Discussion Paper No. 219

Feedback in Tournaments under Commitment Problems: Theory and Experimental Evidence

Oliver Gürtler*
Christine Harbring**

*Oliver Gürtler, Department of Economics BWL II, University of Bonn, Adenauerallee 24-42

53113 Bonn, Germany,

+49-228-739214, oliver.guertler@uni-bonn.de

**Christine Harbring, Department of Personnel Economics and Human Resource Management,

University of Cologne,

50931 Köln, Germany,

+49-221-4707955, Christine.harbring@uni-koeln.de

Feedback in Tournaments under Commitment Problems: Theory and Experimental Evidence[*]

Abstract

In this paper, we analyze a principal's optimal feedback policy in tournaments. We close a gap in the literature by assuming the principal to be unable to commit to a certain policy at the beginning of the tournament. Our analysis shows that in equilibrium the principal reveals intermediate information regarding the agents' previous performances if these performances are not too different. Moreover, we investigate a situation where the principal is not able to credibly communicate her information. Having presented our formal analysis, we test these results using data from laboratory experiments. The experimental findings provide some support for the model.

Keywords: Tournament, Commitment Problems, Feedback, Experiment

JEL classification: C 91, D 83, J 33, M 52

Oliver Gürtler
Department of Economics
BWL II
University of Bonn
Adenauerallee 24-42
D-53113 Bonn
Germany

Phone:+49-228-739214
oliver.guertler@uni-bonn.de

Christine Harbring
Department of Personnel Economics and
Human Resource Management
University of Cologne
Herbert-Lewin-Straße 2
D-50931 Köln
Germany

Phone:+49-221-4707955
christine.harbring@uni-koeln.de

1.   Introduction

Tournaments or contest-like situations are ubiquitous in practice: Besides rent-seeking contests, sports tournaments and beauty contests there are a variety of tournaments within organizations such as promotion tournaments, contests for bonuses or non-monetary benefits ("employee of the month"). Due to this prevalence of tournaments, economic research has extensively focused on the potential advantages and disadvantages of tournaments as well as on their optimal design. Theoretical approaches have been used to analyze rank-order tournaments (e.g., in the seminal paper by Lazear & Rosen 1981 and also in Nalebuff & Stiglitz 1983, O'Keeffe et al. 1984, Rosen 1986, Lazear 1989, Hvide 2002, Grund & Sliwka 2005, Clark & Konrad 2007, Kräkel 2007 or Münster 2007) as well as empirical studies using either field data (e.g., Eriksson 1999, Garicano & Palacios-Huerta 2005) or laboratory data (e.g., Schotter & Weigelt 1992, van Dijk et al. 2001, Sutter & Strassmair 2005).[1]

Most of the models use a one-shot game to represent the tournament, where contestants choose effort once and are then ranked according to their relative performance. This, however, neglects the fact that real-world tournaments usually last for considerable time-periods, e.g. promotion tournaments. In such dynamic tournaments, the tournament organizer (henceforth, the principal) has additional instruments to affect the contestants' (henceforth, agents) behavior. In other words, not all aspects of tournament design can be captured by a single one-shot game. As an important example, the principal can, in a dynamic tournament, decide on releasing information regarding the agents' intermediate performances.

With the current paper we close a gap in the literature by analyzing information revelation in dynamic tournaments theoretically as well as empirically as follows: We assume the principal to be unable to commit to a certain feedback strategy at the beginning of the tournament. This implies that the principal pursues the strategy that is optimal for her ex post, i.e. when intermediate information becomes available. Moreover, we differentiate between two scenarios. While in the first scenario, the principal may always credibly reveal the performance information, she is sometimes unable to credibly communicate the information in the second scenario, even if she wants to. This could be due to the type of information she receives regarding the contestants' intermediate performances. If only informal or subjective information is available credibly revealing this information could be difficult. For example, in large organizations relative performance evaluation is often based on well-defined processes and scales as part of the performance management system. Performance reviews or management panels are usually only held once or twice a year. Information on intermediate performance mostly results from

---

[1] An overview of experiments on tournaments is provided by Harbring & Irlenbusch (2005). For the advantages of using experimental data for analyzing labor market-related research questions see Falk & Fehr (2003).

subjective snap-shot impressions or informal information from discussions with colleagues. Finally, in addition to deriving theoretical predictions regarding this strategic framework which has not yet been analyzed before we also provide a first empirical test of our theoretical findings using data from a laboratory experiment.

There is a recent strand of literature that discusses the role of intermediate performance information in tournaments. In contrast to our model Ederer (2004) and Aoyagi (2004), for example, consider a situation, where the principal *can* commit herself at the beginning of the tournament, whether intermediate information should be released. If information is released, the agents know the intermediate result for sure and choose their efforts according to this information, i.e. efforts vary with this information. From an ex ante point of view, the principal then receives output, which is a function of expected efforts. If information is not revealed, the principal's output is still a function of the agents' efforts. These efforts, however, are now deterministic and depend on the agents' expectations concerning the intermediate information. Comparing both scenarios, Ederer and Aoyagi show that the optimal feedback mechanism usually depends on the form of the effort cost function. Moreover, Gershkov & Perry (2006) consider the possibility of conducting midterm reviews. They demonstrate that it is always favorable to conduct a midterm review, if the results of the midterm review and the final review are aggregated optimally. Otherwise, it may be better to solely monitor the performance at the end of the tournament. All these studies use a different strategic framework and they do not provide an experimental test of their predictions. Only Ederer & Fehr (2006) test Ederer's results in a laboratory experiment and find some support for the model.[2]

The paper is also related to previous work on the disclosure of private information in general. Examples include Grossman & Hart (1980), Grossman (1981) or Milgrom (1981). These papers analyze, whether individuals (e.g. sellers of goods) are interested in voluntarily revealing information (e.g. on product quality) or whether laws requiring positive disclosure are needed. Similar to our model, they find that it is often in the interest of the individuals to reveal information, as a non-revelation of information is interpreted as an unfavorable signal. The current paper is the first to apply this logic to a tournament.

Our main theoretical findings are as follows: Agents clearly react to the principal's feedback decision. If feedback is provided, they choose lower efforts the more the intermediate performances differ. If feedback is not provided, they interpret the non-revelation of information as a "bad" signal regarding the intermediate performances and, thus, reduce their efforts accor-

---

[2] Mohnen & Pokorny (2006) theoretically as well as experimentally analyze a situation where a principal has better information regarding the agents' abilities and can reveal some – also false – information on these abilities. However, the agents' payoffs are based on linear wage contracts instead of a tournament.

dingly. This effect is most distinctive in the first scenario, where information revelation is always feasible. As a result, the principal always reveals her information unless the highest difference in intermediate results has occurred (in which case she is indifferent between revealing and concealing the information). In the second scenario, where information revelation is not always feasible, the principal can conceal unfavorable information and claim that she is unable to communicate it. Here, agents react less extremely to a non-revelation of information so that the principal conceals information on high performance differences.

The experimental results are well in line with these findings. As predicted, agents react to the revelation of higher intermediate differences by exerting lower efforts. Principals correctly anticipate this behavior and, as a consequence, are less likely to reveal their information if the initial situation is quite uneven. Moreover, the agents correctly take into account that a non-revelation of information is more meaningful in the first than in the second scenario. Hence, if they are not informed about the intermediate results, they choose a relatively lower effort in the scenario, where information revelation is always feasible. Principals, however, do not expect the agents to react differently in the two scenarios and do not adapt their decisions appropriately. Finally, we may disentangle behavior of agents being advantaged, i.e. agents having a head start, or disadvantaged, i.e. agents being behind, by the revealed intermediate difference. Although effort should be symmetric in equilibrium we find that advantaged agents tend to exert higher efforts than disadvantaged agents. Interestingly, principals misjudge the situation and expect exactly the opposite.

The paper is organized as follows: In the next section, the model is described and solved. Note that all formal proofs are relegated to Appendix A. Section 3 presents the setup of the experiment, the hypotheses tested as well as the experimental results. In Section 4, the paper's main results are summarized and shortly discussed. Finally, Section 5 concludes.

2. The model

2.1 Description of the model and notation

Consider a situation, in which two homogenous and risk-neutral agents, i=1, 2, compete in a tournament. The winner receives the winner prize $w_1 > 0$, while the loser prize is $w_2 < w_1$ and both prizes are exogenously given. Such competition is usually of a dynamic type, i.e. agents do not choose effort once, but rather repeatedly over a certain period of time. In this model, we focus on the end of such a dynamic tournament and ask, whether the principal is interested in releasing information about the agents' earlier performances in case she cannot commit to a certain feedback policy ex ante (at the beginning of the tournament).

To analyze this problem in the simplest way, we consider the final period of a dynamic tournament and assume the intermediate result before this period to be represented by a random variable θ that is distributed according to the pdf $f(\cdot)$.[3] Let $f(\cdot)$ have a full and bounded support B. The principal observes the realization of θ, the agents do not. Yet, with probability $p \in [0,1]$ the principal is unable to credibly communicate the information to the agents. This may be the case, if the information is "soft" (e.g. information from subjective evaluations of the agents) so that the principal is tempted to misrepresent it.[4] In this situation, the principal would always lie and announce the information that is most favorable to her. Accordingly, the agents would always ignore this information and the principal is just an inactive player. With probability $1 - p$, on the other hand, the information is "hard" so that the principal may decide to conceal it, but cannot announce a realization of θ different from its true realization. Formally, she then chooses a strategy, which maps the observed intermediate result into an announcement policy or message $m \in \{\theta, ni\}$. Here, $m=\theta$ means that she informs the agents about the intermediate result and $m=ni$ that she does not reveal her information. We assume that the agents do not know, whether the principal was unable or unwilling to reveal her information in case information is withheld. Therefore, they receive a signal $s \in \{\theta, n\}$, which either equals $s = \theta$ so that the agents learn the true realization of the intermediate result or $s = n$, in which case the agents learn that no information was revealed (for whatever reason). After having received the signal, the agents choose their final-period efforts $e_i \geq 0$. This means that each agent chooses a strategy $e_i(s)$, which maps the signal into an effort choice. Effort is costly to an agent and the costs are given by the increasing and convex function $C(e_i)$. This cost function satisfies $C(0) = 0$, $C'(0) = 0$ and $C'(e_i) = \infty$, for $e_i \to \infty$, where the last two conditions ensure that equilibrium effort is strictly positive, but finite. Efforts affect the (net) result of the final period, which is given by $z = e_1 - e_2 - \varepsilon$. The term ε is a random variable that follows the pdf $g(\cdot)$ ($G(\cdot)$ denotes the corresponding cdf). Further, assume the realization of ε to be independent of the realization of θ and $g(\theta)$ not to be constant over B.

After the final period, agent 1 is declared the tournament's winner and hence receives the winner prize, if $\theta + z > 0$. Otherwise, agent 2 wins the tournament. The agents choose their

---

[3] Note that θ may alternatively be interpreted as the degree of heterogeneity among agents due to different capabilities. Additionally, an uneven starting position could result from a situation where one agent is favored by his supervisor for some reason.

[4] Essentially, we assume the principal to be unable to commit to a truth-telling strategy. This is a quite sensible assumption, as we focus on feedback decisions under commitment problems.

efforts to maximize their expected income net of costs given the observed signal. The principal chooses her announcement policy so as to maximize the sum of efforts in the final period. As we are dealing with an extensive-form game of imperfect information, we use perfect Bayesian equilibrium as solution concept. Moreover, throughout the paper, we focus on the analysis of equilibria in pure strategies.

