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THE HEBREW UNIVERSITY OF JERUSALEM

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By

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Discussion Paper # 660 (February 2014)

מרכז לחקר הרציונליות

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Investing Even in Uneven Contests:

Effects of Asymmetry on Investment in Experimental All-Pay Contests

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Abstract

Many competitions require investment of nonrefundable resources, e.g., political campaigns, financial markets, sports or courting rituals. One contestant wins the prize for the invested amount, while all others forfeit their investments without receiving compensation. Frequently, contests are asymmetric, due to differing resources or prize valuations. This could lead weaker contestants to avoid investing, and stronger ones to lower their investment. Two experiments explored the effects of asymmetry between the contestants – arising from their endowments or prizes – on investments. Subjects played both symmetric and asymmetric contests, enabling direct within-subject comparisons. We observed an effect of asymmetry only when it concerned endowments: Subjects invested less when their endowments were asymmetric, whereas (a-)symmetry in the prizes did not influence investments. The changes between consecutive investments can be explained by reactions to the previous outcome (win or loss) in terms of regret over the previous investment being too much or too little.

Highlights:

- We examined the effect of asymmetry in contests with nonrefundable investments.
- Asymmetry was created either in the contestants' endowments or their prizes.
- Asymmetry decreased investments when it manifested in endowments, but not prizes.
- Winning and losing influenced round-to-round changes in contestants' investments.
- Investments were driven more by the wish to win than by the prize size.

Keywords: All Pay Auction; Contest; Heterogeneity; Asymmetric Competition; Regret; Competitive Motivation

Introduction

Many aspects of life involve competitions: Animals and plants compete for food, water, mates, and living space; societies compete for resources, allies, and status. Among humans, competitions can be found in sports, in financial markets, in the educational system, in the workplace, between politicians or lobbyists, between companies attempting to secure a contract or a patent, between rivals vying for a mate, and so on (see, e.g., Vaughn & Diserens, 1938).

Two features that characterize many contests are that (1) contestants aim to win a prize or a goal which is indivisible, and (2) participation demands investments that are costly for the contestants, regardless of the contest outcome. To win the prize, contestants invest resources, such as effort and money, which are non-refundable and will not be returned, independent of win or loss. The money spent on campaigning for presidency and the training efforts of athletes are examples of such investments. Of course, winning the contest makes the expenditure worth it—otherwise, why compete?

Competitions impact the way contestants behave, which can result in different levels of overall utility for society. On the one hand, contests can create or increase value (Vickers, 1995); in contests aimed towards innovations or achievements – e.g., R&D and patent races, sporting events – high investments are socially desirable (Runkel, 2006; Szymanski, 2003). On the other hand, competitions can also lead to adverse effects, when contestants exert on aggregate more effort or resources than is reasonable (O'Keeffe, Viscusi, & Zeckhauser, 1984). This result is of concern in politics, lobbying and so forth: When the sum of investments significantly exceeds the prize amount and little or nothing is produced, resources are wasted. In rent-seeking activities, comprising attempts to obtain a given resource without creating new wealth (e.g., increasing one's share of an existing amount, or retaining monopoly privileges), overinvestment is particularly problematic (Tullock, 1980). This phenomenon of overinvestment (or over-dissipation of resources) has been observed in many studies of costly rank-order competitions across various contest features (Baye, Kovenock, & de Vries, 1999; Davis & Reilly, 1998; Gneezy & Smorodinsky, 2006; Lugovskyy, Puzzello, & Tucker, 2010; Potters, de Vries, & van Winden, 1998; Sheremeta, 2010; for a review, see Dechenaux, Kovenock, & Sheremeta, 2012).

An important aspect of contest structure is the relative strengths of the contestants. Competitions have been theorized to be a manifestation of social comparison, which can be used

to evaluate and assess one's abilities (Festinger, 1954). According to this perspective, contests are expected to be most intense when the contestants are similar in the relevant aspects (Festinger, 1954; Goethals & Darley, 1977; Hoffman, Festinger, & Lawrence, 1954). This has been observed in experiments (Dakin & Arrowood, 1981; Kilduff, Elfenbein, & Staw, 2010). However, most contests are asymmetric, in at least two possible ways: contestants not having equal resources, or not holding the same valuation for winning the contest. For example, a small company trying to earn a contract probably has much less funds to invest in first creating its prototype for getting the contract than a big, established company, but it may have much more at stake from winning or losing the contract than the larger company.

Do these asymmetries affect the contestants' behavior? In particular, how much would each contestant invest in asymmetric competitions? Will weaker or less motivated contestants choose to give up and not compete under some conditions? And how does asymmetry affect the contestants' investments in subsequent competitions after they win or lose a contest?

The focus of this paper is the behavior of contestants in asymmetric contests compared to symmetric ones. We examine contests in which all contestants forfeit their investments and only the contestant who made the greatest investment wins the prize, a setup called an *all-pay auction* (Tullock, 1967; 1980). All-pay auctions have been used to model lobbying for licenses and rights, rent-seeking, companies competing on research and development, architectural contests, and political races (Dasgupta, 1986; Hillman & Samet, 1987; Krueger, 1974; Tullock, 1967). We explore how asymmetry between the contestants influences their aggregate investments, as well as their pattern of subsequent investments after winning or losing when competing repeatedly. We examine the effects of asymmetries arising from two different sources: In Experiment 1, contestants are asymmetric in their endowments; in Experiment 2, contestants differ in the size of their potential prize.

