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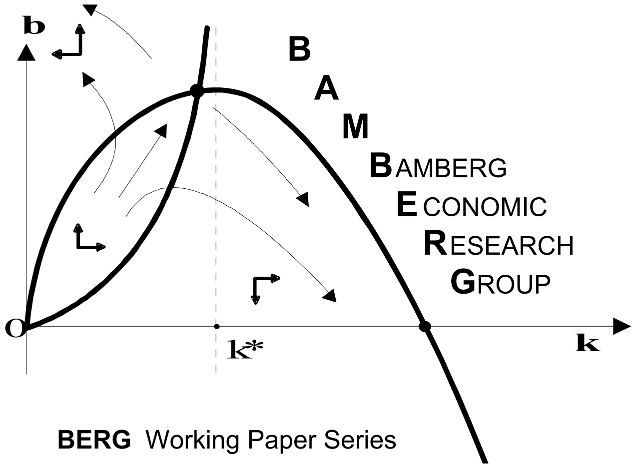

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Round-Robin Tournaments in the Lab: Lottery Contests vs. All-Pay Auctions

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Abstract

We conduct a laboratory experiment to compare the fairness and intensity of round-robin tournaments with three symmetric players, a single prize, and two alternative match formats. Matches are either organized as lottery contests or all-pay auctions. Whereas we confirm the theoretical prediction that tournaments are less fair if matches are organized as all-pay auctions, we reject the predicted difference in tournament intensity. Moreover, the reason for the reduced fairness of tournaments based on all-pay auctions is also at odds with theory. In the lab, such tournaments heavily disfavor (in payoff-terms) the player acting in the final two matches. The reason is the substantially weaker than predicted discouragement of this player when competing first against the loser of the first match. Subjects try to exploit a perceived negative psychological momentum in such situations but only manage to end up in a dissipation trap: an effort-intense, final-like last match which significantly reduces their payoffs.

Keywords: Sequential Round-Robin Tournament; Lottery Contest; All-Pay Auction; Laboratory Experiment; Discouragement Effect; Dissipation Trap

JEL classification: C72, C91, D72, Z20

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1 Introduction

Randomness, or luck, is an inherent element of most contests. Its role, though, varies from case to case. It may be influenced by, inter alia, the nature of the competition (e.g., poker vs chess), the natural environment (e.g., influence of the weather in outdoor sports vs indoor sports), and the legal institutions (e.g., use of video assistants in refereeing). Clearly, some of those rules can be manipulated by the contest designer to influence, e.g., the intensity, fairness, or dynamics of the contest.

In contest theory, randomness is formally captured by the contest success function (*CSF* henceforth). It relates the contestants' efforts to their winning probabilities.[1] Two of the most prominent CSFs in the contest literature are particular versions of the Tullock contest (Tullock, 1980), namely the lottery contest (LC henceforth) and the all-pay auction (APA henceforth). While the APA is perfectly discriminating and always awards the contest prize to the contestant with the highest effort, the LC awards the prize randomly such that a contestant's probability of winning is given by the ratio between her own effort and the aggregate effort of all contestants. A comparison of the APA and the LC has received considerable attention in the literature, both theoretically (see, e.g., Ellingsen, 1991, Che and Gale, 1997, Fang, 2002, Alcalde and Dahm, 2010, Epstein et al., 2011, 2013, Franke et al., 2014, and Konrad, 2009, Chapter 2 for a survey) and experimentally (see, e.g., Millner and Pratt, 1989, Davis and Reilly, 1998, Potters et al., 1998, and Dechenaux et al., 2015 for a survey). A central result is that the APA is more intense than the LC in static environments as long as contestants are not too heterogeneous.

Results on static contests are, however, of limited interest as many real-world contests feature a more complex dynamic structure where the grand contest is composed of a sequence of many component contests or *matches* (see, e.g., Konrad, 2009, Chapter 8). Prominent examples are races (where the overall winner is the contestant who is the first to win a given number of matches), elimination tournaments (a sequence of matches, where only the winners proceed to the next round until only one contestant is left), or round-robin tournaments (where each contestant is matched with every other contestant and the overall winner is the contestant who wins the most matches). Analyzing the impact of the CSF in such dynamic contests has received much less attention in the literature. Moreover, results for static contests are not directly applicable as dynamic phenomena like the *discouragement effect* need to be taken into account.[2]