2.2   Solution to the model

The model is solved by backward induction. Therefore, we start by determining the agents' effort choices. Agent 1 chooses e_1 so as to maximize

$$
\begin{aligned}
EU_1 &= w_2 + E_\theta\big[Prob\{\theta + z > 0\}(w_1 - w_2) - C(e_1)\big|s\big] \\
&= w_2 + E_\theta\big[Prob\{\theta + z > 0\}\big|s\big](w_1 - w_2) - C(e_1) \\
&= w_2 + E_\theta\big[G(\theta + e_1 - e_2)\big|s\big](w_1 - w_2) - C(e_1)
\end{aligned}
\tag{1}
$$

Similarly, agent 2 maximizes

$$
EU_2 = w_2 + E_\theta\big[1 - G(\theta + e_1 - e_2)\big|s\big](w_1 - w_2) - C(e_2)
\tag{2}
$$

when choosing his effort. The first-order conditions to the two maximization-problems are given by[5]

$$
\frac{\partial EU_1}{\partial e_1} = E_\theta\big[g(\theta + e_1 - e_2)\big|s\big](w_1 - w_2) - C'(e_1) = 0
\tag{3}
$$

$$
\frac{\partial EU_2}{\partial e_2} = E_\theta\big[g(\theta + e_1 - e_2)\big|s\big](w_1 - w_2) - C'(e_2) = 0
\tag{4}
$$

It is easy to see that the equilibrium is symmetric, i.e. $e_1 = e_2 =: e$, and this symmetric solution is given by $E_\theta\big[g(\theta)\big|s\big](w_1 - w_2) = C'(e)$. Equilibrium effort is increasing in both, $(w_1 - w_2)$ and $E_\theta\big[g(\theta)\big|s\big]$. This is intuitive. A higher prize spread makes it more attractive to outperform the rival so that both agents choose to increase their effort. Further, $E_\theta\big[g(\theta)\big|s\big]$ is

---

[5] A sufficient condition for this first-order approach to be valid is that agent i's objective function is strictly concave in e_i. To ensure this, we assume that $C(\cdot)$ is sufficiently convex in the following.

a measure of the intensity of competition. If $E_\theta\big[g(\theta)\big|s\big]$ is rather high, the agents believe that, at the beginning of the final period, no one has a high head start. Accordingly, each has a realistic chance of winning the tournament and competition is quite intense. As a consequence, effort is relatively high. Similarly, in case of a low $E_\theta\big[g(\theta)\big|s\big]$, the intensity of competition and the agents' efforts are rather low.

Note that the principal can affect $E_\theta\big[g(\theta)\big|s\big]$ by trying to reveal information about θ. To analyze this possibility in detail, we now turn to the principal's optimal feedback policy and start with the following definition:

Definition 1: Let $B_1(B_2)$ denote the set of parameter realizations for θ, for which the principal chooses (not) to reveal her information, if she is able to. These sets form a partition of B, i.e. $B_1 \cup B_2 = B$ and $B_1 \cap B_2 = \varnothing$.

Making use of the definition, we characterize the principal's feedback policy by analyzing the equilibrium properties of the two sets B_1 and B_2. The following lemma provides a first step of this analysis:

Lemma 1: If B_2 contains an element $\breve{\theta}$, it must also contain all θ with $g(\theta) < g(\breve{\theta}).$[6]

The message of Lemma 1 is very intuitive: If, for a certain intermediate result, the principal does not want to reveal her information, the same must also hold for all results that are strictly worse in the sense that the agents would choose lower efforts given the information was public.

Before we continue with our equilibrium characterization, we introduce a case distinction. In the first case, we assume $p = 0$ so that the principal is always able to credibly communicate her information to the agents. Further, we introduce the following second definition:

Definition 2: Denote by (a) $\overline{\Theta}$ the set of (global) minimizers of $g(\theta)$ in B, (b) $\hat{\Theta}$ the set of (global) maximizers of $g(\theta)$ in B_2 and (c) $\widetilde{\Theta}$ the set of (global) minimizers of $g(\theta)$ in B_2.

Keeping this definition in mind, the following lemma can be derived.

---

[6] The proofs of Lemma 1 and 2 as well as Propositions 1 and 2 can be found in detail in Appendix A.

Lemma 2: Let $p = 0$. Then, in equilibrium, we have $g(\hat{\theta}) = g(\widetilde{\theta})$, for all $\hat{\theta} \in \hat{\Theta}$ and $\widetilde{\theta} \in \widetilde{\Theta}$.

Lemma 2 has an interesting implication. Given that the principal does not reveal her information, the agents would not change their behavior, if (somehow) they were able to get to know the exact value of θ. The intuition for this result is as follows: Let θ be such that the principal does not reveal her information. Then, the agents base their effort decision on the mean of $g(\theta)$ conditional on θ being an element of B_2. If $g(\theta)$ varies within B_2, this conditional mean is lower than $g(\theta)$, for at least one $\theta \in B_2$. Hence, for this θ-realization, the principal would gain from deviating and revealing her information. It directly follows that, in equilibrium, $g(\theta)$ must be constant, for all θ in the set B_2.

Combining Lemma 1 and Lemma 2, we directly obtain the following proposition:

Proposition 1: Let $p = 0$. If θ is such that $g(\theta) > g(\overline{\theta})$, for $\overline{\theta} \in \overline{\Theta}$, the principal always reveals her information. Otherwise, she is indifferent between doing and not doing so.

Proposition 1 implies that the agents always get to know the principal's information, if $p = 0$ and the principal cannot commit to a "no-feedback strategy" ex ante. In other words, the principal is always interested in providing full feedback (either directly by always revealing her information or indirectly by revealing her information unless the least favorable observation has been made).

The result in Proposition 1 seems to be rather extreme. We, therefore, want to analyze, whether it continues to hold, if p is strictly positive. As the following proposition shows, this is not the case.

Proposition 2: Let $p > 0$. Then, there is a cut-off value for $g(\theta)$, denoted by $\hat{g}$, with $g(\overline{\theta}) < \hat{g} < E_{\theta}[g(\theta)]$, for $\overline{\theta} \in \overline{\Theta}$, such that the principal reveals (conceals, is indifferent between revealing and concealing) her information, if $g(\theta) > (<, =)\hat{g}$.

The main difference between Propositions 1 and 2 is the following: In the first scenario, the agents know, whether or not the principal was interested in revealing her information. If then the principal does not communicate her information, the agents interpret this as "bad" news. Hence, they expect one of them to have an extremely high head start and, therefore, choose a

very low effort. Consequently, the principal always reveals her information (unless the worst situation has occurred, in which case she is indifferent between revealing and concealing her information).

In the second scenario, the agents do not know, whether the principal was unwilling or unable to reveal her information. If, in this case, the principal observes a quite uneven intermediate result, she may decide not to reveal her information and claim that she is not *able* to communicate it. In fact, the principal sometimes makes use of this possibility and conceals her information in highly uneven situations.

3. The Experiment

3.1 Experimental Design

The experiment was conducted at the Cologne Laboratory for Economic Research in April 2007. All sessions were computerized using the experimental software z-Tree (Fischbacher 1999). We had three sessions for each of the two treatments - the *Cred*-treatment, where the principal was always able to credibly communicate her information (i.e. $p = 0$) and the *No-Cred*-treatment, where we imposed $p = 2/3$. In each session, 30 students of different disciplines were involved in the experiment: 20 took part as agents and 10 as principals. As every candidate was only allowed to participate in one session, in total 180 students participated in the experiment. A session consisted of 9 identical rounds and lasted for about 90 minutes.

At the beginning of each session, the instructions were handed out and read aloud by the experimenter.[7] Thereafter, the participants were seated in cubicles. The assignment to the cubicles was done by drawing cards. Each cubicle and, accordingly, each subject was anonymously assigned a role as principal or agent, which she/he kept for the entire experiment. In each round of the experiment, 10 groups consisting of one principal and two agents were formed. This matching process was organized such that no participant could meet another participant twice.

In the experiment, each agent's performance (in a given round) was evaluated according to his output which we denoted by "result" $y_i = \theta_i + e_i + \varepsilon_i$, i.e. the agent with the higher value for y_i was declared the winner of the tournament. In this context, θ_i denotes a "starting number" and ε_i an additional "random number" that were assigned to agent *i*. Note that this representation is equivalent to the representation in Section 2, with $\theta := \theta_1 - \theta_2$ and $\varepsilon := \varepsilon_2 - \varepsilon_1$. Dur-

---

[7] A translation of the instruction sheet can be found in Appendix B. Original instructions in German are available from the authors upon request.

ing the experiment we denoted the expression for the output excluding the starting number, $y_i^p = e_i + \varepsilon_i$, as agent i's "preliminary result".

At the beginning of each round, the agents were assigned their starting numbers, which were randomly drawn by the computer. In particular, one (randomly selected) agent in each group was assigned a starting number of 0. The other agent's starting number in this group was either 0, 20, 40, 60, or 80, each realized with a probability of 0.2. As $\theta := \theta_1 - \theta_2$, we have feasible differences between starting numbers of $\theta \in \{-80, -60, -40, -20, 0, 20, 40, 60, 80\}$, with $Prob\{\theta = 0\} = 0.2$ and $Prob\{\theta = k\} = 0.1$, for all other $k \neq 0$.[8]

Each principal got to know the starting numbers of both agents belonging to her group, while the agents did not receive any information in the beginning of the round. The principal could then decide to reveal the information to the agents. In the *Cred*-treatment, the principal's decision to reveal or conceal the information was always carried out and the agents were naturally informed about the principal's decision. In the *NoCred*-treatment, on the other hand, the corresponding decision of the principal was followed by a move of nature. If the principal decided to inform the agents about the starting differences, the move of nature determined afterwards whether this was actually possible. With probability 1/3 the principal was able to reveal her information, with probability 2/3 she was not. After the move of nature, the agents were informed about their starting numbers or not. In the latter case, they did not know whether the starting numbers were intentionally concealed by the principal or whether the principal was willing to reveal the information, but unable to inform the agents. In a next step, the subjects had to submit a belief concerning the behavior of the group member(s) in the other role. Accordingly, the principal had to express a conjecture concerning the agents' effort choices given the realization of the specific starting numbers in this round, i.e. the principal had to state each agent's expected effort given that he or she was advantaged or disadvantaged by the realization of the starting numbers to a certain extent.