The next two sections describe the literature in various fields regarding asymmetric contests, the effect of asymmetry on the intensity of competition, and the contestants' reactions to winning or losing in the competition, before we turn to our own experiments in the sections afterward.

Asymmetric Contests

Theories and meta-analyses in ecology argue that asymmetric contests constitute the majority of cases in animal and plant competitions (Connell, 1983; Lawton & Hassell, 1981; Schoener,

1983). In such cases, asymmetry often arises from the contestants' relative sizes (Schoener, 1983). Asymmetry is predicted to lead to varying behavior: The trade-off between the probability and value of receiving the prize on the one hand, and the costs associated with competing on the other, may be settled differently by each contestant according to their relative competitive position (Enquist, 1985; Maynard Smith & Parker, 1976). For instance, in animal conflicts, the larger animals often dominate the smaller ones and can resort to more aggressive behaviors at a lower cost (Persson, 1985; Young, 2003). Competitions between plants for soil or light exhibit similar characteristics (Schwinning & Weiner, 1998).

When the relevant difference between the contestants is large enough, the weaker contestant may be discouraged from competing altogether. The stronger contestant, predicting that, could then also invest less in the competition. This pattern – termed the "discouragement effect" – has been observed both in non-human animals (e.g., when smaller red deer males give up after sizing up larger competitors before potentially aggressive competitions—Clutton-Brock & Albon, 1979) and in several empirical and experimental studies in humans utilizing the all-pay auction (for a review, see Dechenaux et al., 2012). Economic analyses also predict that sufficient asymmetry decreases the expected individual investment in a competition (Baik, 1994; Baye, Kovenock, & de Vries, 1993, 1996; Hillman & Riley, 1989; Nitzan, 1994; Rapoport & Amaldoss, 2000; Runkel, 2006; Szymanski, 2003).

The chance of winning may loom particularly large in contestants' motivation to invest in a competition (e.g., Kohn, 1992; Vaughn & Diserens, 1938; see next section for further discussion). However, it is important to note that the particular asymmetry in a competition does not necessarily equate to a differential likelihood of winning; the relationship between the two depends on the contest structure, and the absolute as well as relative standings of the contestants (Dechenaux et al., 2012; Szymanski, 2003). In animal conflicts, for example, though large animals may have an aggressive advantage, smaller animals may have other advantages (Persson, 1985). In human wars and asymmetric conflicts as well, strong and weak nations or factions may use different strategies, playing to their respective advantages, so that an apparent strength asymmetry does not necessarily translate to winning odds (Arreguin-Toft, 2001; Mack, 1975).

Winning or Losing

The most obvious reason that people (and other organisms) enter into contests and invest costly resources is the attraction of winning, yet the other, unattractive, side of the coin is no less salient: the possibility of losing. Whereas winning may lead to positive emotions and an increase in perceived competence (Reeve & Deci, 1996), losing can lead to negative emotions, such as shame and guilt (Kohn, 1992; Standage, Duda, & Pensgaard, 2005). Some researchers argue that winning, specifically besting others, is the strongest competitive motivation, overshadowing the desire to do well (Bazerman, Loewenstein, & White, 1992; Kohn, 1992; Malhotra, 2010; Messick & McClintock, 1968). This could be because characteristics of the competitive situation cause arousal, which shifts the focus towards beating the opponent even at a high personal cost (Mead, 1937; Whittlemore, 1924; 1925).

Thinking about competitions in which all investments are nonrefundable, it is easy to see that loss may give rise to negative feelings, including regret over not having invested enough to win the competition – or, conversely, over having invested in the competition at all, rather than keeping one's resources to oneself. But regret may also occur after winning the contest: Along with the positive emotions associated with winning, one may also regret having invested too much, surpassing the opponent by a larger-than-necessary margin. This conjecture fits with an extensive line of research showing that including regret in decision theories can explain behavior in a variety of situations and interactive games (Avrahami, Güth, Hertwig, Kareev, & Otsubo, 2010; Avrahami & Kareev, 2010, 2011; Zeelenberg & Beattie, 1997; Zeelenberg, Beattie, van der Pligt, & de Vries, 1996). Two forms of regret that appear relevant to winning and losing in auctions are thus winner regret ("money left on the table") and loser regret ("missed opportunity to win"). Anticipation of the former should decrease bids during an auction, whereas anticipation of the latter should increase them (Engelbrecht-Wiggans & Katok, 2007, 2008). Overbidding in auctions may be explained by the differential saliency of these types of regret: In most experimental settings – though not necessarily in most real-life situations – only the loser's regret is salient, as only the highest bid is announced (Engelbrecht-Wiggans & Katok, 2007, 2008; Filiz-Ozbay & Ozbay, 2007; Hyndman, Ozbay, & Sujarittanonta, 2012).

