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The Monotonicity Puzzle
An Experimental Investigation of Incentive Structures*

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Abstract

Non–monotone incentive structures, which — according to theory — are able to induce optimal behavior, are often regarded as empirically less relevant for labor relationships. Scientific attention is (therefore) confined to monotone if not linear contracts. This paper reports on experimental tests comparing non–monotone vs. monotone contracts in a simple dynamic agency model. The results demonstrate that selecting the non–monotone contract over of the monotone one is not only optimal from a theoretical point of view, but also remains preferable given the agents' observed behavior. However, roughly 50 per cent of the principals prefer the monotone contract.

Keywords: experimental agency, non–monotone contracts

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1 Introduction

In the field of labor contracts, an important classification is the one of monotone and non–monotone contracts. Monotone contracts grant higher pay to workers with higher effort input or output, respectively. Research on contract theory has shown that there are various contractual relationships where monotone contracts are not the optimal choice. Grossman and Hart (1983) present conditions for monotonicity while the optimality of linear contracts as a variant of monotone contracts is discussed by Christensen and Feltham (2005, ch.19), Hart and Holmström (1987), or Holmström and Milgrom (1987). Although under certain conditions, monotone contracts do not implement the theoretically optimal solution, for practical purposes, non–monotone contracts are often deemed implausible. In fact, monotone contracts are in frequent use, while there are only few non–monotone contractual relations. The popularity of piece rates, target bonuses as percentage of base salary, or variable ratios or quotas (with constant targeted level of performance) are evidence of that.[1]

The widespread use of monotone contracts in practice has led many authors to focus on these types of contracts only. Among others, much theoretical research has been carried out in the LEN framework in agency theory where linear contracts allow for analytical tractability.[2] Incentive effects of linear contracts have also been analyzed in various empirical studies. Many of these investigations reveal a positive correlation between monetary rewards and effort (see, e.g., Bailey et al., 1998; Lazear, 2000; Sprinkle, 2000), whereas others do not find any positive effects (Bonner et al. 2000; Jenkins et al., 1998). A positive relationship between rewards and effort is also reported in experimental analyzes of contractual relationships (e.g., Fehr et al., 1993, 1998), though the evidence suggests that its degree is quite sensitive to the institutional setting (e.g., van der Heiden et al., 2001; Charness et al., 2004).[3]

Many of these experiments directly relate compensation to observable (and

[1]Although there are econometric studies indicating that non–monotone contracts are used, these studies do not focus on individual contracts, but estimate certain parameters thereof. See Prendergast (2002; pp. 1077) and the references therein for mixed results, i.e. some studies find a negative relation between risk and incentives, while others find a positive relation or none. Leonard (1990) reports a U–curve of compensation elasticity with respect to sales also suggestive of non–monotone contracts.

[2]Linear contracts are a characteristic feature of the approach. See, among others, Dutta and Reichelstein (2003), Feltham and Xie (1994) or Indjejikian and Nanda (1999). Recent examples include Sabac (2007) or Feltham and Hofmann (2007).

[3]Models that try to account for the observed behavior include some form of other–regarding preferences like a concern for relative payoffs (e.g., Fehr and Schmidt, 1999; Bolton and Ockenfels, 2000), some sort of reciprocity (e.g., Rabin, 1993; Levine, 1998; Falk and Fischbacher, 1998), or both reciprocity and efficiency concerns (Charness and Rabin, 2002).

verifiable) effort *inputs* (see also Fehr et al., 2004; Falk and Gächter, 2002; Huck et al., 2004), which violates a fundamental feature of agency–relationships, unobservability of the agents' effort choices. Due to this unobservability, in models of the principal–agent type, output is relevant for compensation, while input only has an indirect influence. Accordingly, the studies conducted by Güth et al. (1998) and by Anderhub et al. (2002) deal with incentive effects of output–contingent pay based on monotone contracts. Keser and Willinger (2000) allow for non–monotone contracts, but these contracts do not represent (incentive–) compatible offers. Lukas (2007a) tests for the effects of incentive compatible non–monotone contracts. He finds that the majority of workers ('agents') act as income–maximizers and choose high instead of low efforts despite the non–monotonicity of contracts.

The study by Lukas (2007a), however, neglects some aspects that are relevant for judging the appropriateness of non–monotone incentive schemes: First, the non–monotonicity is not explicitly mentioned in the contract (nor in the subjects' instructions); second, agents are not informed about the set of contracts available and are not allowed to reject contract offers; third, the game does not involve repeated interaction between principals and agents.

This paper extends the previous research along these lines and analyzes reasons for the observed popularity of monotone contracts. In the controlled environment of the laboratory, principals can choose between a theoretically optimal non–monotone and a theoretically sub–optimal monotone contract. Our results demonstrate that agents virtually never reject contract offers and often choose high effort as intended by the principals. Interestingly, this behavior is robust against the different variations of our experimental design, but is more pronounced under the monotone contract. Although the agents' behavior does *not* lead to higher expected payoffs for principals under the monotone contract, we observe that principals do not select the non–monotone contract in a significant way. As such the results highlight the delicate interplay between incentives, behavior, and performance and show that confining attention to monotone (if not linear) contracts is clearly suboptimal from the principals' perspective — a behavioral pattern we call the 'monotonicity puzzle'. From our point of view this puzzle can be resolved as follows: Experiments with observable effort show a positive correlation between effort and reward. If effort is not observable output is used to infer input and, consequently, serves as a proxy for effort. Fairness considerations, which have been identified in observable effort experiments, would then suggest monotone contracts so that higher effort — proxied by output — leads to higher rewards. As long as the theoretically optimal contract is indeed monotone (in outcomes), the effort proxy will do just fine. However, as soon as a non-monotone contract is optimal the effort proxy leads to a suboptimal contract design. And this is what shows up in our experiments. In contrast to Lukas (2007a), the contract feature 'monotone' or 'non–monotone' was explicitly mentioned in our experimental design while it was not in Lukas' design. Lukas (2007a) reports a statistically significant choice of the optimal non–monotone contract by principals — an observation found to be robust against different variations of his experimental design — yet we cannot find statistical significance for non–monotone contract choices in our data.

