Competition with Skill and Luck

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Abstract

Many decisions that people make are driven by the concerns for social ranking. We study experimentally how strong the social ranking preferences are and what characteristics of others influence the perceived ranking. In our experiment the subjects play two games against the computer: a game of skill and a game of luck. After each game the participants observe the winnings of everybody in the group. Each subject has a possibility to reduce the winnings of one other person at a cost to himself. We find that the majority of subjects use this costly option. More importantly, the decisions to subtract money depend on whether the game of skill or luck was played. The pattern of subtractions suggests that winnings made with skill are used as a proxy for social significance and are envied, whereas money won by luck do not convey such a signal.

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1 Introduction

Dominance hierarchies are an ubiquitous feature of relationship among animals. They have been documented in insects (Wilson, 1971), birds (Schjelderup-Ebbe, 1935; Chase, 1982), fishes (Nelissen, 1985; Chase, Bartolomeo, and Dugatkin, 1994), and mammals (Greenberg-Cohen, Alkon, and Yom-Tov, 2004), particularly primates (Sapolsky, 2005; Pereira, 1995; Pereira and Fairbanks, 2002; Cheney and Seyfarth, 1990) . They are an important feature of relationships among men (Veblen, 1899; Maslow, 1937; Sidanius and Pratto, 1999). We argue here that humans who participate in a contest with others have strong preferences on relative outcomes of the contests, and are ready to translate these preferences into costly choices. More importantly, we show that these preferences depend on what the outcome itself says about the underlying factors of the ranking. That is, human subjects care about not the ranking of the outcomes in itself, but for what it says on their position in the social scale, now and in the future.

Most dominance hierarchies have very specific structures: for example, they tend to be linear, or close to linear (see, for example, Chase, Bartolomeo, and Dugatkin (1994); Chase (1982)). A second important feature of these relationships is that the ranking tends to be stable over time. Theories of how it is produced have been developing over the past years. In the original formulation of Landau's model (Landau, 1951), individuals meet randomly in pairs, and participate in a contest. Each one of the two can be a winner with a probability that depends on some idiosyncratic characteristics. The individual who wins in a contest establishes a dominance relationship over the loser. Repeated contests establish an overall dominance relationship among members of the group. By the way this is constructed, the relation is not transitive, and in particular is not linear. In addition, as the size of the society becomes large, for any distribution over the inherent characteristics, the probability that the overall ranking is close to linear is vanishingly small. Already Landau, in the subsequent analysis, considered the possibility that social factors and the outcome of previous encounters affect the probability of winning.

This intuition is now most commonly formulated in the winner and loser effect: The probability that the winner of a contest wins the next contest against a randomly chosen opponent is higher than it is for the same individual at the first encounter. Similarly, the probability that a loser in a previous contest is going to lose in the next one is higher than it is for subjects at the first encounter.

This effect can be the combined result of at least two factors. First, if the probability of winning in the contest depends on some variable that has different values for different individuals, then the probability of success for a winner increases by simple conditioning. Second, among animals the observation of the outcome changes the belief over the distribution of the variable, and can affect the equilibrium behavior. An accurate distinction between these two components is still subject of current research (see Rutte, Taborsky, and Brinkhof (2006) for a survey and a meta-analysis of previous research). But in both cases it provides a link between the experience of success and future behavior in contest when success reveals information about a relevant variable.

Among animals, this unobserved variable is usually described as the Resource Holding Power (RHP, Parker (1974)). Among men the unobserved variable can be a set of qualities like intelligence or social skills. Some evidence of this comes from the research on the connection between the human neuroendocrine reactivity and *perceived* socioeconomic status (see Cummins (2005) for overview). The levels of the stress hormone cortisol are higher in individuals of low status. They are found to have bigger changes in stress indices than dominant individuals.

Suppose we have two environments where competition is possible, and organized in contests. Suppose that the individuals can observe the outcome of the contest, and that the outcome of one of the two contests provides information on some unobservable resource, ability or skill, that can predict success in future contests, while the other does not. Then the outcome of the contest that provides more information is likely to become more important for the individual than the outcome in the contest that does not provide such information.

In our experiment, we consider two tasks which differ precisely in how much information they reveal about the skill of the person. The prediction is that subjects in the experiment will behave differently when they are informed about the ranking of their performance: they will care more about the outcome of the task that provides an informative signal on their skill than about the outcome of the task that does not provide such a signal.

Specifically, the tasks are one of skill and another one of luck. We use the amount by which the subjects are willing to reduce the scores of others as the measure of the importance that they attach to the outcome. The main hypothesis is not that they are willing to reduce others' score, but rather that they do it differently in the skill and luck game. Evidence cited above suggests that subjects should be more sensitive to the ranking in the skill game than in luck game.