Here we explore whether regret can explain how people learn to adjust their strategies in a succession of competitive interactions. In line with previous research showing effects of

outcomes on subsequent decisions (Avrahami & Kareev, 2011), we propose that investments in contests are affected by regret-based reactions to the most recent contest outcome. We examine the various possible influences that can appear in round-to-round contest dynamics, and whether they have an impact on contestants' aggregate investments: Will winning indeed drive contestants to decrease their subsequent investments, due to their regret over investing too much? Or will they increase their investment to remain winners? Will losing cause contestants to increase their investment and try to win the next time, or to decrease their investment so as to not waste further resources? And finally, do such tendencies, if they exist, differ between contestants differing in strength or motivation?

Study Overview

Our two experiments directly explored the influence of asymmetry, by having the same subjects play multiple rounds of both symmetric and asymmetric contests in two blocks. Subjects were assigned to different types defined in terms of the subject's resource endowment (Experiment 1) or how big of a prize they would win (Experiment 2). A subject's type remained constant across the rounds, though they would meet opponents of various types. We believe this to be an important feature of contests in real life: One often retains one's own type throughout various contests over time, but one's opponents usually vary across contests – in some situations, one is faced with stronger opponents, and in others, with weaker opponents.

The repeated nature of our game allows us to analyze not only the overall investment rates, but also the dynamics of behavior – the changes subjects make in their investments over rounds, and specifically, their reactions to the outcomes of their previous investments, whether winning or losing.

The "Invest Game"

Subjects played the "Invest game", a repeated two-player all-pay contest with complete information. In each of the 16 rounds of the game, subjects receive a certain endowment of points (resources) determined by their type, and decide how many points to invest in that round's contest (investments are discrete). In each round for each competing pair, if one subject invests more than the other then the former wins the prize (determined by their type); in case of a tie, each subject receives half of the prize for their type. Investments are non-refundable, regardless

of win or loss. Uninvested points (and prizes) are not transferrable to invest in subsequent rounds; they accumulate and are exchanged for money after the experiment.

In both experiments, subjects can be either of two types, pertaining to their relative position: In Experiment 1, these types vary in the size of each subject's endowment; in Experiment 2, the types vary in the size of the each subject's prize.

Subjects are randomly matched with others on each round. Following standard terminology, we call a contest between subjects of two different types an **asymmetric contest**, and a contest between two subjects of the same type a **symmetric contest**. In our setting, each subject plays both symmetric and asymmetric contests: Half of the rounds are symmetric contests, and the other half are asymmetric contests.

Before each round, subjects are told their opponent's type. They are also notified when there is a change from a block of symmetric contests to one of asymmetric contests (or vice versa). After each round, subjects are told whether they invested more or less than their opponent, whether they received a prize, and their earnings for the round. That is, all of the information in the game, other than the exact value of the opponent's investment, is common knowledge.

Experiment 1 – Asymmetric Endowments

In our first experiment we used the Invest game described above, with the two types defined by endowments of either 96 points per round ("High-E") or 72 points per round ("Low-E"). These types varied as a between-subject factor, with half of the subjects in each session assigned to be High-E and half to Low-E. Symmetry was a within-subject factor, with each subject playing against both types (in one symmetric and one asymmetric block of 8 rounds each). In each round, the pairings were determined randomly from the relevant group of subjects (i.e., stranger design).

There were two versions of the game: P-96, in which the prize was worth 96 points for both types, and P-72, in which the prize was worth 72 points for both types. At the end of the game, subjects received their summed earnings, according to a specified exchange rate. The exchange rates were set such that, on average, subjects earned about twice the student hourly wage for their time spent.

Method

Subjects. Subjects were Hebrew University students, who participated in each experiment for monetary pay. In P-96, 48 students participated, out of which there were 24 females (50.0%); 41 of the subjects (85.4%) were undergraduates. In P-72, 48 students participated: 32 females (66.7%); 44 undergraduates (91.7%).

In P-96, subjects earned an average of 1.75 NIS per round (New Israeli Shekel, worth approximately 0.27$); in P-72, earnings averaged 1.17 NIS per round.

Procedure. The experiment was conducted on PC computers connected to the experiment webpage. Subjects were separated from one another by physical partitions between the PC stations, and were instructed not to communicate with each other. They read the experiment instructions at their own pace from the screen, and were asked to raise their hand if they had questions at any point in the experiment.

The game as described above was explained to the subjects, so that the game and payoff structure, number of rounds (16) and the exchange rate from experimental points to NIS were all common knowledge. The computer randomly generated the contest pairings for each round. Subjects had no way of knowing the identity of their opponent at any stage of the game. After all subjects had submitted their investment for the round, they were shown the round outcome. After all subjects indicated they were ready to continue, another round began. At the end of the experiment, subjects saw their total payoff (in NIS). They were thanked and asked to enter the adjacent room, one by one, to receive their payment.

Results

Investments. Across all contests, the average investment was 45.85 points, that is, a sum of 91.70 points invested per contest. The average was 44.51 in P-96, when competing for a prize of 96 points, and 45.19 in P-72, when competing for a prize of 72 points. The difference between these is not significant ($t(94)=0.19$, $p=.842$). However, as presented in Table 1, the similar investments led to very different degrees of dissipation (i.e., over- or under-investment in the contest) in the two cases, because the benchmark for calculating the degree of dissipation was different: In P-96 the average investment was compared to 48, half of the 96 point prize,

demonstrating no significant over- or under-dissipation; in P-72, the investment was compared to 36, half of the 72 point prize, showing highly significant overdissipation.