---

[8] In contrast to the model in Section 2, we assume θ to be discrete here. This is innocuous, as all results from the previous section hold for a discrete θ as well.
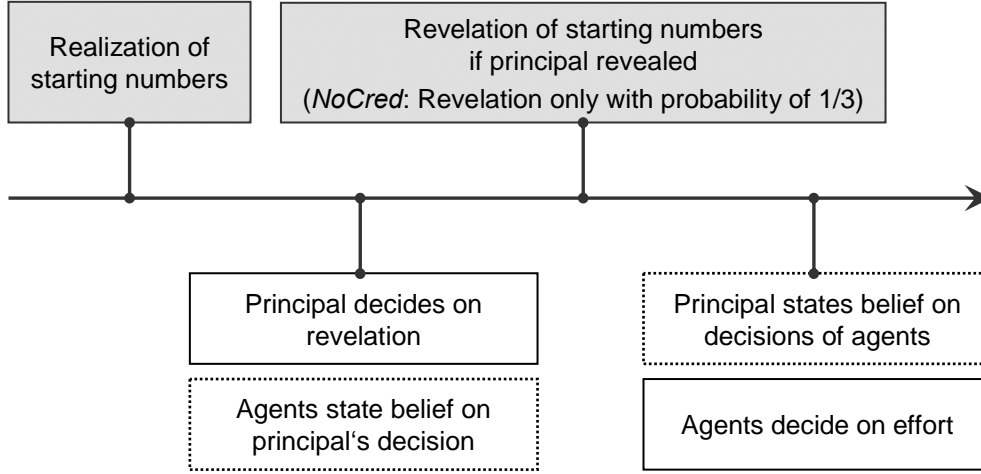
Figure 1: Sequence of decisions

While the principal decided on the revelation of the starting numbers the agents had to speculate, for which of the five differences of starting numbers (0, 20, 40, 60, 80)[9] the principal would reveal her information and for which she would not (see also Figure 1). Thereafter, they had to choose an integer between 0 and 100 reflecting their effort choice incurring costs of $C(e_i) = \frac{1}{12}(e_i)^2$. Payoffs and costs were measured in the fictitious experimental currency "Taler". The instructions sheet included a table with a full overview of the costs regarding each feasible decision. Following the effort choices, the computer determined the realization of ε_1 and ε_2. Both these random numbers were independently and individually drawn from $\{-50, -49, ..., 0, ..., 49, 50\}$ for each agent in each round. Every number from this set was equally likely to be drawn, hence the random numbers approximately follow a uniform distribution on $[-50, 50]$.[10] As $\varepsilon := \varepsilon_2 - \varepsilon_1$, the composed random variable ε approximately follows a triangular distribution with support $[-100, 100]$, which means that $g(\cdot)$ is given by

$$(5) \qquad g(\theta + e_1 - e_2) = \begin{cases} \dfrac{1}{100} + \dfrac{\theta + e_1 - e_2}{10,000} & \text{for } -100 \leq \theta + e_1 - e_2 \leq 0 \\[2mm] \dfrac{1}{100} - \dfrac{\theta + e_1 - e_2}{10,000} & \text{for } 0 \leq \theta + e_1 - e_2 \leq 100 \\[2mm] 0 & \text{otherwise} \end{cases}$$

---

[9] Note that we decided to give starting differences as absolute amounts $|\theta|$, such that only five differences were feasible to facilitate the situation for the participants.

[10] Notice that Propositions 1 and 2 hold for discrete random variables ε_1 and ε_2, too. The approximation by a continuous distribution is, thus, only made to simplify the following analysis.

Finally, the subjects' payoffs were determined. The principal's payment was equal to the sum of the two agents' outputs y_i^p excluding the starting numbers, i.e. the sum of the "preliminary results".[11] Moreover, she obtained a bonus of 50 Taler for every correct effort conjecture. For every unit that her conjecture deviated from the actual effort, the bonus was reduced by 1 Taler, but could not become negative.

The agent winning the tournament, i.e. the agent with the higher output y_i received a prize of $w_1 = 1{,}800$, while the loser prize was set to $w_2 = 800$. Further, the agents were rewarded for correct beliefs, too. If an agent correctly anticipated the principal's decision for the *actually drawn* difference in starting numbers, he received an additional bonus of 100 (and nothing otherwise).

After each round, the principal was informed about the agents' preliminary results, the results and her own payoff resulting from the agents' effort decisions in the tournament. Similarly, the agents were informed about the realization of both agents' starting numbers – also if the principal or nature had decided not to reveal the starting numbers in this round – whether or not they had won the tournament and their own payoff, i.e. the winner or loser prize reduced by the effort costs. Note that the agents were not informed about the principal's decision in the *NoCred*-treatment if the starting numbers were not revealed to them such that they could not infer whether this was due to the principal's decision or nature. After the final round, all participants (principals and agents) were additionally informed about the sum of their bonus payments resulting from the beliefs in each round.

At the end of the experiment, payoffs were converted into Euro at an exchange rate of 1,000 Taler per 1 Euro. All subjects were paid anonymously.

Note that we assume specific functional forms in the experiment. Therefore, we are able to derive closed-form solutions for the equilibrium efforts. Using (3), (4) and $C(e_i) = \frac{1}{12}(e_i)^2$, it is easy to see that the optimal effort simplifies to[12]

---

[11] We do not include the starting number into the payoff function of the principal as we want to avoid that the principal benefits from the realization of a high starting difference which could then distort the agents' effort decisions.

[12] Agent 1's objective function is strictly concave in e_1, if $\dfrac{\partial EU_1^2}{\partial^2 e_1} = E_\theta\big[g'(\theta + e_1 - e_2)|s\big](w_1 - w_2) - C''(e_1) < 0$.

In our example, this condition simplifies to $1{,}000 E_\theta\big[g'(\theta + e_1 - e_2)|s\big] - 1/6 < 0$. As $g'(\theta + e_1 - e_2) \le 1/10{,}000$ (see (5)), this condition is always fulfilled. The same is true for the second agent. This implies that the two agents' objective functions are strictly concave so that the effort given by (6) is indeed optimal.

$$
\begin{aligned}
(6) \quad e &= 6 \cdot E_\theta\big[g(\theta)\big|s\big](w_1 - w_2) \\
&= 6{,}000 \cdot E_\theta\big[g(\theta)\big|s\big]
\end{aligned}
$$

It is important to note that the equilibrium effort of each agent only depends on the size of the starting difference and that efforts are symmetric in equilibrium although one agent is advantaged and the other is disadvantaged by the starting difference.

In the *Cred*-treatment, the principal is always able to credibly communicate her information (i.e. $p = 0$). The optimal efforts directly follow from (5) and (6) (see also Table 1).

Table 1: Theoretical predictions based on parameters of experimental design

		Realization of starting differences $|\theta|$				
		0	20	40	60	80
Principal's decision in equilibrium	*Cred*	reveal	reveal	reveal	reveal	indifferent
	NoCred	reveal	reveal	reveal	conceal	conceal
Agent's decision in equilibrium if starting numbers are known	*Cred*	60	48	36	24	12
	NoCred					
Agent's decision in equilibrium if starting numbers are unknown	*Cred*			12		
	NoCred			30		

In the *NoCred*-treatment, we imposed $p = 2/3$. Here, we can show that the principal conceals her information if $|\theta| = 80$ and $|\theta| = 60$, while in all other situations she is interested in revealing it. To see this, assume the principal to use this strategy: If the agents are not informed about θ, they choose effort $e_{NC}^*(n) = 1/3\,\dfrac{(12 + 24)}{2} + 2/3 \cdot \dfrac{(12 + 24 + 36 + 48 + 60)}{5} = 30$. Then, it is straightforward to check that the principal's strategy is a best response to the agents' strategies and vice versa. It remains to be shown that there is no other equilibrium. To show this, assume the principal to also conceal $|\theta| = 40$. This implies the agent's effort $e_{NC}^*(n)$ to change to $e_{NC}'(n) = 1/3\,\dfrac{(12 + 24 + 36)}{3} + 2/3 \cdot \dfrac{(12 + 24 + 36 + 48 + 60)}{5} = 32$. It directly follows that the principal would then prefer to deviate and reveal $|\theta| = 40$, as this would yield an increase in effort. Similarly, we can eliminate all other equilibrium candidates.

Altogether, the agents choose the same efforts in both treatments, if they are informed about θ. Otherwise, the efforts differ and are given by $e_C^*(n) = 12$ and $e_{NC}^*(n) = 30$.

3.2 Hypotheses

Our hypotheses directly follow from our theoretical model derived in Section 2 as well as its parameterization outlined in the last subsection (see Table 1). We derive hypotheses regarding each treatment and describe the resulting differences between both treatments. The first two hypotheses refer to the principal's decision as well as the agents' decisions in each round.

HYPOTHESIS 1 – DECISION OF PRINCIPAL:

    a. In the *Cred*-treatment, the principal always reveals the starting difference except for the largest starting difference of $|\theta| = 80$.

    b. In the *NoCred*-treatment, the principal always reveals the starting difference except for the two largest starting differences of $|\theta| = 60$ and $|\theta| = 80$.

Note that it follows from the above hypothesis that the principal should reveal the second largest starting difference of $|\theta| = 60$ more often in *Cred* than in *NoCred*. As the principal is indifferent between revealing and not revealing the largest starting difference in *Cred* we might expect that she will also more often reveal $|\theta| = 80$ in *Cred*.

Remember that the equilibrium efforts of agents are symmetric and only depend on the size of the starting difference given as an absolute amount (if revealed) which is reflected by hypothesis 2 on the decisions of the agents (see also Table 1). If the starting difference is not revealed to the agents we conjecture that they make an assumption on the realization of the starting difference and derive their effort decision accordingly. This assumption is based on the principal's behavior in equilibrium as well as the realization of the random move in *No-Cred*.

HYPOTHESIS 2 – DECISION OF AGENT:

    a. If the agents learn the starting difference effort is exerted according to the theoretic prediction (i.e. $e^*(|\theta| = 0) = 60$, $e^*(|\theta| = 20) = 48$, $e^*(|\theta| = 40) = 36$, $e^*(|\theta| = 60) = 24$, $e^*(|\theta| = 80) = 12$). This holds in *both* treatments.

    b. If, in the *Cred*-treatment, the agents do not learn the starting difference, effort is based on the assumption that the starting difference is maximal, i.e. $e_C^*(n) = 12$.

    c. If, in the *NoCred*-treatment, the agents do not learn the starting difference, the corresponding effort is $e_{NC}^*(n) = 30$.

From hypothesis 2b and 2c it follows that average effort should be higher in *NoCred* than in *Cred* if the starting difference is not revealed to the agents.

Each type of player was also asked to state her/his beliefs about the participants in the other role in each round. Thus, our next hypotheses refer to the subjects' beliefs. The conjectured beliefs are in line with the above hypotheses on each participant's decision. Thus, the expected effort for an unknown starting difference should be higher in *NoCred* than in *Cred*.

HYPOTHESIS 3 – BELIEF OF PRINCIPAL:

    a. If the agents learn the starting difference, the principal expects them to choose effort according to the theoretical prediction (i.e. $e^*(|\theta|=0)=60$, $e^*(|\theta|=20)=48$, $e^*(|\theta|=40)=36$, $e^*(|\theta|=60)=24$, $e^*(|\theta|=80)=12$). This holds in *both* treatments.

    b. If, in the *Cred*-treatment, the agents do not learn the starting difference, the principal expects them to choose $e_C^*(n)=12$.

    c. If, in the *NoCred*-treatment, the agents do not learn the starting difference, the principal expects them to choose $e_{NC}^*(n)=30$.

The beliefs of the agents are in line with the hypothesis on the principal's decision, which has been derived before. The agents should expect the principal to reveal the starting difference more often in *Cred* than in *NoCred* in case of the second largest starting difference and probably also the largest difference.

HYPOTHESIS 4 – BELIEF OF AGENT:

    a. In the *Cred*-treatment, the agents expect the principal to always reveal the starting difference except for the largest starting difference $|\theta|=80$.

    b. In the *NoCred*-treatment, the agents expect the principal to always reveal the starting difference except for the two largest starting differences $|\theta|=60$ and $|\theta|=80$.