Experimental design is described in part 2 of the paper. Part 3 discusses the data analysis and part 4 concludes. Methods and instructions are given in parts 5 and 6.

2 Experimental Design

In the experiment the subjects play two different games against the computer: game of skill (S) and game of luck (L).[1] The game of skill is a board game with two players: the subject and the computer. In order to win against the computer the subject needs to use some logical and analytical skills. In the game of luck each subject guesses a number between 0 and 100. She wins if her number is no more than ten units away from the number randomly generated by the computer. Whether the subject wins or loses is entirely determined by chance.[2] Both games are played 10 times in a row.

After each of the two games (played 10 times), the subjects have a possibility to subtract money from one other participant in the experiment. They can also choose to do nothing. If they choose to subtract money from somebody, that person wins less real money in the end of the experiment. The subjects do not know from whom they are subtracting money. The choice of not subtracting money is always available.

The experiment has two order treatments: SL and LS. In the SL treatment subjects are playing the game of skill first, then have a chance to subtract money, then play the game of luck and then again have a chance to subtract money. In the LS treatment the order is reversed: first the game of luck is played and then the game of skill (with subtractions after each game).

All sessions were conducted at the University of Minnesota from February to October 2005. Total of 75 subjects participated in the SL treatment in 5 groups of 13 to 16 people. In LS treatment there were 7 groups of 8 to 16 people with 93 subjects in total. All subjects were undergraduate students taking classes at the University. Each session lasted approximately 45 minutes. Most of the subjects had never participated in economics experiments before.

2.1 Game of Skill

The game of skill is the classic *Hare and Hounds*. This is a combinatorial zero-sum game (see Figure 1). Subjects are playing hounds and the computer is playing hare. The hounds have to trap the hare, and the hare is trying to escape. The hare is trapped

[1]The games were presented to subjects as “Hare and Hounds” and “Guessing game” (see below).

[2]Numbers less than 10 and larger than 90 produce the probability of winning different from the rest. Very few subjects chose numbers in these intervals.

if no move is feasible when its turn comes. The two players (subject and computer) move in alternate periods. The subject can choose one and only one hound to move, and he can only move to the right or vertically (up or down) by one cell. The hare can move by one cell in any direction. The hare is declared a winner when it passes to the left of all three hounds, so that capture is impossible. Neither player can choose to move a piece to an occupied position.

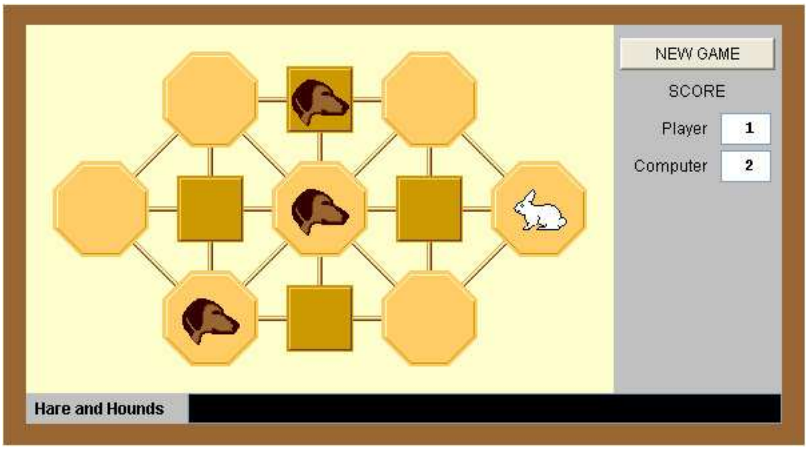

Figure 1: Hare and Hounds game (www.mazeworks.com)

To move a hound subject has to drag and drop it to the cell where she wants to move it. Illegal moves are not allowed by the program. A detailed description of the rules of the game as they were presented to subjects is reported in the Appendix 6.1.

Subjects are given 20 minutes to play 10 games. They earn $1 for every game won. Defeat earns them nothing. Since subjects are playing at different pace, those who finish 10 games early are allowed to continue playing without earning any more money for winning. The computer selects the move following an artificial intelligence program. The original program available at *www.mazeworks.com* has three levels of difficulty. In the experiment the level was set to intermediate.

2.2 Game of Luck

Subjects are asked to guess a number between 0 and 100 that is randomly chosen by the computer. If subject's guess is within a distance of 10 units from the number chosen by the computer on either side, then the subject earns $1. If it is further than that, the subject earns nothing (see Appendix 6.3 for the exact instructions). The game is played 10 times.