Table 1. Dissipation in the two contest versions, P-96 and P-72

Version	Benchmark	Investment (SD)	Significance
P-96	48	44.51 (18.90)	t(47)=-1.28, p=0.207
P-72	36	45.19 (16.23)	t(47)=3.93, p<0.001

Note. The degree of dissipation (or overinvestment) is defined with regard to the prize, such that the average investment is compared to half of the potential prize.

Asymmetry. A linear regression with variance clustered by subject (as each subject made repeated decisions) examined whether asymmetry in endowment affected investments. We first tested whether the P-96 and P-72 reward size cases differed, and as before we found no difference between the two versions (no main effect nor interactions were significant; all *p*'s>.22). Thus, we collapsed across these and report the following results on effect of asymmetry for the combined data.

There were strong main effects of own and opponent's endowments: When a subject had the High-E endowment level (96 points), they tended to invest more ($t(96)=2.99$, $p=.004$); and when a subject's opponent had the High-E endowment level, the subject invested less ($t(96)=-2.46$, $p=.016$). Importantly, there was a significant effect of symmetry: All subjects tended to invest more in symmetric contests than in asymmetric contests ($t(96)=3.57$, $p=.001$). This pattern can be seen in Figure 1. In fact, in every round, the average investment in the symmetric contests was larger than that in asymmetric contests. Interestingly, as shown in Figure 1, the investments in symmetric contests did not depend on the endowments at the subjects' disposal: When competing with others of their own type, subjects who had 72-point or 96-point endowments invested, on average, similar amounts.

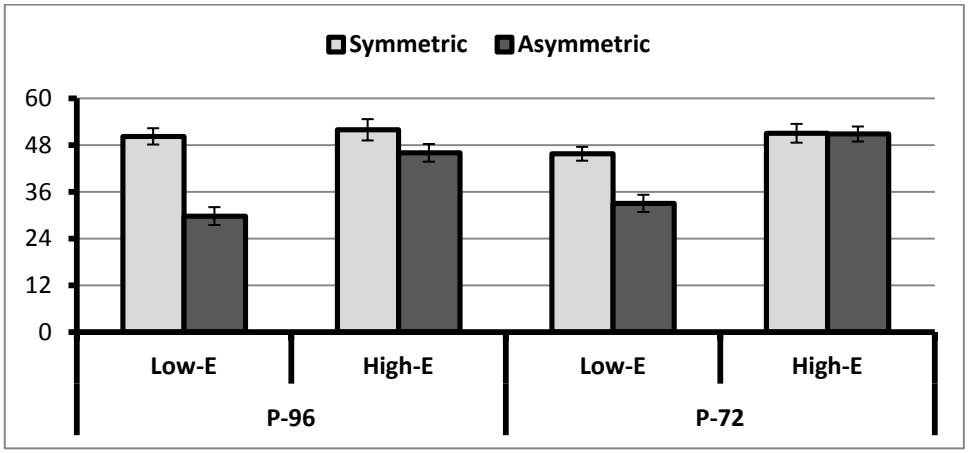

Figure 1. Average investments in the two contest versions, P-96 and P-72, for each type of subject (low or high endowment, Low-E or High-E), in symmetric and asymmetric contests.

Sitting Out. While subjects cannot opt out of the contest per se, they can invest zero in a round and in essence sit out that competition. This is of interest because investing zero can be taken as an extreme manifestation of the discouragement effect. On average, across all contests and subject-types, 13.22% (203 of 1536) of investments were zero. To examine whether this rate differs for the different contests, we submitted the indicator variable to a logistic regression (with variance clustered by subject). There was a higher rate of zero-investments in P-72 (z=2.06, p=.039), probably due to the smaller prize to be won. In both versions, Low-E tended to sit out more than High-E (z=3.79, p<.001), but this effect was smaller in P-72 (z=-2.96, p=.003). Both types of subjects tended to sit out more against High-E subjects (z=3.91, p<.001) – that is, High-E tended to sit out slightly more when they were faced with their equals than when facing weaker subjects, and Low-E tended to sit out more when their opponent was stronger. This pattern is presented in Figure 2.

It is important to note that sitting out was not confined to only a small number of people: Nearly half of the subjects (41 of 96) invested zero in at least one round. In P-96, 13 of 24 Low-E invested zero at least once, along with 6 of the 24 High-E subjects; in P-72, 13 of 24 Low-E subjects invested zero, and 9 High-E subjects.

