

Gerald Eisenkopf  
Sabrina Teyssier

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# Envy and Loss Aversion in Tournaments

Gerald Eisenkopf<sup>\*</sup>    Sabrina Teyssier<sup>#</sup>

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## Abstract

In tournaments, the large variance in effort provision is incompatible with standard economic theory. In our experiment we test theoretical predictions about the role of envy and loss aversion in tournaments. Our results confirm that envy implies higher effort while loss aversion increases the variance of effort. Moreover, we show that standard theory provides a good explanation for competitive behavior when envy and loss aversion do not play a role in the decision making process.

**JEL-Codes:** M52, C90, D03

**Keywords:** Tournament, envy, loss aversion

<sup>\*</sup> Thurgau Institute of Economics, Hauptstrasse 90, 8280 Kreuzlingen, Switzerland, University of Konstanz Department of Economics, University of Konstanz, 78457 Konstanz, Germany; gerald.eisenkopf@uni-konstanz.de

<sup>#</sup> INRA-ALISS, 65 bd de Brandebourg, 94205 Ivry-sur-Seine, France; Sabrina.Teyssier@ivry.inra.fr.

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## 1. Introduction

Laboratory experiments show that average effort in tournaments is relatively high and fairly close to theoretical predictions (e.g. Bull, Schotter and Weigelt, 1987, Harbring and Irlenbusch, 2003, Orrison, Schotter, and Weigelt, 2004). However, these papers report a substantial variance in effort provision. This variance is incompatible with the seminal models by Lazear and Rosen (1981), Green and Stokey (1983) or O’Keefe, Viscusi and Zeckhauser (1984) because experimental participants have the same productivity if ‘effort’ choice is a purely monetary decision. This paper provides a comprehensive explanation for tournament behavior that takes the variance in effort provision into account. In our laboratory experiment we isolate and confirm theoretical predictions about the influence of envy and loss aversion in tournaments. We find that standard tournament theory makes a much more accurate prediction once envy and loss aversion are accounted for.

We elicited the effect of these preferences directly by comparing behavior in the treatments with different modifications of the tournament set-up.<sup>1</sup> In the baseline “*Tournament Treatment*” (TT), subjects played a conventional tournament in groups of two persons. Each subject chose a monetary effort level in order to win a prize. The subject with the higher effort level had a higher chance of winning the prize. In such a tournament, both envy and loss aversion can influence behavior. According to Gill and Stone (2010) a loss-averse subject is disappointed if she provides a high level of effort but does not win the prize. This person may actually provide no effort to minimize this disappointment. Furthermore, a subject may be envious towards her competitor if this other person wins the prize. As in Fehr and Schmidt (1999) and Grund and Sliwka (2005), we consider envy as disadvantageous inequity aversion. In the second treatment, the subjects did not compete against each other. Instead, we took the effort level from a randomly chosen participant from the tournament treatment. Then, a

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<sup>1</sup> We did not use separate games to measure the preferences because Blanco, Engelmann and Normann (2007) show that preferences measured in a specific context may not evaluate the same preferences in a different context.

random mechanism decided which effort level of a subject in this treatment was sufficient to win the prize. In this way, we ensured that all subjects with the same effort level received the same payment. This procedure minimized inequity, and therefore envy, between subjects with a given effort level. Furthermore, the subject from the previous treatment did not get any additional payment. The subjects did not get any information if the randomly chosen subject from the previous treatment had won her tournament. Of course, subjects in this “*No-Envy Treatment*” (NET) received full information about the incentives in the TT.

In the third treatment the individual payment depended again on a subject’s effort choice relative to the effort of a randomly chosen subject from the NET. However, instead of receiving the prize with a certain probability, subjects received the expected payoff immediately.<sup>2</sup> With a correct belief about the effort choice of a subject in the TT, this procedure ensured that the payment did not deviate from the reference point which in turn minimizes both envy and loss aversion. We therefore call this treatment the “*No-Loss-Aversion Treatment (NLT)*”.

As in most previous studies we find that average effort level in the TT is close to the standard equilibrium prediction. We also observe a high variance which is not in line with this prediction. In the NET, the average effort level is lower than the standard equilibrium prediction and the variance is still high. As predicted by Grund and Sliwka (2005), the minimization of envy led to lower effort levels. In the NLT, the average effort level is again close to the standard theoretical prediction and the variance is low. The lower variance in the third treatment in comparison to the two other treatments emphasizes the role of loss aversion in tournaments. When subjects cannot experience losses relative to their expectations, the variance in tournaments is largely reduced. The predictions of Gill and Stone (2010) are confirmed by our data. Lazear and Rosen (1981) and similar contributions provide a fairly

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<sup>2</sup> A subject basically received a share of the prize. The size of the share was determined by the same formula that determined the probability of winning the prize in the other treatments.

accurate description of behavior once concerns for both inequity aversion and loss aversion are eliminated. In this context, average effort is close to equilibrium and the variance in behavior is low.

Our results reveal underlying mechanisms of tournament behavior. More specifically, the design allows a rather precise identification of different preferences which is not feasible with field data. We show that envy and loss aversion are, to some extent, competing preferences. While the former leads to an increase in effort provision, the latter preference induces some subjects to reduce their effort quite dramatically in order to avoid disappointment. These results have a clear implication for the use of tournaments as an incentive device. Lazear and Rosen (1981) argue that tournaments can implement efficient allocations. The existence of envy suggests that a principal who uses a tournament can exploit her employees because they will provide very high effort.<sup>3</sup> However, if an envious person is also loss averse, the potential benefits of envy for the principal are at risk.

Our paper is structured as follows. In section 2, we describe our experiment. Section 3 provides the behavioral predictions in detail and section 4 shows the results. Section 5 concludes.

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<sup>3</sup> Note that in the model of Grund and Sliwka (2005), the resulting disutility of envious competitors is larger than the benefit for the principal.