From the agents' perspective the revelation of the starting difference induces some degree of heterogeneity among agents as one agent is favored in the form of a head start and the other agent is handicapped. According to our theoretic prediction efforts should be symmetric in equilibrium. Other experimental studies, however, indicate that the effort of advantaged agents tends to be higher than that of disadvantaged agents (see Schotter & Weigelt 1992). It seems, therefore, interesting to disentangle the behavior of advantaged and disadvantaged agents regarding actual effort choices and also the principals' beliefs.

HYPOTHESIS 5 – EFFECT OF DISCRIMINATION OF AGENTS:

    a. Effort exerted by the agents is symmetric and does not differ between agents being advantaged or disadvantaged by the realization of the revealed starting difference.

b. Principals expect the agents' efforts to be symmetric such that effort choices of agents being advantaged or disadvantaged by the realization of the revealed starting difference do not differ.

3.3   Results

The statistical analysis will be guided by the above hypotheses based on our theoretic predictions. We will complement the analysis of each treatment by a comparison of both treatments.

3.3.1 Decision of Principal

An overview of the average tendency of each principal to reveal the starting difference to the agents is depicted by Figure 2. It seems obvious that the principal decides to reveal lower starting differences more often than higher starting differences.
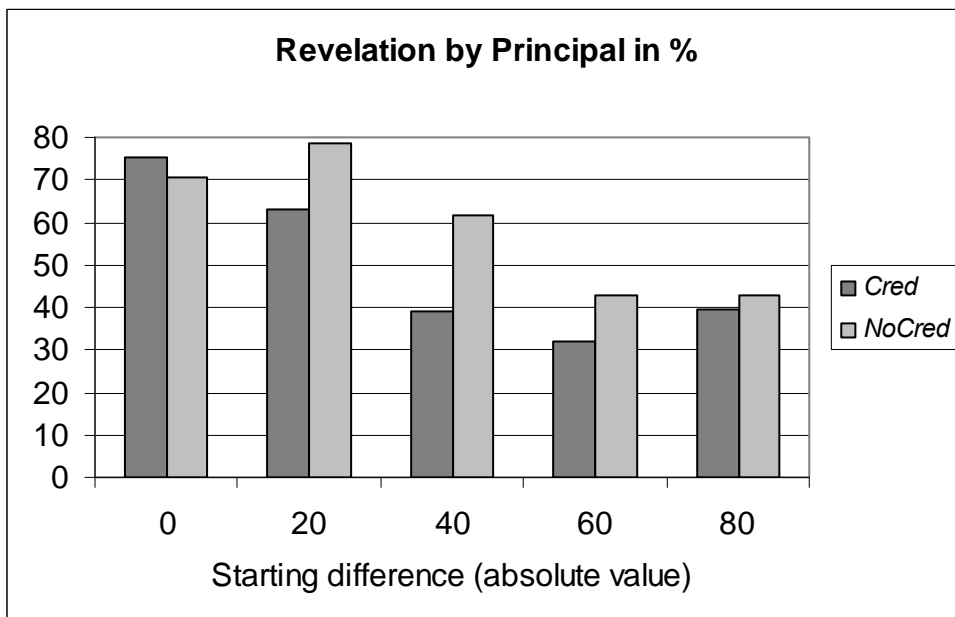

Figure 2: Revelation by principal in % for each starting difference

Table 2 supplies the average tendency of each principal to reveal the starting difference and shows whether the principals decide to reveal each starting difference significantly more often than not by applying the Binomial Test. Averages already indicate that the principal does not always choose to reveal the starting difference for the differences conjectured above but seems to show a decreasing tendency to reveal the differences if they are becoming larger. We find that in both treatments the smallest starting differences tend to be revealed while, additionally, in *Cred* the two largest differences tend to be concealed (see results of Binomial Test in Table 2).

Table 2: Average percentage of revelation per principal

	Realization of starting differences $|\theta|$				
	0	20	40	60	80
Cred	75.48^{+++}	62.93^{++}	39.10	31.88^{--}	39.51^{-}
NoCred	70.51^{+++}	78.74^{+++}	61.67	42.90	42.71
Mann-Whitney U test (one-tailed)	ns	$\alpha = 0.075$	$\alpha = 0.029$	ns	ns

By using the Binomial Test (one-tailed) we state the level of significance at which the null hypothesis can be rejected in favor of the alternative hypothesis that the starting difference is more often revealed than not (+) respectively less often revealed than revealed (−):

+	*weakly significant:*	$0.05 < \alpha \leq 0.10$	−	*weakly significant:*	$0.05 < \alpha \leq 0.10$	
++	*significant:*	$0.01 < \alpha \leq 0.05$	−−	*significant:*	$0.01 < \alpha \leq 0.05$	
+++	*highly significant:*	$\alpha \leq 0.01$	−−−	*highly significant:*	$\alpha \leq 0.01$	

To support these first results we ran probit regressions described by Table 3 below and used the decision of the principal as a dummy variable explained either by the absolute amount of the five starting differences (regressions (1) and (3)) or by binary variables for each of the starting difference being 1 for the realization of a certain starting difference and 0 otherwise (regressions (2) and (4)).

Table 3: Probit regressions[13] with principal's decision as dependent variable (revelation = 1, no revelation = 0) and robust standard errors over subjects

	Cred		*NoCred*	
	(1)	(2)	(3)	(4)
Startingdifference	-0.0123*** (0.0031)		-0.0105** (0.0043)	
Difference0		0.845*** (0.21)		0.669** (0.33)
Difference20		0.655** (0.28)		0.938*** (0.32)
Difference40		0.127 (0.19)		0.379 (0.35)
Difference60		-0.159 (0.22)		0.223 (0.22)
Constant	0.524*** (0.16)	-0.272 (0.17)	0.686*** (0.20)	-0.180 (0.24)
Observations	270	270	270	270

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

---

[13] We also used fixed effects regressions to check the robustness of our results with the principal's decision as a dependent variable; the same coefficients as shown in Table 3 are significant.

We find that obviously the principals' tendency to reveal significantly increases with a decreasing starting difference. Moreover, principals significantly more often reveal the two smallest starting differences compared to the largest starting difference $|\theta| = 80$ which is in line with our above observations.

We can summarize these results by describing the observations on our first hypothesis:

OBSERVATION ON HYPOTHESIS 1a and 1b: In both treatments, the principal shows a decreasing tendency to reveal the starting difference if the difference increases. The principal tends to reveal the two smallest starting differences of $|\theta| = 0$ and $|\theta| = 20$ and reveals them significantly more often than the largest starting difference of $|\theta| = 80$. The two largest starting differences $|\theta| = 60$ and $|\theta| = 80$ tend not to be revealed in *Cred*.

Comparing the average tendency to reveal the starting difference per principal between both treatments by using the Mann-Whitney U test (see also Table 2) we find that the principal neither reveals the second largest starting difference of $|\theta| = 60$ nor the largest starting difference of $|\theta| = 80$ more often in the *Cred*-treatment than in the *NoCred*-treatment. Although our hypotheses can only partly be confirmed we may state that the principals in both treatments seem to understand that it is beneficial to reveal rather low starting differences.

We also checked whether the principals' decisions change over rounds, e.g. whether principals learn to reveal the starting difference more often in later rounds. However, we find no indication for a systematic change in the principals' behavior.[14]

3.3.2 Decision of Agent

The average effort of each agent for each revealed starting difference and also for the situation of an unknown starting difference is depicted by Figure 3.

---

[14] We checked for a trend over rounds by including the number of the period in the regressions reported in Table 3. Moreover, we ran separate regressions including the period as independent variable for the revelation of each starting difference as dependent variable. Finally, we also checked for the significance of the Spearman Rank correlation coefficient.
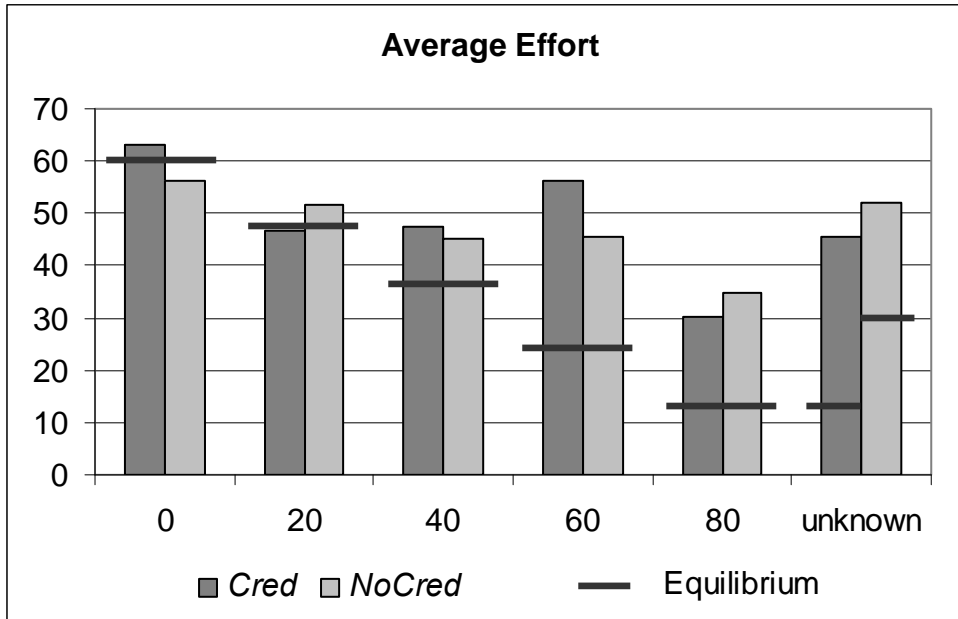
Figure 3: Average effort per starting difference (absolute value) revealed and if unknown

Table 4 provides an overview of the average efforts of each agent compared to the theoretic prediction for each starting difference. While the average efforts seem to be well in line with the theoretic prediction regarding the two smallest starting differences they seem to be above the prediction for larger differences and particularly for unknown differences. By using the Binomial Test we may statistically test whether the average efforts per agent are more often below or above the equilibrium prediction. The results are given in Table 4 and confirm our first impression.

Table 4: Average effort of agents per starting difference and if unknown

		Realization of starting differences $|\theta|$					
		0	20	40	60	80	$|\theta|$ unknown
Cred	Average effort	63.15	46.66	47.37	56.09[++]	30.35[++]	45.62[+++]
	Equilibrium	60	48	36	24	12	12
NoCred	Average effort	56.16	51.49[++]	45.00	45.33[+++]	34.82[++]	51.95[+++]
	Equilibrium	60	48	36	24	12	30
Mann-Whitney U test (one-tailed)		ns	ns	ns	ns	ns	$\alpha = 0.062$

By using the Binomial Test (one-tailed) we state the level of significance at which the null hypothesis can be rejected in favor of the alternative hypothesis that the average effort per agent is more often above the equilibrium prediction than below:

+	*weakly significant:*	$0.05 < \alpha \leq 0.10$
++	*significant:*	$0.01 < \alpha \leq 0.05$
+++	*highly significant:*	$\alpha \leq 0.01$

Although average efforts obviously deviate from the theoretic prediction – particularly for large starting differences – we find that they are qualitatively in line with theory as effort in-

creases with a decreasing starting difference revealed. This is confirmed by running regressions using effort as dependent variable and the starting difference in absolute amount as independent variable (see Table 5).