Before the game the rules are presented to the subjects (see Appendix 6.3). The subjects could ask any questions during the presentation. The game did not start until no more questions were asked.

2.3 Subtraction phase

After playing each game 10 times, subjects are told the amount of money they have won in that game. Then they are proposed a choice to subtract money from another subject (or choose not to do it). The subjects observed the screen like on Figure 2.

Figure 2: The subtraction decision screen.

Three possibilities are available:

1. Choose to subtract any amount from one of other subjects and pay for it;
2. Choose to subtract \$1 with probability 0.25 from one other subject and pay nothing for it;
3. Do nothing.

In the first case, if subject decides to subtract, say, x dollars from somebody, he has to pay $0.1x$ dollars for it. Both amounts of money disappear. The limit on subtractions was imposed so that no subject could lose more than he earned. Also, the subjects who decide to subtract money and pay for it cannot spend more money in payments than they have. The detailed instructions are reported in the Appendix 6.4. It was clear to the subjects that no part of the amount subtracted was going to him or to anyone else.

As is obvious from Figure 2, subjects do not know the identities of others from whom they subtract money. The identities of others who subtract money from them are not known either. On the display presented in Figure 2 each number corresponds to some person in the group. If two subjects win, say, \$5 then two entries of "5" would be presented. Subjects can see only the amounts won by others and not their own as they already know it from the previous screen. The winnings are not sorted in any way to make sure that subjects do think about their choice. The "nobody" choice can appear in the middle of the list and not necessarily at the bottom. Each subject loses the total amount subtracted in real dollars (as well as the payment for the subtraction in case costly option is chosen).

2.4 Order Treatments

The experiment has two order treatments: SL and LS. In the first treatment the order is: skill game, then the subtraction phase, then the display of the current profit, then luck game, then the subtraction phase, then the display of total profit. The slide instructions are given in between all 4 parts of the experiment. Thus, in SL treatment the first time subjects learn about subtraction phase is after they play skill game 10 times. The first time they learn about the luck game is after the first subtraction phase. When luck game instructions are given, subjects are not told anything about what will happen afterwards, so that their behavior is not influenced by the future subtraction phase. In the second treatment, the order is reversed: first the luck game is played, then the subtraction phase takes place, then the current winnings are displayed, then the skill game, then second subtraction, then the display of total earnings. After the first subtraction phase in both treatments the subjects are shown the amount of money that they won in the first game (be it skill or luck). This amount is equal to the sum of the money they made playing the game minus the amount of money that was subtracted from them minus the payments for subtraction. Therefore, the subjects can figure out how much money they lose after the first game. Similar calculation is done for the second game. In the end of the experiment subjects receive a show up payment of $10 plus their winnings after both games net of subtractions and payments for subtractions.

3 Results

3.1 How much skill does the skill game require?

The essential component of the experiment is the different nature of the two games. The game in which subjects have to guess a number is clearly a game of luck. The instructions clearly stated that the computer is going to pick the number randomly. The game of Hare and Hounds is however of some complexity, at least for unexperienced players like the subjects in the experiment. The complete solution (and the optimal strategy for each of the two players, the hare and the hounds) is presented in Berlekamp, Conway, and Guy (2003), Chapter 21. In all trials of the experiment the hounds were initially positioned in three leftmost cells and the hare in the rightmost cell. With this initial position the hounds (in our experiment, the subject) wins if he uses the optimal strategy. This strategy however is complex: a number between 0 and 3 is assigned to every cell, then the positions of the four animals on the board are classified according to the sum of these values. The winning strategy is to in keep the sum equal to 3 at every move, which is possible from the initial position assigned in the experiment. It is highly unlikely that subjects understood this strategy and the underlying classification. Certainly no evidence of this is given in the debriefing notes at the end of the experiment. Instead, subjects show in their decisions and their statements some understanding of how to avoid the most obvious mistakes, and the ability to look ahead in the next two or three moves of the hare.

We may conclude that the Hare and Hounds game was likely perceived by the subjects as a game of skill for the entire set of ten rounds. There was also a sufficient dispersion in the outcome: the mean of the distribution of the amount won is 4.875 with standard error 0.1536. The game was, within the limits of the time and possible learning, neither too hard nor too easy.

3.2 Summary of the Analysis

We analyze the subtraction decisions made after each game. The overall trend in the data is shown on Figure 3.