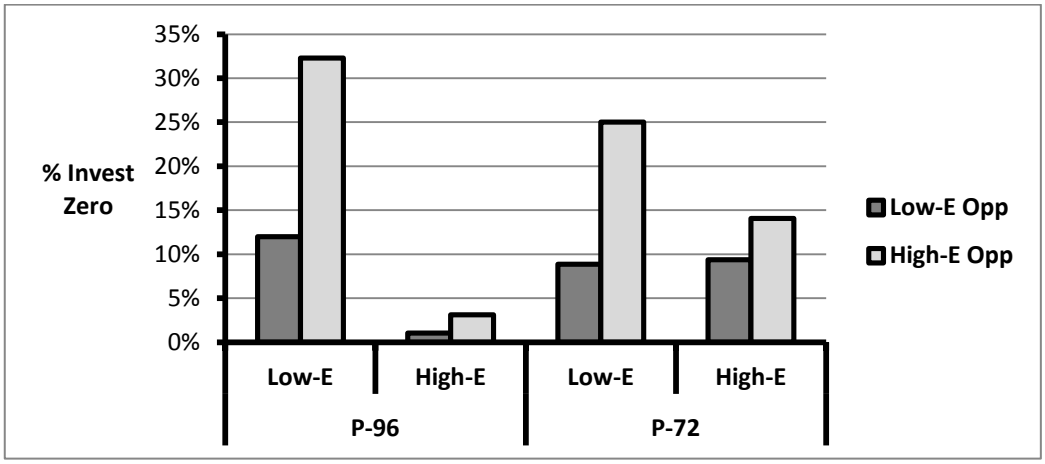

Figure 2. Percent of investments equal to zero in the two contest versions, P-96 and P-72, for each type of subject (low or high endowment, Low-E or High-E), facing either low or high endowment opponent (Low-E Opp or High-E Opp).

Investment Dynamics. Do contestants' investments change systematically over rounds? If so, is there an influence of the outcome in the previous round, winning or losing, on the investment in the following round? Do the size of the prize, or the subjects' endowments, have an effect on changes in consecutive investments?

We used a linear regression model to address these questions, with the change in investment from one round to the next as the dependent variable, as shown in Figure 3. The largest effect was a negative influence of the previous investment ($t(96)=-9.94$, $p<.001$); this could reflect regression to the mean. The outcome (winning vs. losing, as a binary variable) also had a negative influence that was both significant ($t(96)=-4.92$, $p<.001$) and substantial: Following a loss, subjects tended to increase their subsequent investment, whereas they decreased it following a win; the differences according to outcome averaging around 8 points – and held above and beyond a subject's investment. There was also a significant interaction between the investment and the outcome ($t(96)=3.90$, $p<.001$): Specifically, the more a subject invested, the less they were subsequently affected by the outcome. It should be noted though that this finding may be distorted by the small number of observations of loss combined with high investment.

High endowment (High-E) subjects made larger changes from round to round, compared with Low-E subjects ($t(96)=2.22$, $p=.029$). Further, they reacted more strongly to the outcome of the

previous round ($t(96)=-4.21$, $p<.001$). These results can be accounted for by the different range of investments for High-E subjects versus Low-E subjects. We found no significant effect or interaction with the experiment versions (all p's >.39).

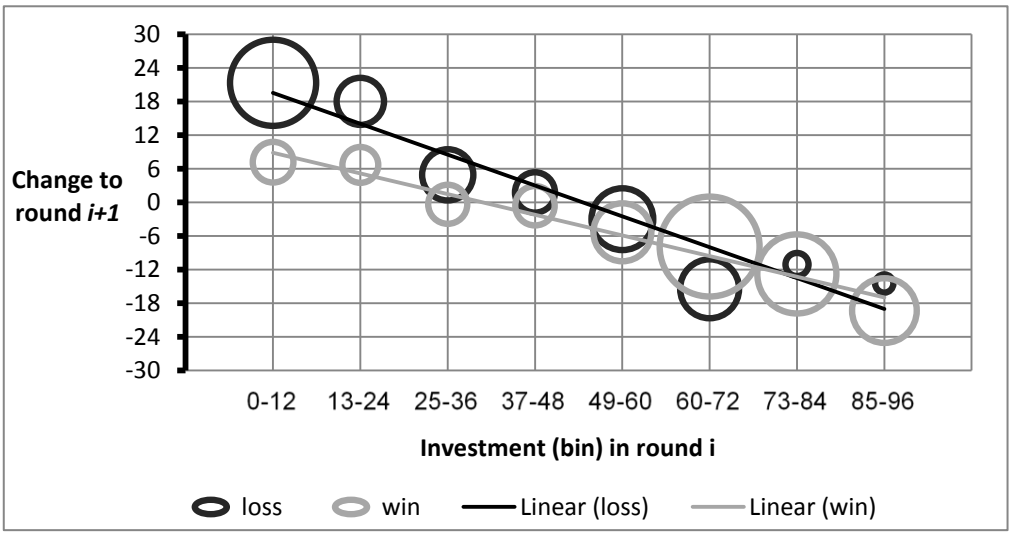

Figure 3. Changes in investments from round to round, following win and loss, averaged over contest version, subject type (low or high endowment), and symmetry. Circle sizes indicate the relative number of observations.

Discussion

Degree of inequality in subjects' endowments – the resources at their disposal for competing – significantly affected their investments in contests. We observed a pattern similar to the discouragement effect reported in the literature: The average investments were lower in asymmetric contests, with a higher proportion of subjects choosing to sit out those contests.

Notably, the investments – in symmetric as well as in asymmetric contests – did not vary with the contest prize amount, as demonstrated by the similarity of investments between the two versions, P-96 and P-72. A possible explanation is that subjects play in order to win, rather than for the actual, absolute value of the prize (as suggested by Sheremeta, 2010). Experiment 2 further examined the effect of the contest prize. We introduced asymmetry in the subjects' prizes, while keeping their endowments equal to each other. Thus we could explore whether the prizes, which had no effect when they differed between contests (in Experiment 1), would influence

investment decisions when they differ within contest rounds. Moreover, we explored whether the impact of asymmetry holds across different sources, that is, endowments and prize amounts..