Table 5: Regressions[15] with effort as dependent variable, robust standard errors over subjects

	Cred		NoCred	
	(1)	(2)	(3)	(4)
Startingdifference	-0.273***		-0.259**	
	(0.075)		(0.099)	
Rev_difference0		13.18***		4.556
		(4.86)		(6.34)
Rev_difference20		0.0149		-1.538
		(4.66)		(5.84)
Rev_difference40		-1.676		-8.626
		(5.86)		(6.96)
Rev_difference60		6.250		-5.069
		(8.67)		(6.90)
Rev_difference80		-14.53**		-19.90***
		(5.80)		(6.68)
Constant	58.43***	47.85***	56.75***	52.44***
	(3.37)	(3.93)	(5.65)	(2.39)
Observations	280	540	130	540
R-squared	0.05	0.05	0.05	0.03

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Moreover, particularly the comparison of the average effort exerted in case of an unknown starting difference with the average efforts exerted for the different starting differences revealed seems important to analyze. We, therefore, ran regressions (2) and (4) summarized by Table 5 using dummy variables for the different starting differences revealed, e.g. Rev_difference0 equals 1 for a revealed starting difference of $|\theta| = 0$ and 0 otherwise. Thus, we may analyze the effect of the revelation of each starting difference compared to an unknown starting difference. We find for both treatments that the effort in case of the largest starting difference is significantly smaller than if the starting difference is not revealed. Thus, one could conclude that in both treatments the largest starting difference of $|\theta| = 80$ should not be revealed by the principal. Moreover, we find that it is beneficial for the principal to reveal the smallest starting difference of $|\theta| = 0$ in *Cred* as effort is significantly larger than in

---

[15] Again, we used fixed effects regressions with the agents' decisions as a dependent variable, too; the same coefficients as shown in Table 5 are significant. Additionally, the revelation of a starting difference of $|\theta| = 40$ turns out to have a significantly negative effect on effort in *NoCred* compared to the case of non-revelation.

case of an unknown starting difference.

Again, we also checked for a change of behavior over rounds and do not find any indication for a trend of efforts exerted.

We may summarize our findings by describing our observations on hypothesis 2:

> **OBSERVATION ON HYPOTHESIS 2a:** Average effort is significantly decreasing with an increasing starting difference revealed in both treatments. Moreover, in both treatments effort is significantly lower for the largest difference of $|\theta| = 80$ if revealed than for an unknown difference (and higher for the lowest difference in *Cred*). If the agents learn the starting difference effort is significantly higher than theoretically predicted for the two largest starting differences $|\theta| = 60$ and $|\theta| = 80$ and, additionally, for $|\theta| = 20$ in *NoCred*.

> **OBSERVATION ON HYPOTHESIS 2b and 2c:** In both treatments effort is significantly higher than theoretically predicted if the agents do not learn the starting difference.

Both average efforts for the situation of an unknown starting difference are much higher than theoretically predicted but their comparison yields a result which is qualitatively in line with theory as effort in *NoCred* is significantly higher than in *Cred* for unknown differences (see Table 4). Note that there is no significant difference between average efforts for each revealed starting difference between both treatments as predicted by theory.

3.3.3 Belief of Principal

We also elicited the subjects' beliefs regarding other participants' behavior to shed some light on potential motives for the actual decisions made. The principal has to state in each round which effort she expects from each of the two agents. Figure 4 provides a first overview of the principal's beliefs.
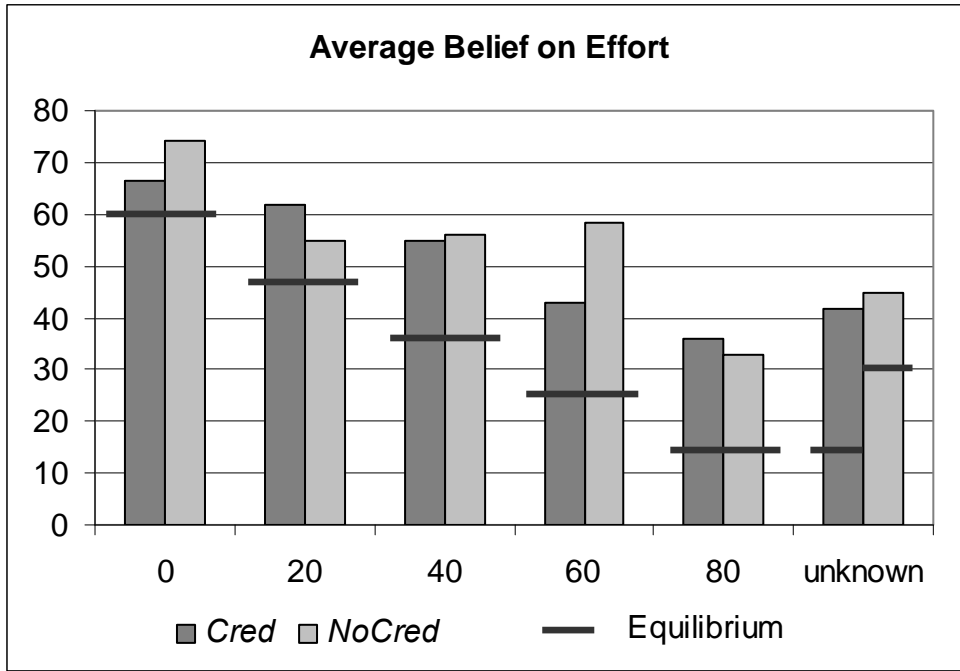
Figure 4: Average effort expected by principal per starting difference (absolute value) revealed and if unknown to agents

We hypothesized that the principal's beliefs are also in line with our theoretic prediction. Table 6 summarizes the average beliefs as well as the results of non-parametric testing. Similar to average efforts described before average expected efforts seem to be above the equilibrium prediction which is again more pronounced for large starting differences and an unknown starting difference. The results of the Binomial Test given in Table 6 are in line with this impression.

Table 6: Average effort expected by principal per starting difference and if unknown

		Realization of starting differences $|\theta|$					
		0	20	40	60	80	$|\theta|$ unknown
Cred	Average effort	66.28[+]	61.96	54.74[+]	43.09	35.81[+++]	41.78[+++]
	Equilibrium	60	48	36	24	12	12
NoCred	Average effort	74.25	54.89	55.91[+++]	58.27[+++]	32.69[+]	45.00[+++]
	Equilibrium	60	48	36	24	12	30
Mann-Whitney U test (one-tailed)		ns	ns	ns	ns	ns	ns

By using the Binomial Test (one-tailed) we state the level of significance at which the null hypothesis can be rejected in favor of the alternative hypothesis that the average belief on effort per principal is more often above the equilibrium prediction than below:

+	*weakly significant:*	$0.05 < \alpha \le 0.10$
++	*significant:*	$0.01 < \alpha \le 0.05$
+++	*highly significant:*	$\alpha \le 0.01$

We also ran regressions using the principal's beliefs regarding average effort in each round as dependent variable (see Table 7). The results show that the effort expected by the principal

seems to decrease with an increasing starting difference (regressions (1) and (3)) which is in line with actual effort choices by the agents and also with our theoretic prediction.

Table 7: Regressions[16] with expected effort as dependent variable, robust standard errors over subjects

	Cred		NoCred	
	(1)	(2)	(3)	(4)
Startingdifference	-0.405***		-0.394***	
	(0.087)		(0.080)	
Rev_difference0		27.14***		28.61***
		(5.32)		(5.89)
Rev_difference20		14.85**		9.432*
		(6.20)		(5.07)
Rev_difference40		11.44		10.72
		(7.68)		(8.67)
Rev_difference60		-1.049		11.43*
		(7.90)		(6.67)
Rev_difference80		-5.379		-12.65***
		(5.56)		(4.57)
Constant	67.70***	42.02***	70.19***	45.19***
	(4.22)	(3.38)	(4.88)	(2.80)
Observations	140	270	65	270
R-squared	0.20	0.19	0.22	0.13

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Analyzing the effect of the revelation of each starting difference compared with an unknown difference by including dummy variables for each difference revealed (regressions (2) and (4)) we find that the expected effort is significantly higher for the two smallest starting difference than for an unknown starting difference in both treatments. Moreover, in *NoCred* expected effort is weakly significantly higher for a starting difference of $|\theta| = 60$ and significantly lower for the largest difference than for an unknown starting difference. Thus, one may conclude that – based on the principal's beliefs – the principal should always reveal the two smallest starting differences; in *NoCred* she should also reveal the second largest and never reveal the largest starting difference. Thus, we may summarize the findings on hypothesis 3:

---

[16] Again, we checked for the robustness of our results by running fixed effects regressions with the principals' expectations as a dependent variable; the same coefficients as shown in Table 7 are significant. Additionally, the revelation of a starting difference of $|\theta| = 40$ has a significantly positive effect on the expectation regarding effort in *Cred* compared to the case of non-revelation.

OBSERVATION ON HYPOTHESIS 3a: Average expected effort is significantly decreasing with an increasing starting difference revealed in both treatments. Moreover, in both treatments expected effort is significantly higher for the two smallest differences of $|\theta| = 0$ and $|\theta| = 20$ if revealed than for an unknown difference. In *NoCred* the expected effort is higher for $|\theta| = 60$ and lower for $|\theta| = 80$ than for an unknown starting difference. If the agents learn the starting difference, the principal expects them to choose efforts that are significantly above the theoretic prediction for the starting differences $|\theta| = 80$, $|\theta| = 40$ and $|\theta| = 0$ in *Cred* and for the starting differences $|\theta| = 80$, $|\theta| = 60$ and $|\theta| = 40$ in *No-Cred*.

OBSERVATION ON HYPOTHESIS 3b and 3c: If the agents do not learn the starting difference, the principal expects them to choose efforts which are significantly more often above the equilibrium prediction than below in both treatments.

Comparing both treatments regarding the principal's beliefs by applying the Mann-Whitney U test we find no significant difference. The comparison of the average efforts expected with the actual effort choices for each starting difference revealed and unrevealed yields some significant differences: The expected effort is significantly higher in *Cred* for $|\theta| = 20$ ($\alpha = 0.035$, Mann-Whitney U test, two-tailed) and, interestingly, if the difference is not revealed the actual effort is significantly higher than expected in *NoCred* ($\alpha = 0.083$, Mann-Whitney U test, two-tailed). Moreover, we find no indication for a change of behavior over rounds.