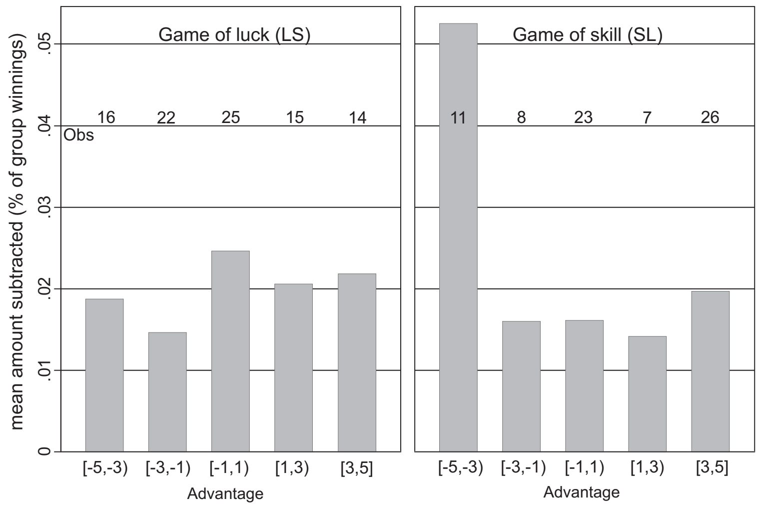

Figure 3: Summary of the subtractions made after luck and skill games measured as a percentage of total winnings in the group. On the x-axis is the advantage (measure of ranking). On the y-axis are the mean subtractions for different ADVANTAGE LEVELS. The number of observations behind each bar is presented by numbers on the graphs.

For each subject the amount subtracted is measured as a percentage of total group winnings. Subjects in both skill and luck games are then divided into five groups depending on the value of their *advantage*, which for given game is equal to the amount won by the subject minus the maximal amount won in the group. For example, in a group of 8 people, if subject wins $4 after the game of skill and the maximum amount won is $7, his advantage is -3. If this subject subtracts $1 and the total group profit is $50, his measure of the amount subtracted is 2%. On the graph, the lowest ranked 20% of subjects subtract in average 5% of total winnings of the group *each*. The number of subjects in each quintile is shown on the picture.

3.3 The Decision to Subtract

At the end of each round of games the subjects had the option to subtract money from one (and only one) of the other subjects, either by paying a cost or not. Although the option of doing nothing was available and clearly specified, subjects decided to subtract money in a large number of cases. If we abstract for the moment from the amount that they decide to subtract, we can allocate each subject in each period in one of three groups: 1) he subtracts money by paying a cost; 2) he subtracts money at no cost; 3) he does not subtract money. Note that the same subject may take different decisions in the two periods. Table 1 describes the distribution over the three groups.

Table 1: The distribution of the subjects in the three groups. The rows refer to the first period, the columns to the second period. The numbers in parentheses are the fractions of the total.

second period first period	sub.	sub. no cost	not sub.	total
sub.	30 (17.86)	14 (8.33)	10 (5.95)	54 (32.14)
sub. no cost	10 (5.95)	36 (21.43)	12 (7.14)	58 (34.52)
not sub.	6 (3.57)	20 (11.90)	30 (17.86)	56 (33.33)
total	46 (27.38)	70 (41.67)	52 (30.95)	168 (100)

Subjects are equally distributed across the three groups in both periods (with the second group, making subtraction at no cost, a larger fraction in the second period). In conclusion, about two thirds of the subjects do subtract money. The distributions in the first and second period do not differ significantly, but the fraction of subjects who subtract at no cost is increasing.

The other factor that can enter into the subjects' evaluation is the ranking of the subject form whom they decide to subtract money. Table 2 shows the average value of the ranking of the subject hit, for each of the two treatments.

Table 2: The average ranking (variable *rwonbyhit*, see Table 12) of the subjects from whom money was subtracted, by skill and luck treatment.

Treatment	Obs	Mean	Std. err.	95% conf. int.	
luck	116	.6883	.0315	[0.6258,	0.7508]
skill	112	.7200	.0301	[0.6603,	0.7797]

Table 2 shows two important facts: first, in both skill and luck the ranking is above the fifty per cent line. Second, there is no significant difference in the values between the two treatments of skill and luck.

More detailed analysis is provided in Table 3, where the same variable is differentiated according to the skill and luck treatment, and to the order in which the two were presented.

Table 3: The average ranking (variable *rwonbyhit*, see Table 12) of the subjects from whom money was subtracted, by skill and luck treatment, and by order.

Game, Order	Obs	Mean	Std. err.	[95% conf.	int.]
skill, SL	49	.6647	.0456	[.5730	.7564]
luck, SL	53	.7223	.0389	[.6441	.8004]
skill, LS	63	.7630	.0395	[.6838	.8421]
luck, LS	63	.6597	.0479	[.5639	.7556]

Again, in all cases the simple principle of hitting the subjects that are higher in the order dominates. Figure 4 illustrates the frequency of ranking of the subject who is hit among those who are hit.