Our findings contribute to the research on agency theory and on labor markets by demonstrating that non–monotone contracts are tolerated by agents, and consequently may not be as implausible as they are often regarded to be. Our observations on principals, however, might help to understand why this type of contract is nevertheless rarely used in labor markets.

The paper is structured as follows. Section 2 includes the model guiding our analyzes. In sections 3 and 4 we present the experimental design and derive our hypotheses. Section 5 discusses the results on agents and principals and the final section concludes.

2 Outline of the model

The model underlying our experimental design is adopted from Lukas (2007b). We consider a two–stage agency model with risk–neutral contracting parties. The agent performs similar tasks in each stage and her actions (effort) $e_t \in \{0,1\}$, $t = 1, 2$, which are unobservable to the principal, cause costs of $C(e_t) = c\,e_t$, $c > 0$. The agent's first–stage action affects the outcome in both stages, $t = 1$ and $t = 2$. It can therefore be considered as 'strategic effort'. Effort in stage 2 affects only the current stage and is considered as 'operational effort'. We assume a binary output distribution in each stage, $x_t \in \left\{x^L, x^H\right\}$, $t = 1, 2$, such that four different output sequences characterized by a first–stage outcome and a second–stage outcome are possible, $(x_1, x_2) \in \left\{x^L, x^H\right\}^2$. Higher effort inputs lead to high(er) probabilities for high outcomes. Given the strategic complements property (Bulow et al., 1985) of strategic and operational effort in Lukas' model setup, low strategic effort in stage 1 cannot be made up by (excessive) operational effort in stage 2. As the principal desires high effort in both stages, he has to rely on incentive–compatible output contingent payments. Let s^{ij}, i, $j \in \{L, H\}$, denote the state contingent payment on which the agent has a legal claim if she achieves outcome i in stage 1 and outcome j in stage 2. The strategic complements property drives the pay structure. We are interested in the following two different, incentive–compatible, pay structures:

$$s^{LL} < s^{HL} < s^{LH} < s^{HH}, \tag{Y}$$

$$s^{LL} < s^{HL} < s^{HH} < s^{LH}. \tag{X}$$

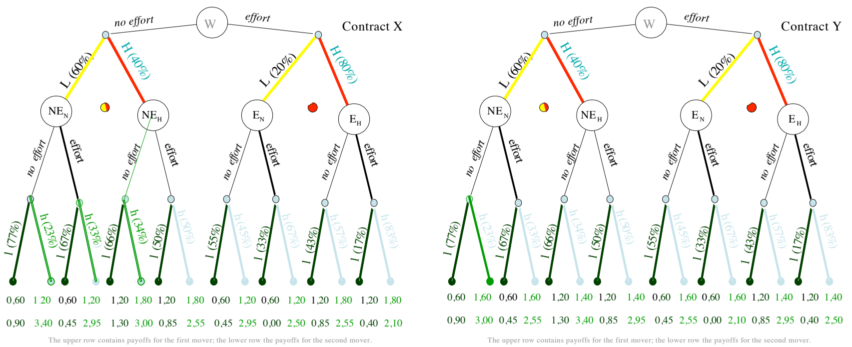
Pay structure Y is monotone in the number of successes while X is non–monotone. X is particularly interesting because a higher payment is given to an agent who succeeds only once (in stage 2) than to an agent who succeeds in both stages. In light of the rationality assumption inherent to the model and given the incentive compatibility of the pay structures Y and X, any agent is expected to accept such a contract and to subsequently exert high effort in both stages.

The set–up might be interpreted as follows. Consider an agent who is new to a firm or in a certain position. Then one could think of the strategic effort in stage 1 as the effort the agent has to exert in order to get acquainted with the work environment and tasks and to learn about the specific requirements of the job. In stage 2, the acquired skills are applied. In case the agent does not qualify properly in stage 1 ($e_1 = 0$), she cannot compensate her failure by spending comparably higher operating effort. As such, learning–on–the–job effort and operating effort are strategic complements. As a result, a low performance x^L in stage 1 indicates that a low effort might have been chosen and that a high outcome x^H in stage 2 is rather unlikely. If the principal intends to induce high effort in stage 2 (because the agent's effort is nevertheless sufficiently profitable) it takes comparably higher incentives than in a situation with x^H being the first–stage outcome. If the agent then does accomplish x^H in stage 2, she acquires a claim on a state contingent payment that is higher than the payment resulting from successes in both stages. A specific example would be a marketing manager who learns about consumer tastes in stage 1 while already being in charge of the company's key accounts. The more she learns in stage 1 the more likely are high sales (x^H) in stage 1 and stage 2. In case she does not meet the sales target in stage 1, the marketing manager appears poorly informed about consumer tastes. High sales in stage 2 are then rather uncertain. Therefore it takes high incentives to induce high effort in stage 2, and the state contingent payment s^{LH} will be higher than s^{HH}.