## 2. Experimental design

The experiment consisted of three treatments and was presented to the subjects in neutral language (the instructions are provided in Appendix A). The first treatment (the *Tournament Treatment* (TT)) corresponds to a basic tournament. In the second treatment (the *No-Envy Treatment* (NET)), only one change is made in comparison to the first treatment. Inequity between competitors is minimized. In the third treatment (the *No-Loss-Aversion Treatment* (NLT)), inequity and losses regarding subjects' expectations, as defined by Gill and Stone (2010), were minimized. Subjects participated in only one treatment. There was no repetition in any of the three treatments. All subjects made one decision.

Subjects in all treatments made an effort choice. They did so by choosing a (monetary) effort level  $e$  between 0 and 15. Each subject had an endowment of 225 points from which she could pay the costs of effort ( $c(e)$ , with  $c(e) = e^2$ ). Subjects could keep the remaining endowment. The subjects had three minutes to decide about their effort level. Unlike in other experiments, the subjects could not just write in a number. They could increase or decrease the effort level by clicking the appropriate button on the screen. Above each button, we wrote how the respective change in effort affected the cost. In this way, we provided clear and immediate information about the (marginal) cost of effort which in turn facilitated economic decision making. If subjects did not click any button, the effort level remained at 0.

### *The Tournament Treatment* (TT)

Subjects in the TT participated in a conventional tournament. Two subjects competed against each other for a prize of 280 points by choosing the effort level. The person with the highest effort won the prize but the effort of each subject was distorted by a random variable ( $\epsilon$ ). This variable was drawn independently for each subject out of a uniform distribution between -7 and 7. The instructions contained a table which informed the subjects about their probability of winning the prize, given the differences in effort between the two competitors.

### *The No-Envy Treatment (NET)*

The NET was organized in the same way as the TT. The only difference is that in the NET, a subject received the prize of 280 points if her distorted effort level was higher than the distorted effort of a randomly chosen subject in the TT. We provided subjects with clear information about the decision problem of the participants in the TT. The subjects also knew that the randomly chosen person did not receive any further payment. They did not receive any information about the final payment of this subject. Effort provision occurred as in the TT.

This treatment minimizes inequity and the effects of inequity aversion as subjects do not create any externality on others' payoff by making their decisions. To guarantee the minimization of inequity between subjects in the NET session, all subjects "competed" against the same randomly chosen person. Furthermore, all subjects experienced the same distortions. The computer generated only two random variables. One variable distorted the effort of all subjects in the same way; the other distorted the effort of the randomly chosen person. Both variables were drawn independently from the uniform distribution between -7 and 7, so that subjects with the same effort received exactly the same payment at the end of the experiment. The randomly chosen subject from the TT session did not receive any additional benefit from being chosen as a benchmark. The participants in the NET did not receive information if this randomly chosen subject had won or lost her own tournament.

### *The No-Loss-Aversion Treatment (NLT)*

This treatment is similar to the NET. Again, subjects compete against a random subject from the TT. However, we eliminate the random variables. Instead of a probability of winning the prize as in the other treatments, in this treatment subjects could receive a share of the prize. The subjects received a table which showed their share of the prize given the differences in

effort between them and the randomly chosen subject. The table was identical to that in the previous treatments, only that columns with percentage values had the headline “Your share” instead of “Your winning probability”.

The experiment was computerized with the software “z-Tree” (Fischbacher, 2007). The recruitment was conducted with the software “ORSEE” (Greiner, 2003). All sessions took place at the University of Konstanz. Subjects were students from this university. 78 subjects participated in the experiment, 26 per session. The sessions lasted for about 45 minutes. 25 points implied a payment of 1 euro.<sup>4</sup>

### 3. Behavioral Predictions

In all treatments, the utility of a subject depends on her own effort, the realization of random variables and the effort of a randomly assigned subject from the TT. In all three treatments we took great care to explain the decision problem of such a randomly drawn subject. Hence, the belief about the effort choice of this randomly chosen subject does not differ systematically across the treatments. We denote this belief with  $\hat{e}$ . For our predictions, we compare the optimal effort choice of the subjects in the different treatments, given  $\hat{e}$ . In this section we discuss the general mechanisms. Appendix C provides numeric details for optimal responses in the different treatments.

In all treatments, a subject  $i$  receives the expected payoff  $E(x_i) = 225 + 280p_i - e_i^2$ . The variable  $p_i$  denotes subject  $i$ 's probability to win, i.e.  $p_i = p_i(e_i, \hat{e}) = \text{Prob}(e_i + \varepsilon_i > \hat{e} + \varepsilon)$ , with  $\varepsilon$  denoting the distortion of the randomly assigned subject's effort. Our predictions use components from three theoretical papers. Following Fehr and Schmidt (1999), we denote

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<sup>4</sup> A euro was equivalent to 1.4 US dollars at the time of the experiment (January 2010).



disadvantageous inequity aversion (or envy) of subjects by  $\alpha \geq 0$ .<sup>5</sup> Like in Grund and Sliwka (2005), envy in tournaments focuses on the differences in prizes between the two subjects.<sup>6</sup> Following Gill and Stone (2010) we denote loss aversion by  $l > 0$ . This parameter measures how the difference between the actual and the expected payoff of the subject affects her utility in the case that this difference is negative.<sup>7</sup> We assume for our predictions that all subjects have the same degree of envy and loss aversion to derive the behavioral predictions. Furthermore, we assume that subjects are risk-neutral.<sup>8</sup>

The expected utility function of subject  $i$  in the TT is written as follows:

$$EU_i^T = 225 + 280[(1 - l(1 - p_i))p_i - (1 - p_i)\alpha] - e_i^2 \quad (1)$$

The expected utility increases in the expected monetary benefit ( $280p_i$ ) and decreases both in the disappointment and envy. Gill and Stone (2010) model disappointment as the gap between the expected and the actual payment, multiplied with the degree of loss aversion ( $l \times 280p_i$ ). Grund and Sliwka (2005) model envy as the income gap between both players multiplied with the degree of disadvantageous inequity aversion ( $\alpha \times 280$ ). Both preferences become relevant if a subject loses the tournament which happens with probability  $(1 - p_i)$ . A subject in the TT maximizes this expected utility by choosing an optimal effort level. In this case, the following first order condition obtains:

$$\frac{\partial EU_i^T}{\partial e_i} = 280 \left[ (1 + \alpha - l(1 - p_i)) \frac{\partial p_i}{\partial e_i} + lp_i \frac{\partial p_i}{\partial e_i} \right] - 2e_i = 0 \quad (2)$$

Inequity aversion and loss aversion lead to two main results. On the one hand, the average of effort increases if subjects are envious. On the other hand, the variance of effort increases if

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<sup>5</sup> Like Fehr and Schmidt (1999) we consider envy as a stronger sentiment than compassion. Hence, we do not consider compassion in the following analysis. It would not affect the qualitative characteristics of our prediction.