3.4 Why do subjects subtract money?

We first consider what motivates a subject to subtract money, without distinguishing the two ways in which this could be done. First factor may be the ranking of the amount won by the subject in that period. If we consider for each period and experimental session the maximum and the minimum amount won by every subject, we can compute the ranking he occupies as a number between 0 (when the subject obtained an amount equal to the minimum) and 1 (the same for the maximum). This variable is called *rwon*

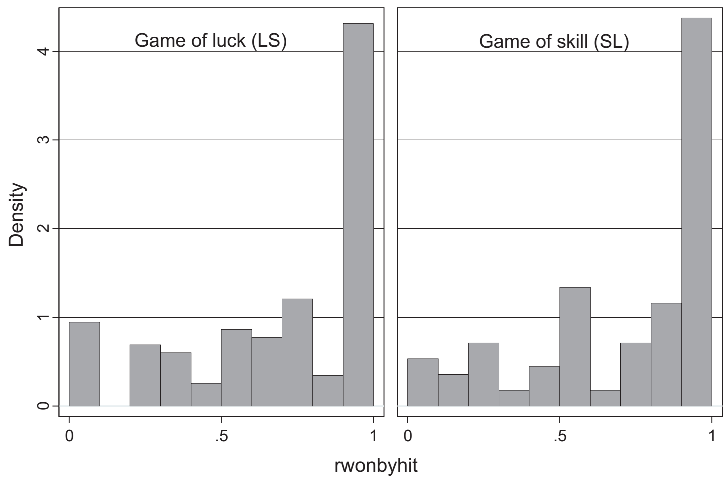

Figure 4: Frequency of ranking of the amount won by the subject who is hit (variable *rwonbyhit*, see Table 12), over the observations in which the subject decided to subtract (costly or not). Left panel: luck game; Right panel: skill game

(see Table 12). We can then allocate each subject in three groups, corresponding to the high, medium and low ranking. Table 4 describes the distribution of the subjects according to the fraction they won in that period.

Table 4: The distribution of the subjects in the three groups according to their ranking (variable *rwon*, see Table 12) in the amount won. The number in parenthesis is the fraction of the total.

ranking won decision	low	medium	high	total
sub.	28 (8.33)	41 (12.20)	31 (9.23)	100 (29.76)
sub. no cost	45 (13.39)	48 (14.29)	35 (10.42)	128 (38.10)
not sub.	32 (9.52)	37 (11.01)	39 (11.61)	108 (32.14)
total	105 (31.25)	126 (37.50)	105 (31.25)	336 (100)

Table 5 displays the estimated coefficients of a logit regression of the decision to subtract for different models.

The decision to subtract (variable *didsub*) is equal to 1 if the subject uses either the costly or the zero-cost (random subtraction) option to subtract. The table shows how this decision (costly or not) depends on the ranking of the subject in the order of amounts won, the nature of the game being played (skill or luck), on the interaction between ranking and skill, and finally on whether the subject is at the top of the ranking or not. The coefficient of the skill variable is significant and positive, the coefficient of

Table 5: Decision to subtract, depending on the position in the ranking of the subject, the skill and luck treatment, and the interaction between this treatment and the ranking. The last regression is limited to the trials in the SL treatment.

logit	didsub	didsub	didsub	didsub
	b/(se)	*b/(se)*	*b/(se)*	*b/(se)*
rwon	–0.566	0.519	0.240	0.617
	(0.377)	(0.526)	(0.611)	(0.831)
skill	–0.108	1.053**	1.093**	1.710**
	(0.235)	(0.458)	(0.467)	(0.697)
rwon·skill		–2.318***	–2.368***	–3.572***
		(0.779)	(0.795)	(1.186)
top			0.427	0.536
			(0.462)	(0.690)
const	1.080***	0.558*	0.635**	0.415
	(0.253)	(0.294)	(0.308)	(0.376)
N	336	336	336	168

the interaction term is significant and negative. The skill treatment makes the subjects more concerned about the ranking, and more willing to subtract money, everything else being equal (average interaction effect is significantly negative). At the same time, higher ranking of the subject makes him less sensitive to the ranking, and less willing to subtract money. The effect is even more clear when the subjects face the skill treatment first.

3.5 Who do the subjects subtract money from?

At the moment of deciding whether they want to subtract or not, and how much, the only information that subjects have available in order to differentiate the other players is the amount each one won in the round of 10 games immediately preceding the decision, and the nature of the game they just played. So when a subject chooses one of the other participants for money subtraction he is really only choosing the amount. How does this amount affect his decision, and how does it depend on the nature of the game being played (skill *versus* luck)?