3 Design of the experiments

We test five different treatments of the sequential principal–agent game with ten decision rounds each. The basic set–up is as follows: The first mover (principal) has to choose between two similar, incentive compatible contracts X and Y. Contract X is characterized by the pay structure given in X, whereas Y characterizes Y's pay structure. That is, contract X awards the highest payoff to the output sequence {*low, high*} and contract Y does so to the sequence {*high, high*}. The contract choice determines the payoff for both the first mover and the second mover (agent) for every possible output sequence. The second mover's effort decision influences the probabilities of the different possible output sequences.

Our first treatment (baseline) is labeled 'no framing with selected contract information' (*NFS*). Here, an agent is matched with the same principal over the whole ten rounds. The principal decides on a contract once and for all rounds and the agent receives information only on the contract chosen by the principal, i.e. agents are given a game–tree visualization of that contract containing probabilities of success and respective payoffs for both players (see Figures 1(a) and 1(b)). The agent must accept the contract offered.



(a) Contract X (non–monotone)

(b) Contract Y (monotone)

Figure 1: Game trees for the contracts

The second treatment ('framing with selected contract information', *FS*) differs from the first one only in that additional information about the contract type ('monotone' or 'non–monotone', respectively) is given to the participants. In the third treatment ('framing with complete information', *FC*), agents are informed about the structure of both contracts, i.e. also about the one not chosen by the principal. In the fourth treatment ('framing with complete information, repeated interaction', *FCR*), agents receive the same information as in treatment *FC*, but the pairs of principal and agent are randomly formed anew for each of the ten decision rounds. The fifth treatment ('framing with complete information, repeated interaction, and rejection opportunity', *FCRR*) is basically the same as *FCR*, but additionally includes the opportunity for agents to reject contract offers. Both in treatment *FCR* and *FCRR* six participants, three principals and three agents, formed a matching group and random matching before each round occurred only within a matching group.

Testing the model in these five treatments is intended to serve the following purposes: Treatment *NFS* establishes baseline results. In treatment *FS*, we investigate whether the explicit statement of the contract type has any impact on agents' decisions. Note that in this treatment agents do not have information about the other contract, i.e. the one that is not selected by the principal, the only additional information they receive is whether their contract is ‘monotone’ or not. Treatment *FC* then controls for the impact of complete information about the set of possible contracts on the agents’ and the principals’ decision. In other words, do principals behave differently if agents know about the properties of all contracts available to their principals? And how do agents respond? Treatment *FCR* allows to control for possible reputation effects, since — other than in *FC* — agents repeatedly interact with different partners. Finally, in treatment *FCRR*, the option to reject a contract offer is introduced in order to test whether agents use this option depending on the contract type and to determine its influence on principals’ behavior.

At the beginning of each session, subjects were given a presentation by one of the experimentators. The presentation was the same for all treatments and conducted by the same experimenter. It included a detailed explanation of the decision context, the game tree (without the relevant payoffs), and on how individual decisions influence outcome probabilities and profits. For the latter, participants were guided through the decision tree for each of the two possible choices in period 1. Then subjects were randomly assigned to their roles and to their seats in the laboratory where they found written instructions.[4] After reading the instructions and during the course of the experiment, subjects could privately ask clarifying questions. They were neither allowed to ask questions in public nor to communicate with other participants. All experiments were conducted via computers using the zTree-software tool (Fischbacher, 2007). On the computer screen, subjects could see their own decision(s), the outcomes of random draws by the computer, and their payoffs (see Figure 2). While agents were informed about the principals’ decisions, principals could not observe the agents’ effort choices. In each round, principals were only informed about their profits and, in treatment *FCRR* about the agent’s rejection decision. This corresponds to the fundamental assumption of unobservable effort in agency models.

In treatments *FCR* and *FCRR*, subjects were randomly re–matched in matching groups consisting of six participants. We made sure that no two participants were matched with each other in two subsequent rounds. Subjects were informed accordingly.

The experiments were run at the Magdeburg Laboratory for Experimental Economics (MaxLab) in June 2006 and April 2007. A total of 220 graduate students recruited from several courses took part in the experiment. The sample size was 19 pairs of subjects in each of the two treatments *FS* and *FC*, and 36 pairs (i.e. 12 matching groups) in each of the two treatments *FCR* and *FCRR*. Sessions lasted for about one hour; there were no time–constraints imposed on subjects’ decision

[4]Complete instructions are included in the Appendix.