<sup>6</sup> The analysis does not change qualitatively, if envious subjects take the costs of effort into account.

<sup>7</sup> We assume loss aversion to be a stronger sentiment than gain aversion, in which utility is reduced if the difference is positive. Again, we do not consider gain aversion because it does not give qualitatively different insights.

<sup>8</sup> In another experiment on the principal-agent relationship in tournaments (Eisenkopf and Teyssier, 2009), we find that risk-aversion does not play a significant role for (monetarized) effort choice in tournaments.

subjects are sufficiently loss averse (see following page). Appendix B provides numeric details for the equilibrium outcome in the TT.

In the NET, the expected utility function is the same as in the TT. However, we eliminated the scope for envy in this treatment, which eliminates  $\alpha$  in the first order condition for subjects in the NET:

$$\frac{\partial EU_i^B}{\partial e_i} = 280 \left[ (1 - l(1 - p_i)) \frac{\partial p_i}{\partial e_i} + lp_i \frac{\partial p_i}{\partial e_i} \right] - 2e_i = 0 \quad (3)$$

The elimination of envy in the NET implies the following prediction<sup>9</sup>:

*Hypothesis 1: Subjects in the No-Envy Treatment provide, on average, less effort than subjects in the Tournament Treatment.*

In both treatments, the impact of loss aversion on effort provision crucially depends on a subject's individual degree of loss aversion and her beliefs about the effort choice of the randomly assigned subject. A sufficiently high degree of loss aversion induces extreme effort choices, as Gill and Stone (2010) show. Depending on the parameter constellation, loss aversion

- induces an effort of 0, if subjects are sufficiently loss averse and believe that the randomly assigned subject will provide high effort;
- induces an effort of up to 15 if subjects are sufficiently loss averse and believe that the randomly assigned subject will provide low effort;
- does not have any impact on the effort choice, if the degree of loss aversion is sufficiently low.

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<sup>9</sup> Hypothesis 1 also holds for a mere reduction of envy.

In the NLT, concerns for loss aversion are eliminated as well as for envy, as the expected payment is equal to the actual payment. Subjects in this treatment receive a share of the prize. The size of this share is equivalent to the respective probability of winning the prize in the other two treatments ( $p_i$ ). The additional elimination of loss aversion implies the resulting change in the first order condition:

$$\frac{\partial EU_i^{EB}}{\partial e_i} = 280 \frac{\partial p_i}{\partial e_i} - 2e_i = 0 \quad (4)$$

In this case, the optimal effort does not depend on loss aversion. Therefore, the best response of subjects in the NLT is less variable. With the same distribution of beliefs about the effort choice of the randomly assigned subject in all treatments, the reduction of loss aversion leads to the second hypothesis:

*Hypothesis 2: The variance of effort choice is larger in the No-Envy Treatment than in the No-Loss-Aversion Treatment.*

Equation 4 provides the optimal effort choice as it is predicted by theoretical models which do not take non-selfish preferences into account, such as Lazear and Rosen (1981). Since the NLT eliminates both envy and loss aversion, we make the following prediction:

*Hypothesis 3: Given correct beliefs about the effort choice of the randomly assigned subject from the Tournament Treatment, the average effort choice in the No-Loss-Aversion Treatment is equal to the effort choice predicted by a conventional tournament model.*

#### 4. Results

We compare average effort between the TT and the NET as well as effort variance between the NET and the NLT. Table 1 and Figure 1 both present the average effort and the variance in each of the three treatments.

	TT	NET	NLT
Average of effort	9.85	7.81	9.54
Variance of effort	11.34	13.52	5.21

Table 1. Average and variance of effort by treatment (26 observations per treatment)

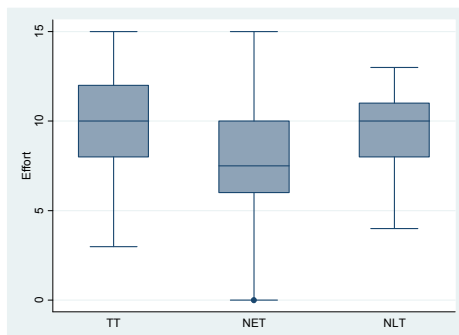


Figure 1. Dispersion of effort by treatment

In the TT, the average effort level is not significantly different from the equilibrium predicted by standard tournament theory (t-test,  $p=0.8177$ ). The equilibrium prediction in this case is 10. Our result is in line with most previous tournament experiments.

Following hypothesis 1, we compare the average effort in the TT and in the NET in order to identify the impact of reduced envy. We observe a significant difference in average effort between both treatments (Mann-Whitney test:  $z=2.156$ ,  $p=0.0311$ ). We confirm that envy increases the effort of subjects in tournaments.

To identify the effect of loss aversion, we compare the effort variance in the NET and in the NLT. An F-test reveals that the variance of effort is significantly higher in the NET than in the NLT ( $p=0.0206$ ).<sup>10</sup> Note that the variance of effort is similar in the TT and in the NET ( $p=0.6627$ ). This result supports our claim that the lack of loss aversion causes the low effort variance in the NLT.