Table 6 presents the regression of the ranking of the subject from whom the money is subtracted on the ranking of the subject who is subtracting and whether he is at the top position in amount won, when the game is a skill game.

The lower the ranking of the subject, the higher the ranking of the subject he hits. The dependence is different in the luck treatment: in this case there is no significant

Table 6: Regression of the ranking of the subject from whom the money is subtracted in skill, depending on the ranking of the subject who is subtracting (*rwon*) and whether his position is at the top of the amount won (*top*). The last regression is limited to the sessions where the skill game was played first.

reg	rwonbyhit	rwonbyhit	rwonbyhit
	b/(se)	b/(se)	b/(se)
rwon	–0.312***	–0.384***	–0.501**
	(0.107)	(0.137)	(0.189)
top		0.108	0.289
		(0.128)	(0.183)
const	0.631***	0.653***	0.649***
	(0.061)	(0.067)	(0.095)
R^2	0.049	0.053	0.089
N	168	168	75

effect either of the fraction won by the subject who is making the subtraction, or his position at the top of the ranking.

3.6 Amount Subtracted

Once a subject has decided that he wants to subtract money from someone, he still has to decide how much. Table 7 reports the average fraction of the amount subtracted over the amount won, for the cases in which the decision to subtract (costly or not) was made.

There is clearly an effect of the order of the two games, that is going to be discussed in the next section. Let us focus on what determines the fraction. Table 8 reports the regression of the fraction subtracted as a function of the ranking of the subject, type of the game and the interaction.

Table 7: The fraction of the the amount won that is subtracted (variable *fresubtracted*: see Table 12), by type of game (skill or luck) and order treatment (SL or LS)

Skill/Luck	Order	Obs	Mean	Std. err.	[95% conf. int.]	
Skill	SL	49	.4457	.0563	[.3323,	.5590]
Luck	SL	53	.4859	.0556	[.3741,	.5976]
Luck	LS	63	.2746	.0395	[.1955,	.3536]
Skill	LS	63	.1863	.0385	[.1092,	.2635]

The higher the ranking of the subject (variable *rwon*) the smaller the fraction that he subtracts in the skill game (interaction effect is significantly negative). This effect is the opposite or insignificant in the luck game. If we look at only first games in two treatments, then we see that after skill subjects subtract bigger fraction of winnings given everything else equal.

Table 8: Fraction of the amount subtracted (variable *fresubtracted*, see Table 12) as a function of the ranking of the amount won by the subject (variable *rwon*), whether the game is skill or luck and the interaction between the two.

reg	fresubtracted	fresubtracted	fresubtracted
	$b/(se)$	$b/(se)$	$b/(se)$
rwon	–0.022	0.110	0.092
	(0.060)	(0.082)	(0.101)
skill	–0.056	0.078	0.341***
	(0.037)	(0.069)	(0.091)
rwon·skill		–0.279**	–0.489***
		(0.119)	(0.161)
const	0.267***	0.203***	0.145**
	(0.039)	(0.047)	(0.056)
R^2	0.007	0.051	0.084
N	336	336	168

3.7 Comparison of SL and LS Treatments

Does the order of the two games, that is the sequence skill-luck (SL) or luck-skill (LS), make a difference in the decision of whether to subtract money, from whom to subtract it, and how much? Inspection of Table 7 shows that the fraction subtracted is significantly different in the two treatments. In addition, fraction changes in a different way over time: it increases in the SL treatment, and decreases in the LS.

The average values in the two treatments are different: Table 9 reports the two values, with the value in SL treatment higher than in LS.

Table 9: The fraction of the the amount won that is subtracted (this is the variable *fresubtracted*: see Table 12), by order treatment (SL or LS)

Order	Obs	Mean	Std. err.	[95% conf.	int.]
SL	102	.4666	.0394	[.3882,	.5449]
LS	126	.2304	.0277	[.1754,	.2855]

The difference is significant: a Mann-Whitney non-parametric rank test gives a $z = 4.974$, with a $p = 0.00001$ for the hypothesis that the fraction subtracted is the same in the two orders. Note that the distribution of the ranking of the subject who is hit is *not* significantly different in the two order treatments. The MW non parametric test fails to reject the null hypothesis ($z = 1.083$, $p = 0.2788$).

So the difference between the two treatments is on the choice of subtracting or not, rather than on the policy that is followed once this decision is taken. The difference is due to the way in which subjects respond to the behavior of the others in the first game. This is clear already from Table 7, if one compares the values for the first and second game. If we test whether the fraction subtracted is the same in the first and second game, separately for the two treatments SL and LS, we find that the hypothesis cannot be rejected in the LS treatment, but it can in the SL: see Table 10.