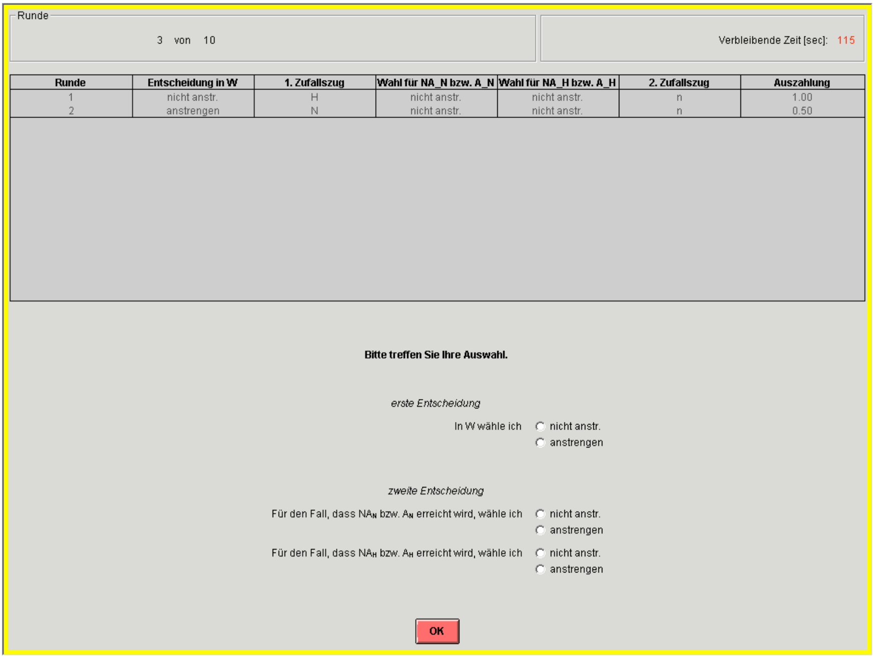


Figure 2: Screenshot of input stage

making. All subjects were anonymously paid off after the experiment. No information was given about the identity of other subjects. Average earnings were € 13.77.

4 Hypotheses

The output sequences $(x_1, x_2) \in \{x^L, x^H\}^2$ stochastically depend on the sequence of effort inputs $(e_1, e_2) \in \{0, 1\}^2$. The probabilities of achieving output sequence (x_1, x_2) conditional on input sequence (e_1, e_2), $\text{Prob}((x_1, x_2) \mid (e_1, e_2))$ are identical in each treatment. The same holds for net payoffs under contract X and Y, respectively. Probabilities and net payoffs are illustrated in Fig. 1 and explicitly given in Tables 6 and 7 in Appendix A.

Since the production environment does not depend on the particular contract chosen, we transform the non–monotone contract X into the monotone contract Y by shifting part of the surplus (€ .40) from the principal to the agent for the output sequence $\left(x^H, x^H\right)$ and in the opposite direction for the output sequence $\left(x^L, x^H\right)$.[5] In addition, if a contract offer is rejected in treatment *FCR*, both principal and agent have to settle with a fixed payment of € 0.50 each and the decision round ends with the agent's rejection.

4.1 Agents' decisions

By applying backward induction in expected payoffs to both contracts, we can deduce our hypotheses. The following refers to the game trees given in Fig. 1.

4.1.1 Contract *X*

Starting in stage–two decision nodes, agents face the following decision under contract *X*:

	expected payoff		income–maximizing
node	no effort	effort	action
NE_N	1.475	1.275	no effort
NE_H	1.878	1.700	no effort
E_N	1.575	1.675	effort
E_H	1.819	1.811	(no effort)

Table 1: *Contract X. Expected net payoffs to agent in stage 2 given stage 1 decision*

Expected net payoffs as given in Table 1 can be used to determine the income–maximizing strategy in stage 1 (decision node *W*). Since the expected payoff when choosing 'no effort' (€ 1.64) at this stage is lower than expected payoff when choosing 'effort' (€ 1.79), the income–maximizing strategy is to choose 'effort'. In summary, income maximizing agents choose 'effort' in stage 1, and 'effort' given E_N and 'no effort' given E_H in stage 2. If an agent instead selects 'no effort' in stage 1, it is always payoff–maximizing to select 'no effort' in stage 2, however.

4.1.2 Contract *Y*

Again, starting with the stage–two decision nodes, agents face the decision under contract *Y* as shown in Tab. 2:

[5]It should be noted that contract *Y* is still not strictly monotone in the number of high outcomes but at least the sequence $\left(x^H, x^H\right)$ leads to a higher payoff than $\left(x^L, x^H\right)$.

node	expected payoff no effort	effort	income–maximizing action
NE_N	1.383	1.143	no effort
NE_H	2.014	1.900	no effort
E_N	1.395	1.407	(effort)
E_H	2.047	2.143	effort

Table 2: *Contract Y. Expected net payoffs to agent in stage 2 given stage 1 decisions*

Expected net payoffs as displayed in Tab. 2 can be used to determine the income-maximizing strategy in stage 1. Since the expected payoff when choosing 'no effort' (1.64) at this stage is lower than the expected payoff when choosing 'effort' (2.00), the income–maximizing strategy is to choose 'effort'. Income maximizing agents under contract Y also choose 'effort' in stage 1, and 'effort' in stage 2. And again, if an agent instead selects 'no effort' in stage 1, it is payoff–maximizing to select 'no effort' in stage 2 as well.

Given the expected payoffs resulting from payoff–maximizing behavior, agents will not reject any contract offered. (Note that the rejection of a contract offer yields € 0.50.)