Additionally, we observe no difference in average effort between the TT and the NLT (Mann-Whitney test:  $z=0.537$ ,  $p=.5916$ ). More accurately, average effort in the NLT is close to the optimal effort choice, assuming correct beliefs about an average effort choice of about 10 by the randomly assigned subject (t-test,  $p=0.3128$ ).<sup>11</sup> These results support our hypothesis that standard tournament theory, e.g. Lazear and Rosen (1981), Green and Stokey (1983) or O’Keefe, Viscusi and Zeckhauser (1984), explains effort decisions in tournaments correctly once both concerns for inequity aversion and loss aversion are eliminated.

## 5. Conclusion

Laboratory experiments repeatedly produce a large variance in effort choice in tournaments which standard tournament models cannot explain. New theoretical contributions address these shortcomings by considering preferences such as inequity aversion and loss aversion. This paper provides clean evidence regarding the impact of these preferences on the behavior of subjects in a tournament. Our results show that disadvantageous inequity aversion, i.e. envy, induces higher effort levels while loss aversion implies higher variance of effort. Standard tournament theory makes precise predictions once inequity and loss aversion do not affect the decision making. Our results support the development of theories with behavioral considerations to explain decisions in tournaments.

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<sup>10</sup> The results are also significant according to Levene’s (1960) robust test statistic and alternative measures proposed by Brown and Forsythe (1974).

<sup>11</sup> Given this belief, the optimal effort choice is 10 as well. Average effort in the expected bonus treatment is close to this optimal response.

Lazear and Rosen (1981) show in their seminal paper how well-designed tournaments induce rational selfish agents to provide the optimal level of effort. This effort choice maximizes the total payoff of the designer of the tournament (i.e. the principal) and the competing agents. By considering additional preferences among the agents, our results challenge this benign function of tournaments. Envy and loss aversion induce some agents to provide excessive effort in order to avoid disappointment and a low payoff relative to the competitor. Other loss-averse agents reduce their effort quite dramatically. Both preferences combined imply a decline in overall utility, a significant risk for the principal and the costly (self-)exploitation of some agents.

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## Appendix

### *Appendix A – Instructions*

We welcome you to this economic experiment.

Your decisions in this experiment, and in given cases the decisions of other participants, influence your payment. It is therefore very important that you read these instructions very carefully. If you have questions, then please address them to us **before** the beginning of the experiment. All participants receive the same instructions.

**During the experiment, talking with the other participants is not allowed.** Failure to comply with this rule is grounds for exclusion from the experiment and forfeit of all payments.

During the experiment we speak not of euros, but of points. Your total income will be calculated initially in points. The total points you achieve during the experiment will then at the end be converted to euros with the exchange rate of

**25 points = 1 euro**

As already mentioned, at the end of today's experiment you will receive **cash** for the points you earned during both parts of the experiment. On the next pages we will explain the exact sequence of events for the first part of the experiment.

### *Instructions for the TT*

#### **1. Structure of the Experiment**

In this experiment a sum of 280 points will be allotted to you or another participant of this experiment. This other participant will be randomly assigned to you and will remain anonymous throughout the entire experiment. Your anonymity will also be preserved the entire time. The other participant receives the same instructions as you and therefore finds himself in the same decision situation as you.

You and the other participant influence which of you receives the 280 points and which of you does not through choice of inputs. You can influence the probability that the sum of 280

points goes to you by increasing or decreasing your input. Likewise the other participant can also influence the probability of receipt through choice of inputs.

- If you increase your input, the probability that you receive the sum goes up.
- If you decrease your input, the probability that you receive the sum goes down.
- If the other participant increases his input, your probability of receipt goes down.
- If the other participant decreases his input, your probability of receipt goes up.

At the beginning of the experiment your input is equal to 0. You can increase the input by clicking on the corresponding field (see the following illustration). Inversely you can reduce your input in a similar fashion. The minimum input is 0, the maximum input is 15.

The screenshot shows an experimental interface with the following elements:

- Top left: "Punkte" section showing "1 von 1".
- Top right: "Verbleibende Zeit (sec): 167".
- Center: Summary statistics:
  - Ihr momentaner geleisteter Einsatz: 10
  - Kosten Ihres Einsatzes: 100
  - Ihr derzeitiger Punktestand: 125
  - Ihr Punktestand, falls Sie die höhere Auszahlung erhalten: 499
- Below: "So viele Punkte können Sie zusätzlich bekommen: 280".
- Two choice boxes:
  - Left: "Wollen Sie Ihren Einsatz um eine Einheit erhöhen? Eine Erhöhung des Einsatzes steigert Ihre Kosten um folgenden Betrag: 21". Includes a button "Einsatz Erhöhen".
  - Right: "Wollen Sie Ihren Einsatz um eine Einheit reduzieren? Eine Reduzierung des Einsatzes senkt Ihre Kosten um folgenden Betrag: 19". Includes a button "Einsatz Reduzieren".
- Below: "Haben Sie den von Ihnen gewünschten Einsatz gewählt?" with an "OK" button.
- Bottom: A table showing the relationship between input differences and probabilities.
 

Differenz zwischen den Beträgen	Ihre Erfolgswahrscheinlichkeit	Differenz zwischen den Beträgen	Ihre Erfolgswahrscheinlichkeit	Differenz zwischen den Beträgen	Ihre Erfolgswahrscheinlichkeit
-14 und weniger	0%	-4	25.5%	5	73.3%
-13	0.3%	-3	30.9%	6	83.7%
-12	1.0%	-2	36.7%	7	87.5%
-11	2.3%	-1	43.1%	8	90.6%
-10	4.1%	0	50%	9	93.6%
-9	6.4%	1	56.9%	10	95.9%
-8	9.2%	2	63.3%	11	97.7%
-7	12.5%	3	69.1%	12	99.0%
-6	16.3%	4	74.5%	13	99.7%
-5	20.7%			14 und mehr	100%

Consider with respect to your choice of input that a higher input is associated with costs. For your input choice a total of 225 points are available to you. You will receive the points that you do not use for your input as payment at the end of the experiment. The following table shows the costs of each chosen input level.