Experiment 2 – Asymmetric Prizes

As in Experiment 1, there were two types of subjects, this time regarding the subjects' prizes: "Low-P" (subjects who would win a prize worth 72 points) and "High-P" (prize worth 96 points). The subjects' types were as before a between-subject factor: In each session, half of the subjects were assigned to be High-P, and half were Low-P. Symmetry was a within-subject factor. The matching was again randomized for each round (stranger design).

There were two versions of the game, relating to both subjects' endowments: E-96, in which both types had 96 points to invest in each round; and E-72, in which the endowments were 72 points for both types.

Method

Subjects. Subjects were Hebrew University students, participating for monetary pay. As in Experiment 1, the payoff was the sum of earnings throughout the game, multiplied by a known exchange rate. In E-96, 48 students participated, out of which there were 33 females (68.7%); 45 of the subjects (93.7%) were undergraduates. In E-72, 48 students participated: 32 females (66.7%); 46 undergraduates (95.8%). None of the subjects in Experiment 2 had participated in Experiment 1.

In E-96, subjects earned an average of 2.12 NIS per round (New Israeli Shekel, worth approximately 0.27$); in E-72, they earned an average of 1.04 NIS per round.

Procedure. The experimental procedure was identical to that of Experiment 1; the game was again played for 16 rounds.

Results

Investments. Across all contests, the average investment was 48.95 points: 53.41 in E-96, in which subjects' endowments were 96 points, and 44.49 in E-72, in which the endowments were 72 points. The former is significantly higher than the latter ($t(94)=-1.97$, $p=.051$). The degree of dissipation is a bit more involved to calculate in this case, since it is defined by the prize, which here varies across subjects. Average investments and the dissipation benchmarks are presented in Table 2.

In symmetric contests, in which the two subjects' prizes are equal, dissipation is defined with respect to the prize as in Experiment 1. In symmetric contests, High-P subjects (with prizes of 96 points) did not exhibit overdissipation in neither E-96 nor E-72. Low-P subjects (with prizes of 72 points) exhibited overdissipation in E-96, but not in E-72. In asymmetric contests, we used half of each subject's prize (type) as the relevant benchmark for examining overdissipation: High-P subjects did not demonstrate overdissipation compared to half of their 96-point prize, in neither E-96 nor E-72; Low-P subjects demonstrated some overdissipation (compared to half of their 72-point prize) in E-96, but not in E-72.

In sum, in both symmetric and asymmetric contests, when subjects had endowments of 72 points (in E-72), there was no overdissipation. When subjects had 96 points to invest (E-96), there was overdissipation only in some contests.

Table 2. Dissipation in the two contest versions, E-96 and E-72, in symmetric and asymmetric contests for each type of subject (low or high prize value, High-P or Low-P)

			E-96		E-72	
	Type	Benchmark	Investment (SD)	Significance	Investment (SD)	Significance
Symm	High-P	48	57.28 (24.75)	t(23)=1.84, p=.079	48.62 (22.03)	t(23)=0.14, p=.891
	Low-P	36	51.87 (29.10)	t(23)=2.67, p=.014	41.17 (20.77)	t(23)=1.22, p=.235
Asymm	High-P	48	56.21 (26.59)	t(23)=1.51, p=.144	49.46 (18.77)	t(23)=0.38, p=.707
	Low-P	36	48.28 (29.65)	t(23)=2.02, p=.054	30.58 (19.83)	t(23)=-1.34, p=.194

Note. The degree of dissipation (or overinvestment) is defined with regard to the prize. In symmetric games, the two subjects' prizes are equal, so the average investment is compared to half of the potential prize. In asymmetric games, we compare each type's investment to their prize.

Asymmetry. As for Experiment 1, we conducted a linear regression of investment amount with variance clustered by subject. There was a significant main effect of the subject's own type: The High-P type, who stood to win more, invested more than did the Low-P type ($t(96)=2.34$, $p=.021$). However, there was no main effect of the opponent's type ($t(96)=-1.40$, $p=.164$). The effect of symmetry was also not significant ($t(96)=1.00$, $p=.318$), in contrast with Experiment 1. These patterns can be seen in Figure 4. We found a significant difference between the two versions, E-72 and E-96, with investments lower in E-72 ($t(96)=-2.04$, $p=.044$); yet, the version did not interact with any of the other variables (all p's >.38).