The corresponding hypotheses regarding agents' behavior are as follows:

Hypothesis 1 (Agents; Contract Acceptance/Rejection) *Income maximizing agents will never reject a contract offer made by principals.*

Hypothesis 2 (Agents; Stage 1 Behavior) *Income maximizing agents will select 'effort' in stage 1.*

Hypothesis 3 (Agents; Stage 2 Behavior) *Income maximizing agents will select 'no effort' in stage 2, if they selected 'no effort' in stage 1. They will select 'effort' in stage 2, given E_N for contract X and given E_H for contract Y.*[6]

4.2 Principals' decisions

To predict principals' choices, one can easily verify that no contract dominates the other in terms of first–order stochastic dominance or second–order stochastic dominance for any effort strategy selected by agents. Given the decisions of income maximizing agents, the expected payoffs for principals selecting contract

[6]As the difference in expected payoffs in node E_H for contract X is only € 0.008 and in E_N for contract Y is only € 0.012, we consider both possible choices as 'payoff–maximizing' in the subsequent analysis.

X is € 1.56 and for principals selecting contract Y is € 1.35. (The principal's decrease in expected surplus of € 0.21 associated with choosing Y instead of X is exactly the increase of the agent's expected surplus of € 0.21.) The hypothesis for income–maximizing principals' behavior then is as follows.

Hypothesis 4 *Income maximizing principals will always select the non-monotone contract.*

Hypothesis 5 *Income maximizing agents will never reject a contract offer by principals.*

Hypothesis 6 *Income maximizing agents select effort in stage 1.*

Hypothesis 7 *Income maximizing agents select effort in stage 2, if they selected effort in stage 1; they select no effort if they selected no effort in stage 1.*

5 Results of the experiments

In this section we will first present the analysis of the principals' decisions and then investigate the agents' decisions. If not indicated otherwise, one–sided non–parametric tests are used and differences are labeled as significant if $p \leq 0.025$ and are labeled as weakly significant if $0.025 < p \leq 0.050$.

5.1 Principals' behavior

We observe, over all treatments, that in about 53 percent of all cases principals select the non–monotone contract X. Treatment–specific numbers are illustrated in Table 3 (treatments *NFS*, *FS*, *FC*) and Fig. 3 (*FCR*, *FCRR*), respectively. Although the non–monotone contract X yields a higher expected payoff than the

	NFS	*FS*	*FC*
(i) Number of X-choices	11	11	9
(ii) Total number of choices	20	19	19
Percentage (i) / (ii)	55.0	57.9	47.3

Table 3: Descriptive data on principals' choices

monotone contract Y, principals do not choose contract X as often as expected. Applying the binomial test to principals' choices in treatments *NFS*, *FS*, and *FC* reveals that principals do not select contract X in a statistically significant way. Similar results can be obtained for principals' choices per matching group for

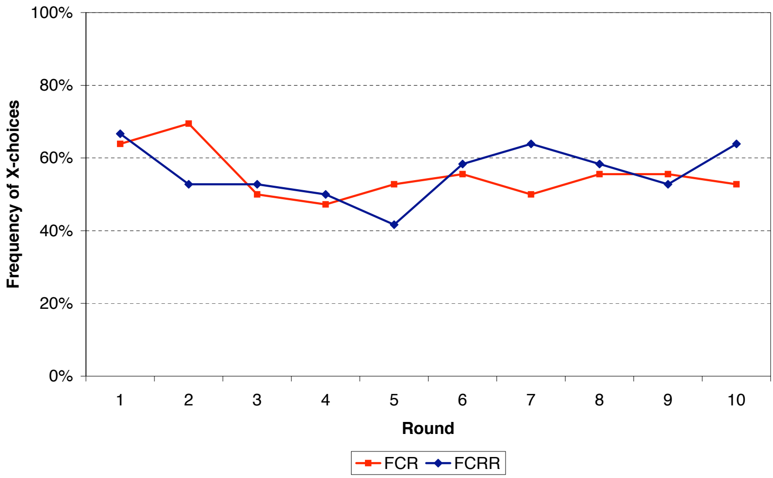


Figure 3: Principals' choices in *FCR* and *FCRR*

eight of the ten rounds in treatments *FCR* and *FCRR*. In both treatments the frequency of choosing X is almost never significantly different from 50 percent (two–tailed, one–sample t–test). This leads to conclusion 1.

Conclusion 1 *In contrast to Hypothesis 4, in all treatments principals do not select the non–monotone contract X in a statistically significant way.*

At first sight, one could be tempted to think that principals concerned over agents' behavior at node E_H might choose X not as often as predicted. At this node, agents' expected payoff from effort is 1.811, and the corresponding expected payoff from 'no effort' amounts to 1.819.[7] But even if agents strictly prefer 'no effort' at this node, in terms of expected payoffs principals are still better off with contract X (1.43) compared to Y (1.34). It follows that other motives must account for observed principals' behavior.

Another possible explanation is that principals are willing to sacrifice some of their own payoff in order to reduce the inequality between their and the agents' payoff. Recent theoretical and experimental work provide reasons for this assumption (e.g. Fehr/Schmidt, 1999; Bolton/Ockenfels, 2000; Charness/Rabin,

[7] See also fn. 6.

2002). In our setting, however, choosing the monotone contract Y instead of the non–monotone contract X even increases the payoff difference according to the theoretical prediction (contract X: principal 1.56, agent 1.79; contract Y: principal 1.35, agent 2.00). Considering agents' actual choices does not change this result for any of the five treatments.