Input	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total cost of input	0	1	4	9	16	25	36	49	64	81	100	121	144	169	196	225

As already mentioned, the probability that the sum is allotted to you depends on your input as well as the input of the other participant. The following table tells you how high the probability you receive the sum actually is. First the difference between your input and the other participant's input is shown. Next to this is the probability you receive the sum as well as the corresponding probability that the other participant receives the sum. The computer decides the actual allotment of the sum.



Table

The difference in inputs between the participants and the resulting probabilities of receiving the higher point sum (rounded)

Difference in inputs	Probability of getting the 280 points		Difference in inputs	Probability of getting the 280 points	
	You	The other participant		You	The other participant
(Your input – other's input)			(Your input – other's input)		
-14	0%	100%	0	50%	50%
-13	0.3%	99.7%	1	56.9%	43.1%
-12	1.0%	99.0%	2	63.3%	36.7%
-11	2.3%	97.7%	3	69.1%	30.9%
-10	4.1%	95.9%	4	74.5%	25.5%
-9	6.4%	93.6%	5	79.3%	20.7%
-8	9.2%	90.8%	6	83.7%	16.3%
-7	12.5%	87.5%	7	87.5%	12.5%
-6	16.3%	83.7%	8	90.8%	9.2%
-5	20.7%	79.3%	9	93.6%	6.4%
-4	25.5%	74.5%	10	95.9%	4.1%
-3	30.9%	69.1%	11	97.7%	2.3%
-2	36.7%	63.3%	12	99.0%	1.0%
-1	43.1%	56.9%	13	99.7%	0.3%
			14	100%	0%

You have exactly 3 minutes (180 seconds) time for the choice of input. The remaining time is shown on the upper right corner of the screen. Your input will be determined using the input at the end of this time.

You may certainly also decide before the end of the 3 minutes. (see on figure 1 above the lower button on the right). A new screen will then appear, on which there is again the possibility to make a revision or to register a definitive decision. When all participants have decided, you will be informed whether you have received the 280 points or not. A questionnaire will then follow and subsequently payment.

**Example:**

You and the other participant initially have an input of 0 each. You increase your input 13 times, then reduce it twice and increase it anew once. After three minutes your input amounts to 12 (=13-2+1). The other participant increases his input 6 times and doesn't change his input anymore thereafter. The difference between your input and the other participant's input is then 6 (= 12-6).

You receive the 280 points with an assigned probability of 83.7%. Correspondingly, the other participant receives the 280 points with a probability of 16.3%. At the same time you and the other participant bear the costs of the respective inputs. An input level of 12 amounts to a cost of 144 points, an input level of 6 amounts to a cost of 36 points.

In the case that the sum goes to you, your total payment will be 361 points (probability 83.7%) and in the case that the sum goes to the other participant you will be paid 81 points (probability 16.3%). In the case that you receive the sum, the other participant receives 189 points (probability 83.7%) and otherwise 469 points (probability 16.3%). The following table once more shows you a detailed calculation of payment to you.

	Payment to you		Payment to the other participant	
	Sum to you	Sum to the other participant	Sum to you	Sum to the other participant
Probability	83,7%	16,3%	83,7%	16,3%
Initial point level	225	225	225	225
Subtraction of the cost of input	-144	-144	-36	-36
Assignment	280	0	0	280
Sum	361	81	189	469

*Instructions for the NET*

**2. Structure of the Experiment**

In this experiment a sum of 280 points can be allotted to you. The allotment depends on your input and the input of a randomly chosen subject from a previous experiment. We explain later which decision this subject had to make.

Through choice of input you influence if you receive the 280 points or if you do not. You can influence the probability that the sum of 280 points goes to you by increasing or decreasing your input. Likewise the input of the randomly chosen subject from the previous experiment also influences the probability of receipt.

- If you increase your input, the probability that you receive the sum goes up.
- If you decrease your input, the probability that you receive the sum goes down.
- If the participant of the previous experiment has chosen a high input, your probability of receipt goes down.
- If the participant of the previous experiment has chosen a low input, your probability of receipt goes up.
- The participant of the previous experiment does not receive any additional payments or deductions at all.

All participants of today's experiment will be measured by the same yardstick, i.e. all participants are compared with the same participant from the previous experiment. Furthermore, all participants of today's experiment who choose identical inputs will receive the same allotment. Hence, a participant with a lower input cannot receive 280 points, if a participant with a higher input does not get 280 points.

At the beginning of the experiment your input is equal to 0. You can increase the input by clicking on the corresponding field (see the following illustration). Inversely you can reduce your input in a similar fashion. The minimum input is 0, the maximum input is 15.

Periode 1 von 1 Verbleibende Zeit (Sek): 167

Ihr momentaner geleisteter Einsatz: 10  
 Kosten Ihres Einsatzes: 100  
 Ihr derzeitiger Punktestand: 126  
 Ihr Punktestand, falls Sie die höhere Auszahlung erhalten: 495

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So viele Punkte können Sie zusätzlich bekommen: 200

Wollen Sie Ihren Einsatz um eine Einheit erhöhen?  
 Eine Erhöhung des Einsatzes steigert Ihre Kosten um folgenden Betrag: 21

Wollen Sie Ihren Einsatz um eine Einheit reduzieren?  
 Eine Reduzierung des Einsatzes senkt Ihre Kosten um folgenden Betrag: 19

Haben Sie den von Ihnen gewünschten Einsatz gewählt?

Differenz zwischen den Beträgen	Ihre Erfolgswahrscheinlichkeit	Differenz zwischen den Beträgen	Ihre Erfolgswahrscheinlichkeit	Differenz zwischen den Beträgen	Ihre Erfolgswahrscheinlichkeit
-14 und weniger	0%	-4	25.0%	5	73.3%
-13	0.3%	-3	30.9%	6	83.7%
-12	1.0%	-2	36.7%	7	87.5%
-11	2.3%	-1	43.1%	8	90.6%
-10	4.1%	0	50%	9	93.6%
-9	6.4%	1	56.9%	10	95.9%
-8	9.2%	2	63.3%	11	97.7%
-7	12.5%	3	69.1%	12	99.0%
-6	16.3%	4	74.5%	13	99.7%
-5	20.7%			14 und mehr	100%

Consider with respect to your choice of input that a higher input is associated with costs. For your input choice a total of 225 points are available to you. You will receive the points that you do not use for your input as payment at the end of the experiment. The following table shows the costs of each chosen input level.