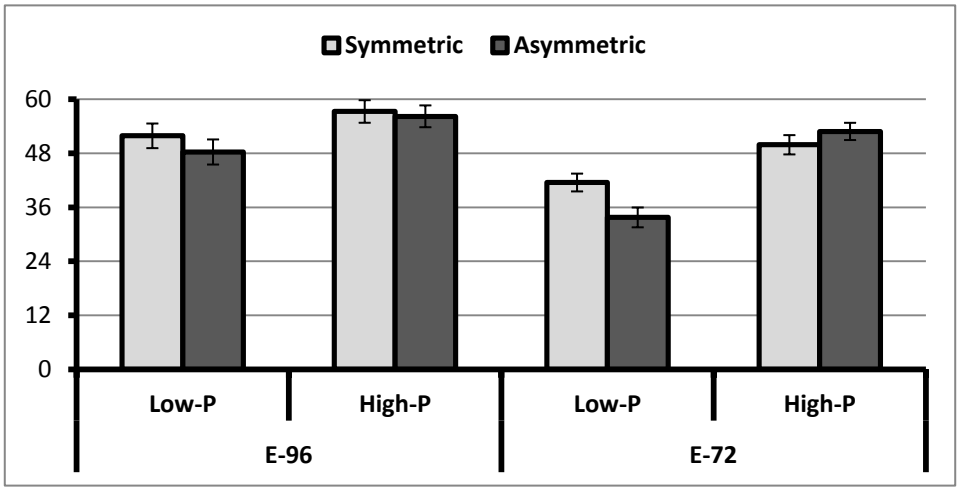

Figure 4. Average investments in the two contest versions, E-96 and E-72, for each type of subject (low or high prize value, Low-P or High-P), in symmetric and asymmetric contests.

Sitting Out. Overall, 14.19% (218 of 1536) of investments were equal to zero, a rate quite close to the 13.22% found in Experiment 1. A logistic regression on the indicator variable showed that subjects chose to sit out more when facing a High-P opponent, who stood to win more ($z=2.66$, $p=.008$). This effect was stronger in E-72 than E-96 ($z=2.08$, $p=.038$). The percentages can be seen in Figure 5.

Investments of zero were distributed among almost half of subjects (47 of 96): In E-96, 14 of 24 Low-P subjects and 9 of 24 High-P subjects; in E-72, 13 of 24 Low-P subjects, and 11 of 24 High-P subjects.

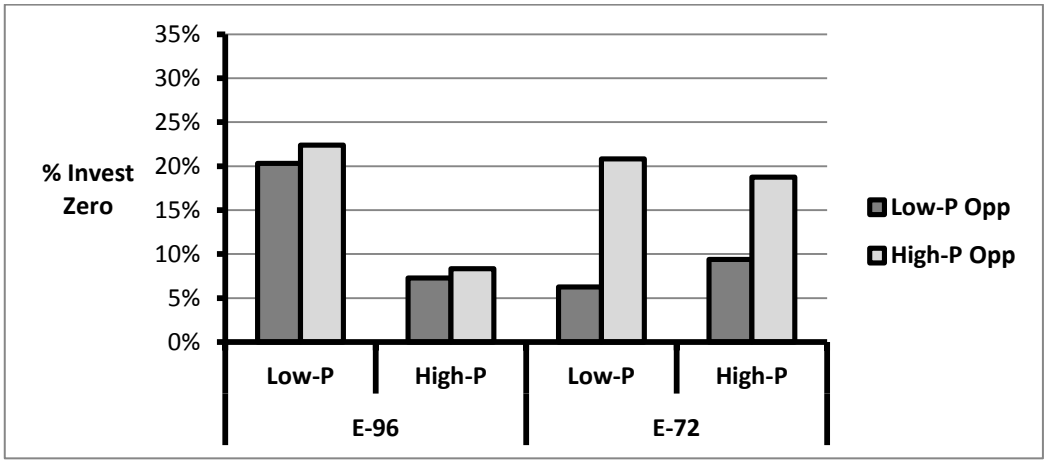

Figure 5. Percent of investments equal to zero in the two contest versions, E-96 and E-72, for each type of subject (low or high prize value, Low-P or High-P), facing either low or high prize opponent (Low-P Opp or High-P Opp).

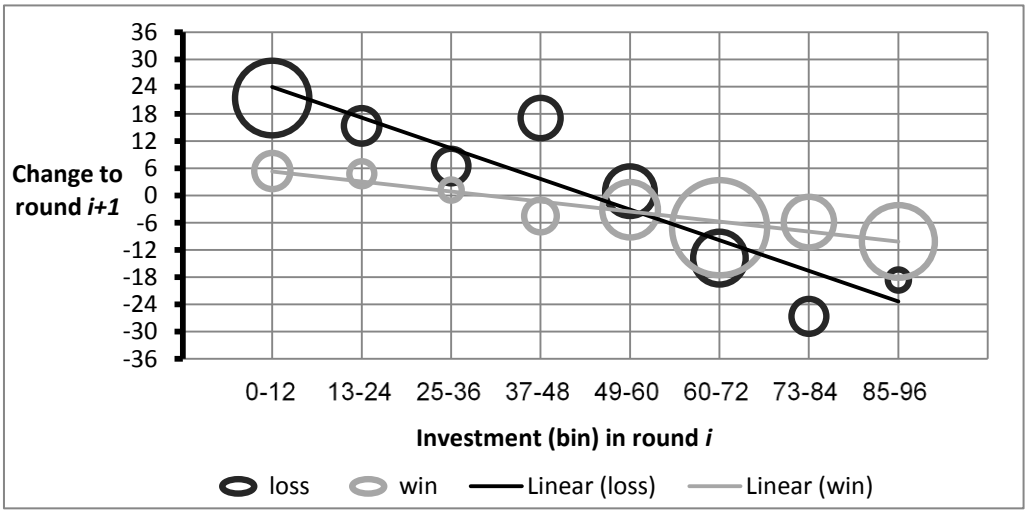

Figure 6. Changes in investments from round to round, following win and loss, averaged over version, subject type (low or high prize), and symmetry. Circle sizes indicate the relative number of observations.