In order to get a more detailed picture of principals' behavior, we now turn to an analysis of individual responses in treatments *FCR* and *FCRR*, where principals repeatedly decide on a contract. As they can only observe the outcomes of random draws by the computer and the corresponding payments, they do not know the agents' effort choices. Inference from outcomes to action choices is limited to knowing that high payoffs are more likely to be the result of high effort instead of low effort. Table 4 illustrates the development of individual contract choices contingent on payoffs realized in the previous round. Since we do not find systematic differences in individual responses between the two contract types, the table aggregates data over both contracts. In general, we observe a tendency to

(a) Treatment FCR

	Response after round								
	1	2	3	4	5	6	7	8	9
payoff < maximum ('lose')	0.78	0.83	0.75	0.69	0.75	0.81	0.75	0.78	0.64
stay with contract	0.50	0.53	0.59	0.72	0.78	0.66	0.78	0.86	0.74
change contract	0.50	0.47	0.41	0.28	0.22	0.34	0.22	0.14	0.26
payoff = maximum ('win')	0.22	0.17	0.25	0.31	0.25	0.19	0.25	0.22	0.36
stay with contract	0.75	0.83	1.00	0.73	0.89	1.00	1.00	1.00	0.92
change contract	0.25	0.17	0.00	0.27	0.11	0.00	0.00	0.00	0.08

(b) Treatment FCRR

	Response after round								
	1	2	3	4	5	6	7	8	9
payoff < maximum ('lose')	0.72	0.78	0.81	0.81	0.89	0.83	0.61	0.83	0.81
stay with contract	0.58	0.54	0.72	0.59	0.66	0.73	0.68	0.60	0.79
change contract	0.42	0.46	0.28	0.41	0.34	0.27	0.32	0.40	0.21
payoff = maximum ('win')	0.28	0.22	0.19	0.19	0.11	0.17	0.39	0.17	0.19
stay with contract	0.80	0.88	0.57	0.86	0.75	1.00	0.79	1.00	1.00
change contract	0.20	0.12	0.43	0.14	0.25	0.00	0.21	0.00	0.00

Table 4: Principals' individual responses to observed payoffs

stay with the contract type chosen in the previous round. This holds true for both events ('winning' and 'losing'). If we find a change of behavior, this is most likely in the case of losing. In treatment *FCR*, particularly, the tendency to stay with the previous contract becomes more pronounced over time. The above findings indicate that principals' behavior is dominated by inertia and additionally guided by a form of the 'Win–Stay–Lose–Change' learning heuristic (cf. Novak and Siegmund, 1993). Over the ten rounds of our experiment, this type of individual 'learning' does not result in a change in aggregate behavior, however.

There are no significant differences in principals' behavior between the treatments. Neither the presence nor the absence of a statement of the contract type, neither repetition of the decision process by the agent nor by the principal and neither the presence nor the absence of agents' opportunity to reject a contract proposal has a significant influence on principal's contract choice. As our baseline treatment *NFS* is comparable to Lukas' (2007a) treatment *FP* (framing with principal[8]), our data do not reinforce his finding of a statistically significant choice of non–monotone contracts when the contract type is not explicitly mentioned. Yet our results show that the choice of the non–monotone contract *X* does not remain significant against different variations of the experimental design which is at odds with theoretical predictions.

5.2 Agents' behavior

In treatment *NFS*, there are 11 agents confronted with contract *X* (*X*–agents), and 9 agents confronted with contract *Y* (*Y*–agents). In *FS*, the respective numbers are 11 *X*–agents and 8 *Y*–agents and in treatment *FC*, there are 9 *X*–agents and 11 *Y*–agents. In treatments *FCR*/*FCRR*, each agent faces contract *X* on average 5.5/5.6 times and contract *Y* on average 4.5/4.4 times, respectively. The following analysis distinguishes between *X*–agents and *Y*–agents.

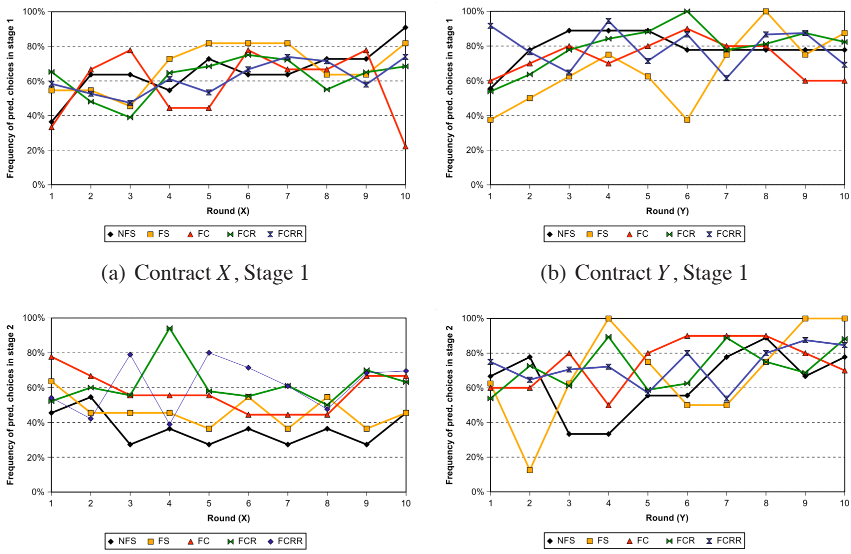
5.2.1 Payoff–maximizing behavior

Our first hypothesis (Hypothesis 1) is related to agents' contract acceptance decisions in treatment *FCRR*. Of the 183 times that principals offer (non–monotone) contract *X*, only one offer is rejected; contract *Y* (177 offers) is never rejected by agents. Apparently, the expected payoff is high enough under either contract given the intended effort strategy to dominate the certain payoff of € 0.50 following contract rejection. Conclusion 2 follows immediately.