Input	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total cost of input	0	1	4	9	16	25	36	49	64	81	100	121	144	169	196	225

As already mentioned, the probability that the sum is allotted to you depends on your input as well as the input of a randomly assigned participant from an earlier experiment. The following table tells you how high the probability you receive the sum actually is. First the difference between your input and the earlier participant's input is shown. Next to this is the probability you receive the sum. The computer decides the actual allotment of the sum.

Table 2

The difference in inputs between your input and the input of a participant from the previous experiment and the resulting probabilities of receiving the higher point sum (rounded)

Difference in inputs	Your Probability of getting the 280 points	Difference in inputs	Your Probability of getting the 280 points
<i>(Your input – other's input)</i>		<i>(Your input – other's input)</i>	
-14	0%	0	50%
-13	0.3%	1	56.9%
-12	1.0%	2	63.3%
-11	2.3%	3	69.1%
-10	4.1%	4	74.5%
-9	6.4%	5	79.3%
-8	9.2%	6	83.7%
-7	12.5%	7	87.5%
-6	16.3%	8	90.8%
-5	20.7%	9	93.6%
-4	25.5%	10	95.9%
-3	30.9%	11	97.7%
-2	36.7%	12	99.0%
-1	43.1%	13	99.7%
		14	100%

You have exactly 3 minutes (180 seconds) time for the choice of input. The remaining time is shown on the upper right corner of the screen. Your input will be determined using the input at the end of this time.

You may certainly also decide before the end of the 3 minutes. (see on figure 1 above the lower button on the right). A new screen will then appear, on which there is again the possibility to make a revision or to register a definitive decision. When all participants have decided, you will be informed whether you have received the 280 points or not. A questionnaire will then follow and subsequently payment.

### 3. The decision context of the participants in the previous experiment

The randomly assigned participant also had the chance to receive 280 points. Her probability for an allotment depended on her input and the input of another participant in the same experiment. The allotment of 280 points to one participant implied that the other participant did not receive anything. The two participants were randomly assigned to each other. They could not observe each other and remained anonymous throughout the entire experiment. If one person increased her input, her probability to receive 280 points increased. The probability of the other person sank at the same time. Otherwise the conditions in this experiment and the conditions in the previous one were identical:

- Each participant had 225 points to choose an input level between 0 and 15.
- The costs were the same as in table 1.
- For any difference in inputs, the probability of receiving 280 points was identical.

Table 2 contained the same parameters in the previous experiment.

Therefore, the participant in the previous experiment faced the same problem as you do. However, she was compared with a person, who participated at the same time. Only one of these two persons received 280 points.

**Example:**

You initially have an input of 0. You increase your input 13 times, then reduce it twice and increase it anew once. After three minutes your input amounts to 12 ( $=13-2+1$ ). A randomly chosen participant from the previous experiment is chosen. This previous participant had chosen an input of 6. The difference between your input and the previous participant's input is then 6 ( $=12-6$ ).

You receive the 280 points with an assigned probability of 83.7%. At the same time you bear the costs of the inputs. An input level of 12 amounts to a cost of 144 points.

In the case that the sum goes to you, your total payment will be 361 points (probability 83.7%). Otherwise you will be paid 81 points (probability 16.3%). The participant of the previous experiment does not receive any payment. The following table provides a detailed calculation of your payoffs.

	Payment to you	
	Sum to you	No Sum
Probability	83,7%	16,3%
Initial point level	225	225
Subtraction of the cost of input	-144	-144
Assignment	280	0
Sum	361	81

*Instructions for the NLT***4. Structure of the Experiment**

In this experiment a sum of up to 280 points can be allotted to you. The allotment depends on your input and the input of a randomly chosen subject from a previous experiment. We explain later which decision this subject had to make.

Through choice of input you influence the share of the 280 points you receive. You can influence this share by increasing or decreasing your input. Likewise the input of the randomly chosen subject from the previous experiment also influences this share.

- If you increase your input, your share goes up.
- If you decrease your input, your share goes down.
- If the participant of the previous experiment has chosen a high input, your share goes down.
- If the participant of the previous experiment has chosen a low input, your share goes up.
- The participant of the previous experiment does not receive any additional payments or deductions at all.

All participants of today's experiment will be measured by the same yardstick, i.e. all participants are compared with the same participant from the previous experiment. Furthermore, all participants of today's experiment who choose identical inputs will receive the same share. Hence, a participant with a lower input will receive a smaller share than a participant with a higher input.

At the beginning of the experiment your input is equal to 0. You can increase the input by clicking on the corresponding field (see the following illustration). Inversely you can reduce your input in a similar fashion. The minimum input is 0, the maximum input is 15.

Periode 1 von 1 Verbleibende Zeit [Sek]: 167

Ihr momentaner geleisteter Einsatz: 10  
 Kosten Ihres Einsatzes: 100  
 Ihr derzeitiger Punktestand: 126  
 Ihr Punktestand, falls Sie die höhere Auszahlung erhalten: 495

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So viele Punkte können Sie zusätzlich bekommen: 200

Wollen Sie Ihren Einsatz um eine Einheit erhöhen?  
Eine Erhöhung des Einsatzes steigert Ihre Kosten um folgenden Betrag: 21

Wollen Sie Ihren Einsatz um eine Einheit reduzieren?  
Eine Reduzierung des Einsatzes senkt Ihre Kosten um folgenden Betrag: 19

Haben Sie den von Ihnen gewünschten Einsatz gewählt?