Investment Dynamics. We again used a linear regression model to examine whether the subjects' prizes and endowments and their outcome in the previous round – win or loss (as a binary variable) – had an effect on the changes between their consecutive investments. As in Experiment 1, the previous investment had a large negative effect on its successor, reflecting regression to the mean ($t(96)=-9.26$, $p<.001$). Also similar to Experiment 1, we find a large

influence of losing versus winning ($t(96)=-6.76$, $p<.001$), holding regardless of the size of the investment. There was also again a significant interaction between the investment and the outcome ($t(96)=5.68$, $p<.001$): The larger the previous investment, the smaller the reactivity to the outcome (though again this result may be slightly misleading due to low numbers of observations for mid-level investments). There were no interactions with the subjects' types or with symmetry (all p's >.22). There was no significant difference in reactivity as a function of the contest version (endowment level; all p's >.12). Figure 6 presents the relationship between the previous investment, outcome, and following investment.

Discussion

The results of Experiment 2 show that subjects' investments were affected by the size of their own prize. Yet, the size of the opponent's prize – and the symmetry or asymmetry of the two prizes – did not influence the investments. Thus, there was no discouragement effect as a consequence of asymmetry in contestants' prizes. We observed a significant impact of subjects' endowments, with greater investments – and even some overdissipation – when endowments (equal for both subjects) were higher (in E-96 vs. E-72).

The round to round dynamics also resemble those observed in Experiment 1; we observed a large impact of the previous outcome of win or loss on the subsequent investment – implying that the outcome matters, even though the amount of the prize does not.

General Discussion

As is the case in many real-world competitive situations – between children, animals, lawyers or athletes – we observed in our two laboratory contest games that subjects invested heavily in competitions. They staked and risked often quite high amounts compared to the resources at their disposal and those available to be won. Yet, in contrast with previous research, we rarely observed overdissipation. Interestingly, overdissipation in our study was observed only in contests in which the endowment was greater than the possible prize.

Because common competitions involve contestants competing against either similar or non-similar counterparts (Schoener, 1983; Szymanski, 2003), we directly contrasted behavior in symmetric and asymmetric contests. In our experiments, each subject took part in both kinds of contests while their own type was kept constant.

In our two experiments, different sources of asymmetry had different effects on behavior: Differences in contestant strength (endowment, in Experiment 1) seem to matter more than differences in motivation (prize size, in Experiment 2). Only in the former case, in which asymmetry came from differing endowments, did asymmetric contests lead subjects to invest less than in symmetric contests, resembling the discouragement effect described in past literature. A possible explanation for less effect of prize difference than endowment difference is that when the prizes differ, it is not entirely clear who is the stronger and who is the weaker contestant; whereas the contestant who has a larger potential prize has more of an incentive – and indeed, more of a tendency – to compete and invest more, this does not necessarily put that contestant in an advantageous position. In this case, contestants may have no clear idea about how to change their investments and hence may leave them similar to the symmetric situation. On the other hand, in contests in which the endowments differ, the weaker contestants may be more aware of their disadvantageous position and so may be inclined to invest less.

Relatedly, not all subjects chose to compete all of the time, and this depended on their relative strength and motivation: When faced with an opponent with a greater endowment or a greater prize, subjects were more inclined to sit out the contest. This pattern can be seen as another manifestation of the discouragement effect (Dechenaux et al., 2012; Festinger, 1954). Investing zero in the contest can also reflect the lack of an outside option in our game situation; in many natural settings, when contestants of differing strengths encounter each other, they may choose not to compete but instead find new opponents with more similar capacities (Eshel & Cavalli-Sforza, 1982).

Regarding round to round changes in investments, we observed that subjects adjusted their investments in reaction to their outcome (win or loss) in the previous round, as conjectured. Importantly, subjects' reactions to win or loss were very similar across contests, strengths and motivations: They tended to invest a smaller amount following a win, and invest a larger amount following a loss. These reactions imply that subjects regretted winning by what they thought was too large of a margin, and regretted not having invested enough when they lost (Engelbrecht-Wiggans & Katok, 2007).

In both experiments, the prize amount to be won did not play a large role in determining investments. Hence, it can be argued that contestants compete in order to win rather than for the

actual, absolute value of the prize (Bazerman et al., 1992; Kohn, 1992; Malhotra, 2010; Messick & McClintock, 1968; Sheremeta, 2010). If a contestant is driven by the desire to win and the likelihood thereof, then the endowments of both contestants – influencing the likelihood – can be expected to play a role (as indeed observed in Experiment 1), while the possible prize is not as important (as observed in Experiment 2).

One caveat of our study is that we examined a specific degree of asymmetry for endowments and prizes. It is possible that a larger difference between contestants will lead to a different pattern of behavior, and specifically to an influence of prize asymmetry on investments. Future studies should examine other endowment- and prize-pairings, and possibly a combination of different endowments and prizes, to further understanding of the separate and combined effects of contestants' strengths and motivations.

Acknowledgements

Work reported in this paper was supported by grant 2009/298 from the United States – Israel Binational Science Foundation to Yaakov Kareev, Peter M. Todd and Judith Avrahami.

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