Conclusion 2 *In line with Hypothesis 1, in treatment FCRR agents do not reject contract offers.*

[8] In Lukas' (2007a) study, framing refers to presenting the decision problem in a labor relationship context.

In order to analyze decisions within and between treatments and contracts, we determine the relative frequency of individual income–maximizing decisions per contract type and round (in treatments *FCR* and *FCRR* the frequency refers to matching groups[9]). The frequencies obtained as the number of individuals who show income–maximizing behavior over the total number of individuals or as the averages of the twelve matching groups' percentage calculations, respectively, are illustrated in Figure 4.



(a) Contract X, Stage 1

(b) Contract Y, Stage 1

(c) Contract X, Stage 2

(d) Contract Y, Stage 2

Figure 4: Frequencies of income–maximizing agent's behavior

Table 5 shows the number of rounds in which we observe a significant[10] majority of subjects (or matching groups) displaying income–maximizing behavior.

In only 20 percent of all cases (10 rounds out of 10 rounds $\times$ 5 treatments) we find significant income–maximizing behavior for contract X in stage 1. This number decreases to 8 percent in stage 2. For contract Y, the respective numbers are 36 percent in stage 1 and 26 percent in stage 2. This leads to the following

[9]Recall that in these two treatments, principals choose contracts anew in each round and, thus, the number of agents in each matching group facing contract X or Y might change over time. Accordingly, we calculated the frequency for each matching group based on the actual number of agents facing the respective contract type.

[10]We applied Binomial tests and t–tests for *FCR* and *FCRR*, respectively.

(a) Contract X

Stage	*NFS*	*FS*	*FC*	*FCR*	*FCRR*
1	1 (1)	4 (0)	0 (0)	3 (1)	2 (0)
2	0 (0)	0 (0)	0 (0)	1 (1)	3 (3)
$1+2$	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)

(b) Contract Y

Stage	*NFS*	*FS*	*FC*	*FCR*	*FCRR*
1	3 (3)	2 (1)	0 (0)	7 (7)	6 (5)
2	1 (1)	3 (3)	0 (0)	4 (3)	5 (2)
$1+2$	0 (0)	1 (0)	0 (0)	2 (0)	2 (1)

Table 5: Number of rounds with at least weakly significant income–maximizing behavior (no. of significant cases in parentheses)

conclusions:

Conclusion 3 *In contrast to Hypothesis 2, only a minority of subjects maximizes their incomes and selects 'effort' in stage 1.*

Conclusion 4 *At stage 2, we observe only a small number of subjects behaving in line with Hypothesis 3.*

Over the two stages, we do not observe any significant income maximizing behavior for contract X, while for contract Y in at least 5 of the 50 cases subjects maximize their incomes. This observation led us to analyze possible differences between the two contract types.

5.2.2 Differences between contracts

Figure 5 displays the average frequency of income–maximizing decisions over the two stages (stage 1+2) for contracts X and Y. Applying a two-tailed χ^2–test on individual data (and a Mann–Whitney–U–test on matching groups) reveals that contract Y performs significantly better (in terms of income–maximization) than contract X in 14 of the 50 cases (10 rounds $\times$ 5 treatments). Similar holds true for the single stages, the respective number is 6 for stage 1 and 9 for stage 2.[11] Ana-

[11] Our observations imply that the maximin–criterion does not provide a complete explanation. To see this, note that for X and Y, contract rejection yields € 0.50 and contract acceptance (based on the maximin–criterion) yields a payoff of € 0.90. To ensure this payoff, agents must choose 'no effort' in stages 1+2. Given the observed differences in behavior at stages 1+2, there must be additional influences that guide subjects' behavior here. At stage 2 (ignoring behavior in stage 1), the maximin–criterion and income–maximization coincide for contract X, but not for contract Y. We find an increase of income–maximizing behavior under contract Y, however, which even contradicts the maximin explanation.

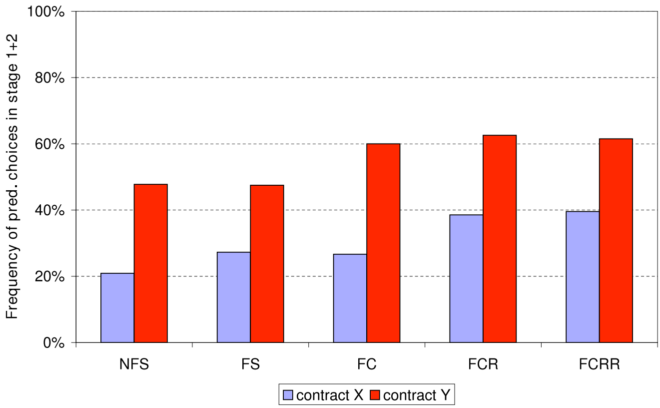


Figure 5: Frequency of income–maximizing decisions for the two contract types in stages 1+2 in the different treatments

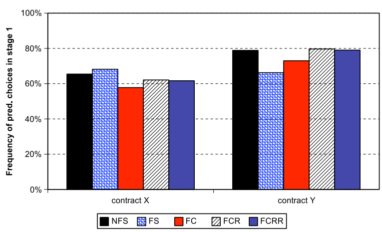
lyzing behavior aggregated over the first five rounds and over the last five rounds reveals a higher share of income–maximizing behavior under the monotone contract Y than under the non–monotone contract X from the first rounds on. This difference in behavior between contracts seem to increase over the rounds.

