0.528 chance of winning (the chances of all three players must always sum to 1.000), then Player 1 will be assigned ticket numbers 1 through 71 (71 tickets), Player 2 will be assigned ticket numbers 72 through 472 (401 tickets), and Player 3 will be assigned ticket numbers 473-1000 (528 tickets).

After each player has been assigned her tickets, the computer will randomly generate a number between 1 and 1000. The winner of the contest will be the player holding the lottery ticket number corresponding to the randomly drawn number. Thus, the greater the "chances of winning" are for a player, the more lottery tickets that will be assigned and thus, the more likely she is to be holding the winning ticket.

Note that under this rule it is possible for a player to win the contest as long as she holds at least 1 ticket. This rule for determining a winner is the same for both stages of the tournament.

Description of the Computer Displays

During each game you will have at most two decisions to make. At the beginning of each game (trial), you will be given $1.00. Your first decision is how much, if any, you wish to spend during the semi-finals. You will be presented with the following screen that will provide you with the following information:

Trial 1

Stage 1 - The Semi-finals

You are Player 1 in Group A

Both you and the other two players in your group have $1.00

The Champion of the finals will receive a prize of $6.00

Please enter the amount you wish to spend on the semi-finals competition:

[ ] ← Enter your amount here…

Submit

Assume that Player 1 of Group A decides to spend $0.95 (out of his $1.00 budget) during the semi-finals. After she types this amount into the white box, she has to click on the **Submit** button to confirm his decision. The remaining amount she has is $0.05 ($1.00 – $0.95). If she loses the semi-finals, then this will be her earnings for the trial. If she wins the semi-finals, this is the amount left for her to compete with in the finals.

Example. Suppose that each of the three players in Group A spent the following:

Player 1: $0.95
Player 2: $0.05
Player 3: $0.15

Then, the total amount spent by group members = $1.15

Player 1's chances of winning = $0.95 / $1.15 = 0.826 → 82.6% chance of winning

Player 2's chances of winning = $0.05 / $1.15 = 0.043 → 4.3% chance of winning

Player 3's chances of winning = $0.15 / $1.15 = 0.131 → 13.1% chance of winning

Total chances of winning: 1.000 → 100%

At the completion of stage 1, all players in Group A will be presented with the following screen:

	Starting Budget	Amount spent	Amount remaining	Chance of Winning	Ticket numbers
Player 1	$1.00	$0.95	$0.05	0.826	1-826
Player 2	$1.00	$0.05	$0.95	0.043	827-870
Player 3	$1.00	$0.15	$0.85	0.131	871-
Total amount spent:		$1.15		1.000	

You are Player 1. The winning ticket is 283. You win!

Continue

In this example, Player 1 in Group A wins her semi-finals match and advances to the finals. Once she clicks on 'Continue' she will be shown the second-stage decision screen with the following information:

Trial 1

Stage 2 - The Finals

Congratulations! You are the Group A Finalist

You have $0.05 remaining from you initial budget

The winner of the Finals will become the Champion and receive a prize of $6.00

Please enter the amount (between $0.00 and $0.05) that you wish to spend on the Final match:

Enter your amount here…

Submit

The Group A finalist can spend any amount she wishes for the Finals match **up to the remaining amount of her budget**. In this example, the Group A finalist has $0.05 remaining. She knows that each of the other seven group finalists also started with $1.00; however, she **does not know** how much any of her other opponents have at the start of the final match. In this example, suppose the Group A finalist spends all of her remaining $0.05.

Once she decides how much to spend, each player is asked to click on the **Submit** button. When all eight finalists have confirmed their decisions, the computer will compute their chances of winning the Final match exactly as in semi-finals (using the same formulas) and determine the tournament *Champion*. The finalists will then be shown the results of the final match.

	Starting budget	Amount spent	Amount remaining	Chance of Winning	Ticket numbers
Group A	$0.05	$0.05	$0.00	0.019	1 - 19
Group B	$0.87	$0.87	$0.00	0.332	20 - 351
Group C	$0.15	$0.15	$0.00	0.057	352 - 408
Group D	$0.10	$0.10	$0.00	0.038	409 - 446
Group E	$0.20	$0.20	$0.00	0.076	447 - 528
Group F	$0.75	$0.30	$0.40	0.115	529 - 638
Group G	$0.60	$0.40	$0.20	0.153	638 - 790
Group H	$0.55	$0.55	$0.00	0.210	791 -1000
Total amount spent:		$2.62		1.000	

The winning ticket is 942. You did not win. The Group H Finalist is the Champion and wins the $6.00 prize.

Continue

In this example, the Group F finalist spent less than half of her remaining amount ($0.30) while the Group A, B, C, D, E and H finalists spent all of their remaining endowments. As it turned out, the Group H finalist won the finals and became the *Champion* earning the prize of $6.00.

Once the tournament is over, all the players will view the same screen, which summarizes the final results of the game.

Once the prize value is announced, your primary consideration in this trial is to determine how much to spend in **each stage** of the tournament. The more you spend in the semi-finals, the greater your chances of winning this stage of competition. However, the more you spend during the semi-finals, the less money you have to spend in the finals, if you reach it, and the less money you have if you do not receive the prize. Recall that only the Champion receives a prize, and every player, including the Champion, keeps what remains of his or her initial budget.

View Earnings History. If you wish to review your results from the previous trial, you may do so by clicking on the button labeled 'Review previous results' at the bottom of the screen showing tournament diagram at the conclusion of the previous trial.

Summary

There are 24 individuals in this experiment who will participate in 60 trials. At the beginning of each trial, the computer will randomly divide the **24** individuals into **8** groups of **3** players each. Thus, at the beginning of each trial, you will be randomly matched with two other anonymous players. These group members will change from one trial to another. Each player will be given the same initial budget of $1.00. Earnings from previous trials cannot be used. Communication between the players during the experiment is strictly forbidden.

Once all players have made their decisions for stage 1, the computer will determine the winner of each of the eight groups. These group finalists will then make their stage 2 decisions. Once all eight finalists have entered their decisions, the computer will determine the Champion and award the prize to that player. The other players' earnings will only be that which they did not spend during stage 1 or stage 2.

Payment at the End of the Session

At the beginning of the experiment, 10 trials will be randomly selected out of 60 and you will be paid your earnings for these 10 trials. Therefore, it is important to do your best on each trial. Your earnings will be paid to you in cash at the rate of two US dollars for every experimental dollars.

Please look up to indicate that you have completed reading the instructions. The supervisor will start the experiment in just a few minutes. Thank you for your participation.