3.3.4 Belief of Agent

The agents were asked to state their belief regarding the decision of the principal in each round, i.e. they had to state whether they expected the principal to reveal the starting difference for each possible realization of the starting difference. Figure 5 depicts the average expectations per agent.
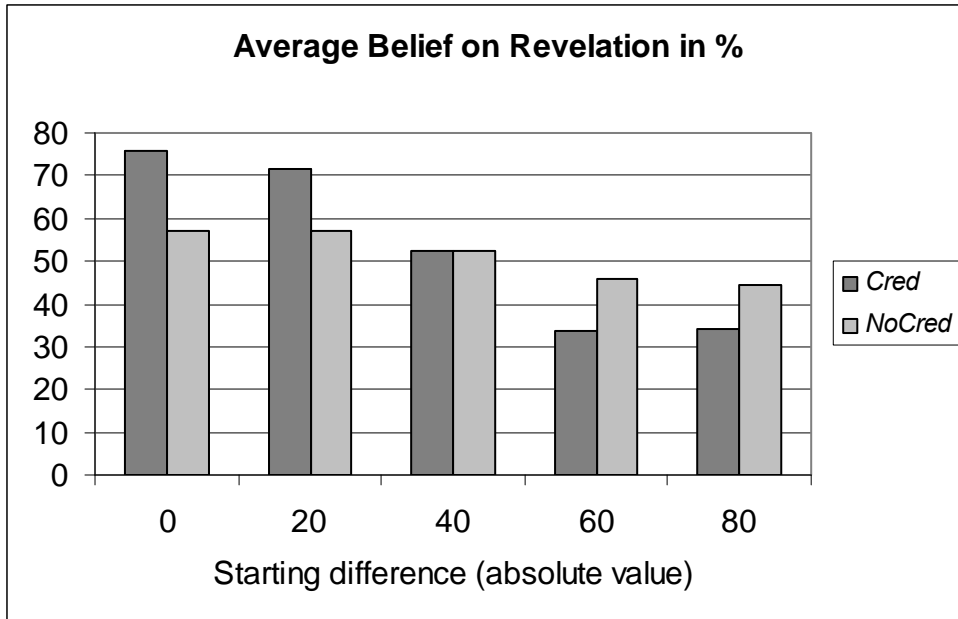
Figure 5: Average belief on revelation of starting difference in %

Table 8 provides an overview of averages and an indication of whether differences are revealed or not (see results of Binomial Test). Averages indicate that rather small starting differences are expected to be revealed which is confirmed by the Binomial Test. Moreover, it seems as if expectations are more extreme for particularly small and large starting differences in *Cred* than in *NoCred*.

Table 8: Average percentage of agents' beliefs regarding the information revelation

	Realization of starting differences $|\theta|$				
	0	20	40	60	80
Cred	75.56^{+++}	71.67^{+++}	52.22	33.52^{---}	34.07^{---}
NoCred	57.22^{+++}	56.85^{+++}	52.41	45.93^{---}	44.63^{---}
Mann-Whitney U test (one-tailed)	$\alpha = 0.002$	$\alpha = 0.013$	ns	$\alpha = 0.051$	$\alpha = 0.050$

By using the Binomial Test (one-tailed) we state the level of significance at which the null hypothesis can be rejected in favor of the alternative hypothesis that the starting difference is expected to be more often revealed than not (+) respectively less often revealed than revealed (–):

+	*weakly significant:*	$0.05 < \alpha \le 0.10$	–	*weakly significant:*	$0.05 < \alpha \le 0.10$
++	*significant:*	$0.01 < \alpha \le 0.05$	– –	*significant:*	$0.01 < \alpha \le 0.05$
+++	*highly significant:*	$\alpha \le 0.01$	– – –	*highly significant:*	$\alpha \le 0.01$

Running probit regressions (see Table 9) we find that the agents' expectation that the principal reveals the starting difference is increasing with a decreasing starting difference (regressions (1) and (3)). Furthermore, they significantly more often expect the three smallest starting differences to be revealed than the largest starting difference in both treatments (regres-

sions (2) and (4)) which is roughly in line with the theoretic prediction. Checking for a change of behavior over rounds yields no significant result.

Table 9: Probit regressions[17] with agent's belief as dependent variable (if revelation = 1, no revelation = 0) and robust standard errors over subjects

	Cred		NoCred	
	(1)	(2)	(3)	(4)
Startingdifference	-0.0161***		-0.00455*	
	(0.0028)		(0.0025)	
Difference0		1.103***		0.317*
		(0.20)		(0.17)
Difference20		0.983***		0.308*
		(0.18)		(0.16)
Difference40		0.466***		0.195**
		(0.14)		(0.099)
Difference60		-0.0152		0.0327
		(0.060)		(0.025)
Constant	0.738***	-0.410***	0.217*	-0.135
	(0.12)	(0.13)	(0.13)	(0.12)
Observations	2700	2700	2700	2700

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Thus, we can summarize the results regarding Hypothesis 4 as follows:

OBSERVATION ON HYPOTHESIS 4a and 4b: In both treatments, the agents' expectations regarding the principal's revelation of the starting difference increase with a decreasing starting difference. In both treatments, the agents expect the principal to reveal the two smallest starting differences $|\theta| = 0$ and $|\theta| = 20$ and the three smallest starting differences significantly more often than the largest starting difference $|\theta| = 80$. Moreover, they significantly expect the principal not to reveal the two largest starting differences $|\theta| = 60$ and $|\theta| = 80$.

Comparing the agents' expectations in both treatments Figure 5 already reveals that obviously agents expect revelation more often for the smallest starting differences in *Cred* than in *No-Cred* and less often for the two largest starting differences which is confirmed by non-parametric testing. Thus, the agents expect the principal to significantly more often reveal the second largest starting difference $|\theta| = 60$ as well as the largest difference $|\theta| = 80$ in *NoCred* than in *Cred* which is in contrast to our theoretic prediction.

---

[17] We ran fixed effects regressions with the agents' expectations as a dependent variable; the same coefficients as shown in Table 9 are significant.

We also compared the average expectation of each agent to the average actual tendency to reveal the starting difference of the principal in both treatments and found only a few differences.[18]

3.3.5 Effect of Discrimination of Agents

So far we have only analyzed average efforts aggregated over subjects being advantaged or disadvantaged by the realization of the starting difference. According to our theoretic prediction effort is symmetric in equilibrium. However, being advantaged or disadvantaged by the starting difference can make a difference in such unfair tournaments for actual behavior as already shown by Schotter & Weigelt (1992). This study confirms that average effort exerted is significantly higher than theoretically predicted in unfair two-person tournaments similar to the setting we analyze in this study (see also Weigelt et al. 1989).[19] Moreover, while their findings show that both – advantaged and disadvantaged subjects – exert higher efforts than predicted their results indicate that advantaged subjects exert higher efforts than disadvantaged ones. However, in most cases this difference is not significant.

Table 10 provides an overview of the average efforts exerted by advantaged and disadvantaged agents for each starting difference. Interestingly, we find that the average efforts of advantaged agents are almost always significantly above the theoretic prediction (see results of the Binomial Test). The effort of disadvantaged subjects is neither more often above than below the prediction except for the effort exerted in *NoCred* for a starting difference of 40 when effort is more often below the equilibrium effort than above. Comparing the effort of advantaged and disadvantaged subjects by using the Wilcoxon-Signed Rank test for dependent pairs for the efforts chosen by the two agents in each round we find that the effort of advantaged agents tends to be significantly higher than the effort of disadvantaged agents particularly for the two smallest starting differences.

---

[18] Agents expect the principal to reveal the starting difference more often for $|\theta| = 40$ in *Cred* ($\alpha = 0.057$, Mann-Whitney U test (two-tailed)) and less often for the two smallest starting differences in *CredNoCred* ($\alpha = 0.099$ for $|\theta| = 0$ and $\alpha = 0.002$ for $|\theta| = 20$, both Mann-Whitney U test (two-tailed)).

[19] In a later study Orrison et al. (2004) find that only effort elicited by unfair two-person tournaments is higher than predicted. This effect is reduced if the number of participants increases.

Table 10: Average effort of advantaged and disadvantaged agents per starting difference if revealed

		Realization of starting differences $|\theta|$			
		20	40	60	80
Cred	Advantaged	52.27^{++}	55.04^{+++}	68.40^{+++}	38.09^{+++}
	Disadvantaged	43.46	37.30	39.80	28.55
Wilcoxon-Signed Rank test (one-tailed)		$\alpha = 0.092$	$\alpha = 0.048$	$\alpha = 0.038$	ns
NoCred	Advantaged	57.94	64.27^{+++}	55.08^{+++}	42.82^{+++}
	Disadvantaged	43.88	23.36^{---}	39.67	22.27
Wilcoxon-Signed Rank test (one-tailed)		$\alpha = 0.059$	$\alpha = 0.003$	ns	$\alpha = 0.099$

By using the Binomial Test (one-tailed) we state the level of significance at which the null hypothesis can be rejected in favor of the alternative hypothesis that the average effort of each agent is more often above the equilibrium prediction than below:

+	*weakly significant:*	$0.05 < \alpha \le 0.10$
++	*significant:*	$0.01 < \alpha \le 0.05$
+++	*highly significant:*	$\alpha \le 0.01$

We also ran regressions as shown by Table 5 using effort of advantaged and disadvantaged subjects as dependent variable. While the results indicate that the effort of advantaged agents increases with a decreasing starting difference we find no such results for disadvantaged agents in both treatments. Moreover, the separate analysis of advantaged and disadvantaged agents does not indicate any change of behavior over rounds. We can conclude by summarizing our findings on hypothesis 5a:

OBSERVATION ON HYPOTHESIS 5a: Effort exerted by the agents being advantaged by the realization of the revealed starting difference is significantly higher than the effort of disadvantaged agents for the two low starting differences $|\theta| = 20$ and $|\theta| = 40$ in both treatments as well as for $|\theta| = 60$ in *Cred* and for $|\theta| = 80$ in *NoCred*.

As the principal states her beliefs for each of the two agents separately we may also disentangle her beliefs regarding the advantaged and the disadvantaged agent. Table 11 provides an overview of the respective principal's beliefs.

Table 11: Average belief of effort of advantaged and disadvantaged agents per starting difference if revealed

		Realization of starting differences $|\theta|$			
		20	40	60	80
Cred	Advantaged	57.88	47.38	33.91	31.59^{+++}
	Disadvantaged	66.03^{+++}	62.10^{++}	52.27	41.83^{++}
Wilcoxon-Signed Rank test (one-tailed)		$\alpha = 0.002$	$\alpha = 0.028$	ns	ns
NoCred	Advantaged	49.89	45.82	45.73^{++}	32.83
	Disadvantaged	59.88^{+++}	66.00^{+++}	70.82^{+++}	32.56
Wilcoxon-Signed Rank test (one-tailed)		$\alpha = 0.029$	$\alpha = 0.006$	$\alpha = 0.002$	ns

By using the Binomial Test (one-tailed) we state the level of significance at which the null hypothesis can be rejected in favor of the alternative hypothesis that the average expected effort of each agent is more often above the equilibrium prediction than below:

+	*weakly significant:*	$0.05 < \alpha \leq 0.10$
++	*significant:*	$0.01 < \alpha \leq 0.05$
+++	highly significant:	$\alpha \leq 0.01$

Comparing the average efforts with the theoretic prediction we find that the beliefs regarding efforts exerted by disadvantaged agents tend to be more often above the prediction than below in most cases. Moreover, Table 11 reveals that the principal rather expects disadvantaged agents to exert higher efforts than advantaged agents which can be summarized as follows:

> **OBSERVATION ON HYPOTHESIS 5b:** Principals expect the effort of agents being disadvantaged by the realization of the revealed starting difference to be significantly higher than that of advantaged agents for the two low starting differences $|\theta| = 20$ and $|\theta| = 40$ in both treatments as well as for $|\theta| = 60$ in *NoCred*.