Table 10: MW test of the hypothesis that the fraction subtracted in the first and second game is the same. The test is run for the two order treatment (SL or LS)

Treatment	z-value	p-value
SL	1.124	.2608
LS	3.880	.00001

This difference suggests that subjects react differently to a previous experience in the two changes, depending on the nature of the game they played first. To analyze this change more closely, let us see how the decision to subtract changes between two games in each treatment. We assign each subject to one of the three groups that we have already used: he is in group 1 if he subtracted and paid in the first period; in group 2 if he subtracted and did not pay; group 3 if he did not subtract. We define now the switch between groups as

$$\text{switch} = \text{group}_{\text{second game}} - \text{group}_{\text{first game}}$$

For example, if in the SL treatment the subject paid for subtracting money in the first game (the skill game, in this case) and did not subtract at all in the second game (luck), then the variable *switch* = 3 - 1 = 2. This variable can take values in $\{-2, -1, 0, 1, 2\}$. The smaller the value the more inclined to subtract the subject becomes in the second game compared to the first.

Table 11 reports the coefficients from the ordered logit regression of the variable switch on the fraction lost in the first game, type of treatment (SL or LS) and the interaction of this variable with the order variable *issl*.

The fraction lost by subject after the first game (variable *frlost*) influences the decision to subtract in the second period, and does so differently in the two treatments. In

Table 11: Ordered logit regression of the switch in behavior of the subjects. The variable *frlost* is the fraction lost by the subject in the first game; issl is one if treatment is SL and 0 otherwise.

ologit	switch	switch
	$b/(se)$	$b/(se)$
frlost	–0.233	1.371**
	(0.437)	(0.602)
issl	–0.148	0.451
	(0.301)	(0.350)
frlost·issl		–3.091***
		(0.871)
const	1.525***	1.581***
	(0.162)	(0.165)
N	168	168

the SL treatment subjects retaliate: the more subjects lose the more they subtract in the second game. In LS we have the opposite behavior: the more they lose the less they subtract in the second game.

4 Conclusions

Our first main conclusion is that subjects in the experiment have strong preferences on the relative outcome (instead of simply the absolute monetary value of the outcome). In an environment in which they had the choice of doing nothing about the outcome of others, or subtracting money from them, they chose the option of reducing the payoff of others.

The second and more important conclusion, however, is that the preferences over the ranking of the outcome depend on how the outcome was obtained, and what this reveals on their ability compared to that of others. More specifically, their behavior in the subtraction phase shows that they attach more importance to the relative outcome in the case (the skill game) where the outcome gives an informative signal on some skill or ability, than they do in the case (the luck game) where the signal is completely uninformative. This conclusion is independent of the interpretation that one gives of the motivations that drove them to subtract money from others in the subtraction phase of the two treatments.

If we consider the skill revealed by the success in the skill game as a form of resource holding power (RHP) as in Parker (1974), then the behavior of our subjects is consistent with the theory that their preference over the two relative outcomes (in skill and luck) is a way of measuring how the probability of success in future contests has changed: a net decrease after a low ranking in the skill game, no effect in the case of the luck game.

5 Methods

5.1 Subjects

There were five sessions run in SL treatment (three with 16 subjects, one with 14, one with 13). The total number of subjects in SL treatment was 75. There were 7 sessions run in the LS treatment (two with 16 subjects, two with 15, one with 13, one with 10 and 8). Total number of subjects in LS treatment was 93.

5.2 Instructions

Before subjects played the game they were given a verbal slide presentation of the rules (see slides in Appendix 6). The subjects could ask any questions about the rules of the game at the time of the presentation. The game started once no further questions were asked. In order to make presentations consistent across the sessions, the same experimenter presented the rules at all times. Subjects were also instructed to maintain silence and not talk to each other during the play.

5.3 Presentation

The experiment was conducted using z-tree (Fischbacher, 2007), LabView 6 and Java based software. The game of skill was realized as a Java applet. This was a modified version of the original applet provided at www.mazeworks.com. The game of luck was realized as a z-tree program.

6 Appendix

6.1 Rules of the Hare and Hounds Game

This is the description of the rules taken from www.mazeworks.com:

"On each turn, a single hound moves to a directly connected empty square or octagon, followed by the hare's similar move. The hounds may only move vertically or forward (to the right), not backward. The hare may move in any direction. To move a piece, drag and drop it with the mouse. There are no captures. The hounds win by trapping the hare so that he is unable to move. The hare can win two ways. He can escape, which he does by moving past (to the left of) all three hounds. Also, if the hounds move 10 times in a row without advancing (i.e. they only move up and down) then the hounds are stalling and the hare wins."