The previous result might suggest that, from a principal's point of view, contract Y is preferable since this contract induces 'effort' more often than contract X does (see figure 5 and table 5). This, however, is not the case, as the above result does not carry over to payoffs. In FS, FCR, and $FCRR$, contract X still generates a significantly higher payoff to principals than contract Y ($p < 0.07$, two-tailed exact Mann–Whitney–U test) given observed choices by the agents. In contrast, principals do select contract Y more often than predicted.

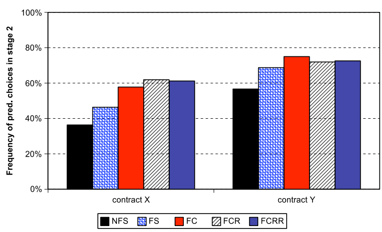
In order to find an explanation for observed agents' decisions, we investigate possible differences between treatments.

5.2.3 Treatment Differences

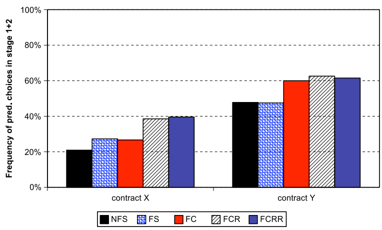
We find significant differences regarding income–maximizing behavior at stages 1+2 for contract X between treatment NFS on the one hand and treatments FCR and $FCRR$ on the other ($p < 0.05$, two-tailed exact Mann–Whitney–U test). In particular the combination of repetition and complete information significantly increases income maximizing behavior. Ceteris paribus, non–monotone contracts perform the better the less often agents (employees) interact with the same principal. Interestingly, this effect is more pronounced in the early rounds of the experiments. This suggests that the effect results from anticipation rather than from experience. More detailed investigations demonstrate that the observed differences in stage–1+2 behavior are mainly caused by differences in stage–2 behavior. Figure 6 presents the average individual frequency for each treatment and contract type for stage 1, stage 2, and stages 1+2.



(a) stage 1



(b) stage 2



(c) stages 1+2

Figure 6: Frequency of income maximizing behavior over treatments

What do treatment differences teach us about the appropriateness of non–monotone contracts? First of all, we do not find treatment differences for the monotone contract Y. As intuition would suggest the presence of an inferior alternative from the agents' point of view — the non–monotone contract X — does not significantly change their behavior, and it does not matter whether they repeatedly interact with principals or whether they are allowed to reject contract offers. Turning to the non–monotone contract, treatment differences exist between the NFS treatment and both the FCR and $FCRR$ treatment. Note that in the latter two treatments an agent interacts with the same principal *less* often than in the former treatment. As employment relationships usually feature repeated performance appraisals and corresponding bonus payments, non–monotone contracts are likely to perform worse than monotone ones based on our results. As such they add support for the prevalence of monotone contracts.

6 Conclusion

Theoretical research in labor economics and contract theory is often restricted to monotone or linear contracts, presumably because of the practical popularity of these types of contract. Such a confinement, however, neglects the fact that in many cases non–monotone contracts implement optimal incentive structures. Therefore, more insights into the behavioral effects of non–monotone contracts are needed.

In this paper, we test incentive–compatible monotone and non–monotone contracts in a setting where principals should choose the non–monotone one. We observe more income–maximizing agents under the monotone contract than under the — strategically equivalent — non–monotone contract. Nevertheless, even with agents' higher efforts under the monotone contract, principals' expected payoffs remain lower than under the non-monotone contract. In contrast, we observe the 'monotonicity puzzle', that is about every second principal chooses the monotone contract. Ruling out different explanations by our treatment design and comparing our data with results from Lukas (2007a), the experimental findings suggest that principals seem to prefer monotonicity because they proxy observable outcomes with unobservable effort which leads to a monotone contract as the highest possible output is associated with the highest possible effort. Clearly this output–effort heuristic results in suboptimal contract design if incentive compatibility calls for non–monotone contracts. Furthermore, given that the theoretically optimal non–monotone contract is chosen, it performs worse if there is repeated interaction. Thus, our paper provides one possible experimental explanation for the popularity of monotone contracts in real–world labor markets.

A Appendix A: Tables

effort	output sequence			
	(x^L, x^L)	(x^H, x^L)	(x^L, x^H)	(x^H, x^H)
$(0, 0)$	0.463	0.264	0.138	0.136
$(0, 1)$	0.402	0.200	0.198	0.200
$(1, 0)$	0.110	0.344	0.090	0.456
$(1, 1)$	0.066	0.136	0.134	0.664

Table 6: Probabilities of net payoffs

	contract		contract	
	X	Y	X	Y
output seq.	2nd mover (agent)		1st mover (principal)	
(x^L, x^L)	0.90	0.90	0.60	0.60
(x^H, x^L)	1.30	1.30	1.20	1.20
(x^L, x^H)	3.40	3.00	1.20	1.60
(x^H, x^H)	3.00	3.40	1.80	1.40

Table 7: State contingent payoffs (in €) under different contracts

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