This is in clear contrast to the actual behavior of agents as rather advantaged agents exert higher efforts than disadvantaged agents. Figure 6 compares the actual efforts exerted by advantaged and disadvantaged agents to the principal's beliefs. However, differences are in most cases not statistically significant. Exceptions are the following using the Mann-Whitney U test, two-tailed: Advantaged agents in *Cred* $|\theta| = 60$ ($\alpha = 0.035$), disadvantaged agents in *Cred* $|\theta| = 20$ ($\alpha = 0.007$), advantaged agents in *NoCred* $|\theta| = 40$ ($\alpha = 0.083$), disadvantaged agents in *NoCred* $|\theta| = 40$ ($\alpha = 0.005$) and $|\theta| = 60$ ($\alpha = 0.082$).
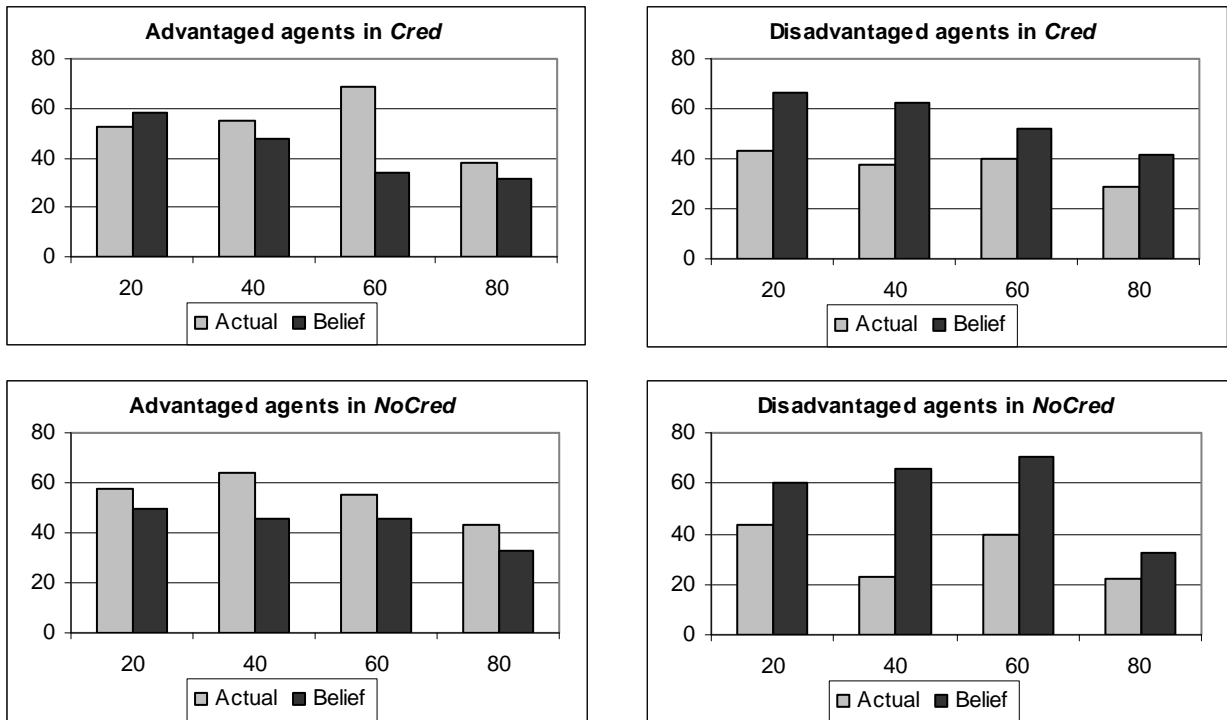
Figure 6: Comparison of actual effort and belief for advantaged and disadvantaged agents

4. Summary and discussion

Summarizing the principals' behavior first we may confirm that the principals' decisions seem to be in line with the basic logic of the strategic setting analyzed here and, thus, principals are more likely to reveal low than high starting differences. This behavior is consistent with the principals' beliefs who expect agents' efforts to be strictly decreasing in the starting difference, if the latter is revealed. Moreover, this behavior also seems to be an adequate response to the agents' actual efforts, as these efforts are indeed reduced, if the initial situation becomes less even.

Comparing the two different treatments, our hypothesis concerning the principals' decisions has not been confirmed. In particular, principals do not conceal information more often in the *NoCred* than in the *Cred* treatment. As principals do not expect the agents to behave differently in the two treatments in case of a concealed starting difference, this behavior seems to be rational. Considering the agents' actual efforts, however, we see that the principals misinterpret the situation: As opposed to the principals' beliefs, agents well choose higher efforts in *NoCred* than in *Cred*, if they are not informed about the starting difference. Moreover, the agents' actual efforts for a concealed starting difference are significantly higher than for the largest starting difference. This is in line with the principals' beliefs regarding the comparison of effort choices for the different situations within *NoCred*. Hence, it seems surprising that the

principals still seem to reveal the largest starting difference quite often in *NoCred*. They might have been better off, if they had acted according to the theoretic prediction.

As indicated before, agents choose lower efforts, if a relatively high starting difference is revealed. Although the actual efforts generally exceed the theoretic prediction, this is qualitatively in line with the model. Moreover, agents capture to some degree that a non-revelation of information is not best news, at least in the *Cred* treatment. As a consequence, they choose a lower effort in case information is withheld than if they know the starting difference to be zero. While a non-revelation of information, therefore, has an effect on the agents' efforts, this effect is not as strong as theoretically predicted. This, however, is in line with the agents' beliefs and the principals' decisions, which are also not as extreme as predicted by the model. The agents' decisions across the two treatments fit well to the model, too. If they learn the starting difference, efforts do not differ across the treatments. And, the agents correctly take into account that a non-revelation of information is more meaningful in *Cred* and, thus, choose a relatively higher effort in the *NoCred* treatment.

If we disentangle the effort choices of agents being disadvantaged and advantaged by the realization of the starting difference we make a surprising observation: Actual effort choices of advantaged agents seem to be higher than those of disadvantaged agents. This is in contrast to our theoretic prediction according to which efforts should be symmetric in equilibrium. However, it seems in line with an earlier study by Schotter & Weigelt (1992). Note that the results by Schotter & Weigelt are somewhat weak and that other studies (Weigelt et al. 1989 as well as Orrison et al. 2004) find almost no significant difference between advantaged and disadvantaged agents. In all of these studies the degree of being disadvantaged resp. advantaged does not change within one treatment. Thus, we may conclude that if agents know that their initial position may change over rounds they might be tempted to seize the chance of a subjectively perceived favorable position and exert a higher effort although this is not optimal.[20]

In contrast, analyzing the principals' beliefs shows that they rather expect disadvantaged agents to exert higher efforts than advantaged agents which is more pronounced for low starting differences. Thus, the principals obviously misjudge the agents' behavior.

To conclude, the experimental findings support the theoretical model and can shortly be summarized as follows:

---

[20] Harbring et al. (forthcoming) find that the emergence of the marginal cost of effort plays an important role for the exertion of efforts in an experiment on contests among asymmetric agents who may individually sabotage each other. Ex ante discrimination obviously discourages participants less than being sabotaged by others in a certain round. Their theoretic framework differs, however, considerably from ours.

1. Being informed about the initial standing, agents choose a lower effort the higher the starting difference.

2. Principals correctly anticipate this behavior and are, thus, less likely to reveal their information the less even the initial situation.

3. Agents correctly take into account that a non-revelation of information is more meaningful in the *Cred* than in the *NoCred* treatment. Hence, if they are not informed about the initial standing, they choose a relatively lower effort in *Cred.*

4. Principals, however, do not expect the agents to react differently in the two treatments if the information regarding the initial standing is not revealed. Consequently, they do not condition their decisions on the treatment.

5. Agents being advantaged by the realization of the revealed starting difference tend to choose higher efforts than agents being disadvantaged. Principals, however, expect the opposite.

5.   Conclusion

To sum up the behavior of principals and agents is quite well aligned, also in the light of their own expectations regarding the other participants' behavior. The behavioral patterns qualitatively correspond to our theoretic predictions. However, we do not find a striking difference between the two situations analyzed. Thus, it seems as if it does not make much of a difference here whether information can credibly be revealed with certainty or only with some probability.

Interestingly, in case of an unknown initial standing agents do not choose efforts as low as predicted by theory. Thus, one might conclude that principals do not need to worry about the necessity to disclose intermediate information whenever possible as it seems as if the effect of non-disclosure is not as strong as predicted. Note that this is not only important for the design of tournaments, but also for all other situations, where disclosure of information plays a role.

One important result we find is that the heterogeneity created by the revelation of the intermediate performance matters for the exertion of efforts although theory predicts that efforts should be symmetric in equilibrium. We observe an obvious misjudgment of the principals: While the advantaged agents tend to exert higher efforts than disadvantaged ones, principals expect exactly the opposite. Thus, principals need to be aware of the fact that they do not enhance the effort of the agents being behind by disclosing midterm results but rather discourage them compared to the agents having a headstart. This surprising result definitely deserves further investigation.

Appendix A: Proofs of Lemma 1, 2 and Proposition 1, 2

Proof of Lemma 1:

Note first that the agents form expectations about the principal's feedback policy and, accordingly, about the two sets B_1 and B_2. In equilibrium, these expectations must be correct. This means that the agents correctly anticipate the principal's strategy and the sets of parameter values, for which the principal does and does not try to reveal her information.

Bearing this in mind, the proof is by contradiction. Let the parameter realization be θ_j and suppose $g(\theta_j) < g(\breve{\theta})$. Further, let θ_j belong to B_1. This means that, after having observed this parameter realization, the principal is interested in revealing her information. This, however, is only possible, if $g(\theta_j) \geq E_\theta\big[g(\theta)|n\big]$.

As $g(\theta_j) < g(\breve{\theta})$, it follows that $g(\breve{\theta}) > E_\theta\big[g(\theta)|n\big]$ so that it is not profitable for the principal to conceal her information after having observed $\breve{\theta}$. Hence, $\breve{\theta}$ cannot belong to B_2, which is a contradiction and completes the proof of the lemma. ∎

Proof of Lemma 2:

The proof is again by contradiction. Suppose that the parameter realization is $\hat{\theta} \in \hat{\Theta}$. Per definition, the principal then does not reveal her information. Hence, the agents' equilibrium effort is given by

$$C'(e) = E_\theta\big[g(\theta)|n\big](w_1 - w_2) = \frac{1}{\int\limits_{B_2} f(\theta)d\theta} \int\limits_{B_2} g(\theta)f(\theta)d\theta(w_1 - w_2).$$

If $g(\hat{\theta}) > g(\widetilde{\theta})$, for some $\widetilde{\theta} \in \widetilde{\Theta}$, it must be that

$$g(\hat{\theta}) = g(\hat{\theta})\frac{\int\limits_{B_2} f(\theta)d\theta}{\int\limits_{B_2} f(\theta)d\theta} = \frac{1}{\int\limits_{B_2} f(\theta)d\theta} \int\limits_{B_2} g(\hat{\theta})f(\theta)d\theta > \frac{1}{\int\limits_{B_2} f(\theta)d\theta} \int\limits_{B_2} g(\theta)f(\theta)d\theta = E_\theta\big[g(\theta)|n\big]$$

Then, however, the principal gains from deviating and revealing her information about θ. Therefore, in equilibrium $g(\hat{\theta}) > g(\widetilde{\theta})$ cannot hold. As $g(\hat{\theta}) \geq g(\widetilde{\theta})$, by Definition 2, it directly follows that $g(\hat{\theta}) = g(\widetilde{\theta})$, for all $\hat{\theta} \in \hat{\Theta}$ and $\widetilde{\theta} \in \widetilde{\Theta}$. ∎

Proof of Proposition 1:

Combining Lemma 1 and 2, we can directly see that the principal always reveals her information, if $\theta \notin \overline{\Theta}$. Hence, if information is not revealed, the agents believe that $\theta \in \overline{\Theta}$. This implies that the principal is indifferent between revealing and concealing her information, if $\theta \in \overline{\Theta}$. ∎

Proof of Proposition 2:

We start by demonstrating that the principal always conceals her information, if $g(\theta) = g(\overline{\theta})$. If this were not true, it must be that $g(\overline{\theta}) \geq p \cdot E_\theta[g(\theta)] + (1-p) \cdot E_\theta[g(\theta)|ni]$. Note that the term $p \cdot E_\theta[g(\theta)] + (1-p) \cdot g(\overline{\theta})$ describes a lower bound for the right-hand-side of the inequality. As $g(\theta)$ is not a constant, we have $E_\theta[g(\theta)] > g(\overline{\theta})$ and, accordingly, $p \cdot E_\theta[g(\theta)] + (1-p) \cdot g(\overline{\theta}) > g(\overline{\theta})$. This implies that the inequality can never be satisfied and completes the first part of the proof.