Differenz zwischen den Beträgen	Ihre Erfolgswahrscheinlichkeit	Differenz zwischen den Beträgen	Ihre Erfolgswahrscheinlichkeit	Differenz zwischen den Beträgen	Ihre Erfolgswahrscheinlichkeit
-14 und weniger	0%	-4	25.0%	5	73.3%
-13	0.3%	-3	30.9%	6	83.7%
-12	1.0%	-2	36.7%	7	87.5%
-11	2.3%	-1	43.1%	8	90.6%
-10	4.1%	0	50%	9	93.6%
-9	6.4%	1	56.9%	10	95.9%
-8	9.2%	2	63.3%	11	97.7%
-7	12.5%	3	69.1%	12	99.0%
-6	16.3%	4	74.2%	13	99.7%
-5	20.7%			14 und mehr	100%

Consider with respect to your choice of input that a higher input is associated with costs. For your input choice a total of 225 points are available to you. You will receive the points that you do not use for your input as payment at the end of the experiment. The following table shows the costs of each chosen input level.

Input	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Total cost of input	0	1	4	9	16	25	36	49	64	81	100	121	144	169	196	225

As already mentioned, your share depends on your input as well as the input of a randomly assigned participant from an earlier experiment. The following table tells you how high the share actually is. First the difference between your input and the earlier participant's input is shown. Next to this is your share.

Table 2

The difference in inputs between your input and the input of a participant from the previous experiment and the resulting share of the point sum (rounded)

Difference in inputs	Your share of the 280 points	Difference in inputs	Your share of the 280 points
<i>(Your input – other's input)</i>		<i>(Your input – other's input)</i>	
-14	0%	0	50%
-13	0.3%	1	56.9%
-12	1.0%	2	63.3%
-11	2.3%	3	69.1%
-10	4.1%	4	74.5%
-9	6.4%	5	79.3%
-8	9.2%	6	83.7%
-7	12.5%	7	87.5%
-6	16.3%	8	90.8%
-5	20.7%	9	93.6%
-4	25.5%	10	95.9%
-3	30.9%	11	97.7%
-2	36.7%	12	99.0%
-1	43.1%	13	99.7%
		14	100%

You have exactly 3 minutes (180 seconds) time for the choice of input. The remaining time is shown on the upper right corner of the screen. Your input will be determined using the input at the end of this time.

You may certainly also decide before the end of the 3 minutes. (see on figure 1 above the lower button on the right). A new screen will then appear, on which there is again the possibility to make a revision or to register a definitive decision. When all participants have decided, you will be informed whether you have received the 280 points or not. A questionnaire will then follow and subsequently payment.

### 5. The decision context of the participants in the previous experiment

The randomly assigned participant had the chance to receive 280 points, i.e. she received either 280 points or nothing at all. Her probability for an allotment depended on her input and the input of another participant in the same experiment. The allotment of 280 points to one participant implied that the other participant did not receive anything. The two participants were randomly assigned to each other. They could not observe each other and remained anonymous throughout the entire experiment.

If one person increased her input, her probability to receive 280 points increased. The probability of the other person sank at the same time. Otherwise the conditions in this experiment and the conditions in the previous one were identical:

- Each participant had 225 points to choose an input level between 0 and 15.
- The costs were the same as in table 1.

The probability of receiving 280 points was identical to the shares in table 2. Table 2 contained the same parameters in the previous experiment, but the columns 2 and 4 had the headlines “**Your Probability of getting the 280 points**” and not “**Your share of the 280 points**”.

For example, if one participant of the previous experiment had chosen an input of 8 and the other one an input of 12, the participant with the lower input received the 280 points with a probability of 22.5%. The participant with the higher input received the 280 points with the corresponding counter-probability of 74.5%

Therefore, the participant in the previous experiment faced the same problem as you do. However, she was compared with a person, who participated at the same time. She either received all the 380 points or nothing at all. Only one of these two persons received 280 points.

**Example:**

You initially have an input of 0. You increase your input 13 times, then reduce it twice and increase it anew once. After three minutes your input amounts to 12 (=13-2+1). A randomly chosen participant from the previous experiment is chosen. This previous participant had chosen an input of 6. The difference between your input and the previous participant's input is then 6 (= 12-6).

You receive a share of 83.7% of the 280 points (i.e.. 234.36) At the same time you bear the costs of the inputs. An input level of 12 amounts to a cost of 144 points.

The participant of the previous experiment does not receive any payment. The following table provides a detailed calculation of your payoffs.

	Payment to you
Share of 280 points	83,7%
Allotment	234.36
Initial point level	225
Subtraction of the cost of input	-144
<b>Sum</b>	<b>315.36</b>

**6. Comprehension Questions**

*(for the TT, similar questions in the other treatments, plus control questions for the decision situation of the assigned participant from the TT)*

Please mark the correct answer

	True	False
My payment depends only on my input.		
The other participants in this room have no influence on payment to me.		
One other participant competes with you for the 280 points.		
A participant from today who provides less input than I do can receive the 280 points if I don't accomplish it.		

**Question 1:** You provide an input of 5, the other participant an input of 12.

- How high are your input costs; how high are the other participant's costs?
- How high is your probability of receiving the additional 280 points?

**Question 2:** You increase your input 6 times, and then decrease it twice. Then the three minutes are over, although you haven't confirmed your decision and you actually wanted to increase your input once more. How high is your input now (Please circle)?



**Question 3:** You provide an input of 14, the other participant an input of 13.

- How high is your probability of receiving the additional 280 points?
- How high is your payment at the end of the experiment if you receive the sum? (in points)
- How high is your payment at the end of the experiment if the other participant receives the sum? (in points)
- How high is the payment to the other participant at the end of the experiment if you receive the sum? (in points)
- How high is the payment to the other participant at the end of the experiment if the other participant receives the sum? (in points)

### Appendix B – Equilibrium in the TT

If we assume that only envy exists but not loss aversion, each subject maximizes his expected utility that is written as follows for subject  $i$ :

$$EU_i = 225 + 280[p_i(1 + \alpha) - \alpha] - e_i^2$$

As a random term distorts the effort exerted by subjects and it is i.i.d. following a uniform distribution between -7 and +7, the probability to win for subject  $i$  is written:

$$p_i = \begin{cases} \frac{1}{2} + \frac{e_i - e_j}{2 \times 7} + \frac{(e_i - e_j)^2}{8 \times 49} & \text{if } e_i < e_j \\ \frac{1}{2} + \frac{e_i - e_j}{2 \times 7} - \frac{(e_i - e_j)^2}{8 \times 49} & \text{if } e_i \geq e_j \end{cases}$$

Then, the maximization of the subject  $i$ 's expected utility gives:

$$e_i^* = 10(1 + \alpha)$$

Therefore, the equilibrium effort level increases in subjects' envy. If we assume that only loss aversion exists but not envy, each subject maximizes his expected utility that is written as follows for subject  $i$ :

$$EU_i = 225 + 280p_i(1 - l(1 - p_i)) - e_i^2$$

Due to the square of the probability of winning in this case, the solutions of the maximization of the utility function are very complex. Therefore, we present in the following table equilibria for determined values of loss aversion,  $l$ .