6.2 Instructions for the Hare and Hounds Game

The following slides were shown to explain the rules:

Rules of the Game

- You move the hounds, the computer moves the hare
- On each turn, a single hound moves to a directly connected empty square or octagon, followed by the hare's similar move.
- The hounds may only move vertically or forward (to the right), not backward.
- The hare may move in any direction.
- To move a hound, drag and drop it with the mouse.

Rules of the Game

- The hounds win by trapping the hare so that he is unable to move.
- The hare wins if it escapes, which he does by moving past (to the left of) all three hounds.
- If the hounds move 10 times in a row without advancing (i.e. they only move up and down) then the hounds are stalling and the hare wins.

Hare and Hounds game: Payment

- In each period, if you win you get one dollar
- If you lose you get nothing

6.3 Instructions for the Game of Luck

These are the instructions given to subjects on the screens while they were choosing:

"In each period, a random number X between 0 and 100 is generated. Please choose a number Z between 0 and 100. Your profit in this period is $1 if the distance between Z and X is less than 10 and $0 otherwise."

In addition the following slides were used to present the rules of the luck game before the game began:

Guessing Game

- You have to guess a number between 0 and 100
- You will do this ten times in a row
- Each time the computer will select a different number between 0 and 100: all numbers have the same probability
- You win if you come at least ten units close to the number chosen by the computer

Guessing Game: Example

- You choose 56 and the computer chooses 30: You lose
- You choose 17 and the computer chooses 11: You win
- You choose 73 and the computer chooses 81: You win

Guessing Game: Payment

- In each period, if you win you get one dollar
- If you lose you get nothing

6.4 Subtraction Phase Instructions

The following instructions were given to subjects on their screens

"Here you see the profits of all subjects but yourself. You have a possibility to burn money of somebody else. You can do one of the three things: 1) Choose a subject from the list and enter positive amount to burn; 2) Choose a subject from the list and enter zero amount to burn; 3) Choose "nobody" from the list and enter zero amount to burn. In case 1, you have to pay for burning money: if you choose to burn Y dollars, you lose 0.1*Y dollars. In case 2, $1 will be burned from the chosen subject with probability 25% and you don't pay anything. In case 3 nothing happens. Your Profit now is $4. Therefore in case 1 you can choose to burn up to $40 dollars."

In addition, slide presentation was used to explain the rules of subtraction:

- Now you can burn money of some other player
- The way to do it is explained in the screen
- In the screen you see the profits of all subjects but yourself.

You can do one of three things:

- Choose a subject from the list and enter a positive amount to burn. In this case you have to pay for burning money: if you choose to burn Y dollars, you lose Y/10 dollars.
- Choose a subject from the list and enter zero amount to burn. In this case, $1 will be burned from the chosen subject with probability 25% and you don't pay anything.
- Choose "nobody" from the list and enter zero amount to burn. In this case nothing happens.

6.5 Data

The following data variables were obtained from the experiment:

Table 12: Variables name and definition

Variable name	Definition
issl	0/1 variable, =1 if the order is SL
skill	0/1 variable, =1 if the game is the skill game
didsub	0/1 variable, =1 if subject subtracted money (costly or not)
won	amount in dollars (from 0 to 10) won by the subject (after skill or luck)
subtracted	amount in dollars subtracted by the subject, =0 dollars if the subject subtracted at zero cost
esubtracted	amount in dollars subtracted by the subject, =0.25 dollars if the subject subtracted at zero cost
wonbyhit	amount in dollars won by the other participant from whom the subject subtracted money
lost	amount in dollars lost to subtraction by the subject in the first game
wmin	smallest amount won in the game by any subject
wmax	largest amount won in the game by any subject
top	0/1 variable, =1 if the subject won the largest amount
rwon	ranking of the amount won: *rwon = (won - wmin)/(wmax - wmin)*
rwonbyhit	ranking of the amount won by the subject who was hit: *rwonbyhit = (wonbyhit - wmin)/(wmax - wmin)*
fresubtracted	fraction of the amount subtracted: *fresubtracted = esubtracted / wonbyhit*
frlost	fraction of the amount lost by the subject in the first game: *frlost = lost / won*

1. The variable *subtracted* is equal to 0 when the subject chooses to subtract an amount of $1 with probability 25%.

2. The variable *esubtracted* is equal to .25 when the subject chooses to burn $1 with probability 25%.

3. *rwon* = 0 for the smallest winnings in the group, and *rwon = 1* for the biggest winnings in the group.

4. The variable *rwonbyhit* is equal to 0 when the subject decides not to subtract

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