From Lemma 1, we further know that the principal decides to conceal her information up to a certain point (i.e. up to a certain value $g(\theta)$), at which it becomes profitable to reveal her information. Denote this value by $\hat{g}$. It is easy to show that $\hat{g} \geq E_\theta[g(\theta)]$ can never hold. To see this, note first that the principal is indifferent between concealing and revealing her information, if $g(\theta) = E_\theta[g(\theta)|n]$. Now, let (in contradiction to the proposition) $\hat{g} = E_\theta[g(\theta)] + t$, with $t \geq 0$. The condition $\hat{g} = E_\theta[g(\theta)|n]$ can then be transformed into $E_\theta[g(\theta)] + t = p \cdot E_\theta[g(\theta)] + (1-p) \cdot E_\theta[g(\theta)|ni]$. For $t=0$, we have $E_\theta[g(\theta)|ni] < E_\theta[g(\theta)]$ (this follows from Lemma 1) and the condition $\hat{g} = E_\theta[g(\theta)|n]$ is violated. Similarly, for $t > 0$, the expression on the left-hand-side of the condition is strictly higher than $E_\theta[g(\theta)]$, while the corresponding expression on the right-hand side is weakly smaller than $E_\theta[g(\theta)]$. Hence, the condition can never be satisfied. This means that the cut-off value $\hat{g}$ must lie within the (open) interval $(g(\overline{\theta}), E_\theta[g(\theta)])$ and completes the proof of the proposition. ∎

Appendix B: Experimental Instructions: Treatment *Cred*

Throughout the experiment any amount will be measured in the fictitious currency **"Taler".**

There are **participants Y** and **participants X**. At the beginning of the experiment a random move decides about whether you become participant Y or participant X. You keep your role **throughout the entire experiment**.

In each round you only play with participants who belong to your group. Every **group** consists of **three participants**: **one participant Y** and **two participants X**, who are called **X1** and **X2** due to distinction.

In each round your group consists of different participants such that you will never play with the same participant more than once.

The experiment described as follows consists of **9 rounds**.

Decision by participant Y

At the beginning of each round participant Y gets to know the starting numbers of participants X1 and X2 in his group.

Participant Y has to decide, whether he wants to **disclose** the **starting numbers to participants X1 and X2** or whether he wants to keep them **secret**.

The starting numbers are announced to participants X1 and X2, if participant Y decides to disclose them. Otherwise, participants X1 and X2 receive the following message:

> "You do not get to know your starting numbers this round, since participant Y decided not to disclose them in this round."

Finally, participant Y is asked to **conjecture** the **numbers chosen by** his fellow group members **X1 and X2** in this particular round.

Decision of participant X

At the beginning of each round participants X are asked to **conjecture**, whether **participant Y** is going to **disclose their starting numbers or not**. They are asked to do this conjecture for all 5 possible starting differences.

The **starting numbers** for participants X1 and X2 are **newly-drawn** at the beginning of **each round**. A random move decides about who of these two participants gets a **starting number of 0** and who gets a starting number out of the **set {0, 20, 40, 60, 80}**. Each starting number of the given set is realized with the same probability.

Therefore, in each round one participant X has a starting number of 0 and the other participant X has a starting number out of the set {0, 20, 40, 60, 80}. Hence, there exist **5 possible starting differences,** i.e. 5 possible differences between the starting numbers: {0, 20, 40, 60, 80}.

Participants X only get to know their starting numbers, if participant Y decided to disclose them.

In each round both participants X select an **integer out of the set {0, 1, ..., 100}.** Each number is associated with certain costs. These costs rise by the selected number and are given by the attached table.

The computer draws a **random integer** out of the set {-50, -49, ..., 0, ..., 49, 50} for each of the two players. Every number from the set is equally likely to be drawn.

Payment per round for participant X

The selected numbers by the participants, the random numbers drawn and the starting numbers determine the payment in a round as follows:

The participant with the **higher result** gets a **high payment of 1800 Taler**, while the other participant with the **lower result** gets a **low payment of 800 Taler**. (In case of identical results there is a fair coin flip to determine the participant who gets the high and the participant who gets the low payoff.) The costs for the own number are subtracted from this payment. The outcome of this is the **payment in this round**.

The result and the payment in a round are determined as follows:

Preliminary result = number + random number

Result = preliminary result + starting number = number + random number + starting number

Payment in a round to participant X = high (low) payment – costs of own number

In addition, every participant X receives a **bonus of 100 Taler**, if his **conjecture is correct** regarding participant Y's disclosure of the starting numbers in this particular round. If his conjecture proves to be wrong, he does not receive a bonus payment.

Every participant X learns after each round whether he received a high or low payment as well as his payment for this round and the starting numbers of both participants. He gets to know the sum of his bonus payments at the end of the experiment.

Payment per round for participant Y

Participant Y receives a lump-sum payment of 800 Taler per round, as well as 5 times the sum of the preliminary results of his fellow group members X1 and X2 in this round:

Payment in a round for participant Y = 800 + 5 * (preliminary result X1 + preliminary result X2)

In addition, each participant Y receives a **bonus payment of 50 Taler for each number of participants X1 and X2** that he conjectured correctly in this round. Therefore, the bonus payment in a round can amount to a maximum of 2 * 50 = 100 Taler. The amount of the difference between conjecture and actual number will be subtracted from the 50 Taler. The minimum bonus payment is zero.

After each round all participants Y learn their payment for the round, the preliminary results, the results and, as a reminder, the starting numbers of participants X1 and X2. The sum of their bonus payments is announced to them at the very end of the experiment.

All participants receive a lump-sum payment of 2500 Taler at the beginning of the experiment.

At the end of the experiment the sum of payments from all rounds is given to the participants at an **exchange rate of 1 Euro for 1000 Taler**. The payments are conducted anonymously.

Thank you very much for participating in the experiment!

References

Aoyagi, Masaki. 2004. Information Feedback in a Dynamic Tournament. Mimeo, Osaka University.

Clark, Derek J., and Kai A. Konrad. 2007. Contests with Multi-Tasking. *Scandinavian Journal of Economics*, forthcoming.

Ederer, Florian. 2004. Feedback and Motivation in Dynamic Tournaments. Mimeo, MIT.

Ederer, Florian, and Ernst Fehr. 2006. Communication and Information in Dynamic Tournaments: Theory and Evidence. Mimeo, MIT and University of Zurich.

Eriksson, Tor. 1999. Executive Compensation and Tournament Theory: Empirical Tests on Danish Data. *Journal of Labor Economics* 17, no. 2:262-280.

Falk, Armin, and Ernst Fehr. 2003. Why labour market experiments? *Labour Economics* 10, no. 4:399-406.

Fischbacher, Urs. 1999. z-Tree – Zurich Toolbox for Readymade Economic Experiments – Experimenter's Manual. Working Paper No. 21, Institute for Empirical Research in Economics, University of Zurich.

Garicano, Luis, and Ignacio Palacios-Huerta. 2005. Sabotage in tournaments: Making the beautiful game a bit less beautiful. Discussion Paper, University of Chicago and Discussion Paper 5231, CEPR, London.

Gershkov, Alex, and Motty Perry. 2006. Tournaments with Midterm Reviews. Mimeo, University of Bonn.

Grossman, Sanford J. 1980. The Informational Role of Warranties and Private Disclosure about Product Quality. *Journal of Law & Economics* 24, no. 3:461-483.

Grossman, Sanford J., and Oliver D. Hart. 1980. Disclosure Laws and Takeover Bids. *The Journal of Finance* 35, no. 2:323-334.

Grund, Christian, and Dirk Sliwka. 2005. Envy and Compassion in Tournaments. *Journal of Economics and Management Strategy* 14, no. 1:187-207.

Harbring, Christine, and Bernd Irlenbusch. 2005. Incentives in tournaments with endogenous prize selection. *Journal of Institutional and Theoretical Economics* 161, no. 4:636-663.

Harbring, Christine, Irlenbusch, Bernd, Kräkel, Matthias, and Reinhard Selten. Sabotage in Corporate Contests. *International Journal of the Economics of Business*, forthcoming.

Hvide, Hans K. 2002. Tournament Rewards and Risk Taking. *Journal of Labor Economics* 20, no. 4:877- 898.

Kräkel, Matthias. Emotions in Tournaments. *Journal of Economic Behavior and Organization*, forthcoming.

Lazear, Edward P. 1989. Pay Equality and Industrial Politics. *Journal of Political Economy* 97, no. 3:561-580.

Lazear, Edward P., and Sherwin Rosen. 1981. Rank-order tournaments as optimum labor contracts. *Journal of Political Economy* 89, no. 5:841-864.

Milgrom, Paul R. 1981. Good news and bad news: representation theorems and applications. *Bell Journal of Economics* 12, no. 2:380-391.

Mohnen, Alwine and Kathrin Pokorny. 2006. Is Honesty the Best Policy? An Experimental Study on the Honesty of Feedback in Employer-Employee Relationships. Discussion Paper, University of Cologne.

Münster, Johannes. 2007. Selection Tournaments, Sabotage, and Participation. *Journal of Economics and Management Strategy*, forthcoming.

Nalebuff, Barry J., and Joseph E. Stiglitz. 1983. Prizes and Incentives: Towards a General Theory of Compensation and Competition. *Bell Journal of Economics* 14, no. 1:21-43.

O'Keeffe, Mary, Viscusi, W. Kip, and Richard J. Zeckhauser. 1984. Economic Contests: Comparative Reward Schemes. *Journal of Labor Economics* 2, no. 1:27-56.

Orrison, Alannah, Schotter, Andrew, and Keith Weigelt. 2004. Multiperson tournaments: An Experimental Examination. *Management Science* 50, no. 2:268-279.

Rosen, Sherwin. 1986. Prizes and Incentives in Elimination Tournaments. *American Economic Review* 74, no. 4:701-715.

Schotter, Andrew, and Keith Weigelt. 1992. Asymmetric tournaments, equal opportunity laws, and affirmative action: Some Experimental Results. *Quarterly Journal of Economics* 107, no. 2:511-539.

Sutter, Matthias, and Christina Strassmair. 2005. Communication, cooperation and collusion in team tournaments - An experimental study. Discussion Paper, University of Innsbruck.

Weigelt, Keith, Dukerich, Janet, and Andrew Schotter. 1989. Reactions to discrimination in an incentive pay compensation scheme: A game-theoretic approach. *Organizational Behavior and Human Decision Processes* 44:26-44.

van Dijk, Frans, Sonnemans, Joep, and Frans van Winden. 2001. Incentive Systems in a Real Effort Experiment. *European Economic Review* 45, no. 2:187-214.