Degree of loss aversion, $l$	Equilibria
[0,0.2]	(10,10)
[0.3,1.3]	No equilibrium
[1.4,2.1]	(0,9) and (9,0)
[2.2,3.4]	(0,10) and (10,0)
[3.5,5.6]	(0,11) and (11,0)
[5.7,10.8]	(0,12) and (12,0)
[10.9,36.8]	(0,13) and (13,0)
[36.9,∞]	(0,14) and (14,0)

Table A1. Equilibria by loss aversion degree

We observe that there exist two asymmetric equilibria when subjects are sufficiently loss averse.

When we combine envy and loss aversion, the previous results still hold: (i) on average, the equilibrium effort levels increase in envy and (ii) there exist two asymmetric equilibria when subjects are sufficiently loss averse.<sup>12</sup>

*Appendix C – Optimal responses in every treatment*

- Tournament treatment (TT)

The following table presents the effort level that is the optimal response of a subject in the TT depending on her loss aversion and envy degrees, and on her beliefs on the effort exerted by the random subject in the TT. The optimal responses of subjects who have beliefs equal to the equilibrium effort level without envy in the TT are presented in grey.

Beliefs on effort in the TT, $\hat{e}$	Degree of loss aversion											
	0			0.5			1			5		
	0	0.5	1	0	0.5	1	0	0.5	1	0	0.5	1
0	6	7	8	7	8	9	8	9	9	11	11	12
1	6	8	9	7	9	10	8	9	10	12	12	12
2	7	8	9	8	9	10	9	10	11	13	13	13
3	7	9	10	8	10	11	9	11	11	14	14	14
4	7/8	9	11	9	10	11	10	11	12	14	15	15
5	8	10	11	9	11	12	10	12	13	15	15	15
6	8	10	12	9	11	13	10	12	13	15	15	15
7	9	11	12	10	12	13	11	13	14	15	15	15
8	9	11	13	10	12	14	11	13	15	0	15	15
9	10	12	14	10	13	14	0	14	15	0	0	15
10	10	12	14	3	13	15	0	14	15	0	0	15
11	7/8	13	15	2	14	15	0	15	15	0	0	0
12	5	13	15	1	14	15	0	15	15	0	0	0
13	2/3	14	15	1	14	15	0	0	15	0	0	0
14	0	14	15	0	0	15	0	0	15	0	0	0
15	0	0	15	0	0	15	0	0	0	0	0	0

*Table C1. Best responses in the TT depending on effort beliefs, loss aversion and envy*

In the TT, envy increases the effort level, independently of beliefs about the effort of the randomly assigned subject and of loss aversion. Loss aversion increases the effort level for low beliefs on the effort of the randomly assigned subject and decreases the effort level for high beliefs on the effort of the randomly assigned subject, independently of envy. For a given distribution of beliefs about the effort of the randomly assigned subject, the average of effort is higher when subjects are envious and the variance of effort is higher when agents are loss averse. Therefore, as envy is minimized in the NET, the average effort should be higher in the TT than in the NET.

- No-Envy Treatment (NET)

In the NET, the effort level only depends on the loss aversion of subjects and on the beliefs on the effort of the randomly assigned subject in the TT. The optimal responses of subjects to the beliefs about the effort of the randomly assigned subject in the TT are found in table A1 in columns with envy equal to 0, i.e. columns 2, 5, 8 and 11. In the NET, when loss aversion is low the subject's optimal response to the equilibrium effort level without envy and loss aversion in the TT, i.e. 10, is equal to 10 as well. For higher degrees of loss aversion in the NET, the subject's optimal response to the effort level 10 is very low or equal to zero.

<sup>12</sup> When envy is very strong relative to loss aversion, there exists only a symmetric equilibrium inducing the maximum effort levels: (15,15). Nevertheless, such values of envy are only marginally observed in experiments eliciting envy (Blanco et al., 2008, Dannenberg et al., 2009, Teyssier, 2009).

For a given distribution of beliefs about the effort of the randomly assigned subject, the variance of effort is higher when subjects are sufficiently loss averse. Therefore, as loss aversion is minimized in the NLT, the variance of effort should be higher in the NET than in the NLT.

- No-Loss-Aversion Treatment (NLT)

In the NLT, only beliefs on the effort of the randomly assigned subject in the TT affect the effort choice of the subject. The optimal responses of subjects to the beliefs about the effort of the randomly assigned subject in the TT are found in Table A1 in columns with envy and loss aversion equal to 0, i.e. column 2. As envy and loss aversion are minimized in the NLT, the predictions of the standard tournament model should be verified. For beliefs equal to the equilibrium effort level without envy and loss aversion in the TT, i.e. 10, the optimal response is equal to 10 as well, as predicted by standard tournament theory.

THURGAU INSTITUTE  
OF ECONOMICS  
at the University of Konstanz

Hauptstr. 90  
CH-8280 Kreuzlingen 2

Telefon: +41 (0)71 677 05 10  
Telefax: +41 (0)71 677 05 11

[info@twi-kreuzlingen.ch](mailto:info@twi-kreuzlingen.ch)  
[www.twi-kreuzlingen.ch](http://www.twi-kreuzlingen.ch)