Among dynamic contest formats, round-robin tournaments (*RRT*s henceforth) have so far received the least attention in the contest literature, although they are frequently used in practice, especially in major sport competitions.[3] Recent theoretical contributions on strategic behavior in sequential RRTs show that, in general, the intensity and fairness critically depend on the discriminatory power of the CSF (Laica et al., 2021). In particular, Krumer et al. (2017) and Sahm (2019) analyze sequential RRTs with three symmetric participants and a single prize for the player ranked first. For matches organized as APAs, Krumer et al. (2017) show that the RRT is not fair, as a contestant's ex-ante winning prob-

[1] Szymanski (2003) discusses the role of the contest success function in sports.

[2] See, e.g., Konrad (2012) for a theoretical treatment, Davis and Reilly (1998), Zizzo (2002), and Llorente-Saguer et al. (2019) for experimental evidence, and Malueg and Yates (2010), Iqbal and Krumer (2019), and Sonnabend (2020) for empirical evidence.

[3] Examples include the the major European soccer leagues (including the English Premier League) with up to 20 teams, the first rounds (group or pool stages) of Rugby World Cups (since 1987), FIFA Soccer World Cups (since 1950) with down to only four teams, and the Olympic preliminaries of Badminton (since 2012) or Wrestling (2000, 2004) with three teams.

ability and expected payoff depend on her position in the sequence (with a considerable advantage for the contestant who competes in the first and the last match). The reason are pronounced asymmetries in intermediate continuation payoffs causing a strong discouragement effect for the contestant who competes in the last two matches. In contrast, Sahm (2019) shows that the RRT is almost fair (with a slight disadvantage for the player who competes in the first and the last match), if matches are organized as LCs because the discouragement effect is much less pronounced than with APA-matches. Moreover, the aggregate expected effort is smaller with APA-matches than with LC-matches. Empirically, Krumer and Lechner (2017) analyze data from the Olympic Wrestling competitions (organized as three-player RRTs) and show that the wrestler competing in the first and last match has a significantly higher probability to win the tournament, but the effect is much smaller than theory predicts with APA-matches and it does not seem to be induced by the discouragement effect of the wrestler who competes in the last two matches. More generally, evidence from the NBA (Taylor and Trogdon, 2002), the NHL (Fornwagner, 2019), and the German Soccer Bundesliga (Deutscher et al., 2022) suggests that contestants exhibit forward-looking behavior. Lauber et al. (2023) conduct the first experimental test of behavior in three-player RRTs with matches organized as APAs and different prize structures. They confirm many theoretical predictions, but also show that intensity is higher than predicted, especially in RRTs with a single prize, and that dynamic behavior is also subject to a psychological momentum.

This paper is the first to experimentally test the impact of the CSF (APA or LC) on the intensity, fairness, and dynamics of a three-player RRT. It therefore contributes to three strands of the (experimental) literature: the comparison of LC and APA, the analysis of dynamic contests, and, more specifically, the study of RRTs.

Our findings can be summarized as follows: First, subjects significantly overbid compared to the theoretical predictions in both treatments. Whereas overbidding remains stable across rounds in the LC-treatment, we observe learning effects in the APA-treatment that reduce overbidding with experience for the two players who compete in the first match. Second, we cannot confirm that the tournaments differ in intensity: a subject's overall effort choice per tournament in the LC-treatment is not significantly different from the one in the APA-treatment. Third, RRTs with APA-matches are less fair than RRTs with LC-matches, but the difference is marginally significant. Fourth, RRTs with APA-matches heavily disfavor the player acting in the last two matches in terms of payoffs (but not winnings). In RRTs with LC-matches, the player acting in the last two matches wins and earns significantly more than the player acting in the first and last match, but winnings and earnings of these players do not differ significantly from winnings and earnings of the player acting in the first two matches. Fifth, the player acting in the last two matches is not as strongly discouraged as predicted by theory if she competes first against the loser of the first match. This holds especially in RRTs with APA-matches where this player is predicted to effectively drop out of the RRT. Instead, subjects in this player-role seemingly try to exploit a negative momentum of the first match loser and therefore choose a significantly higher effort than predicted. As a result, they often end up in a final-like, effort-intense last match – a *dissipation-trap*. This explains why these subjects have significantly lower payoffs than the others, and why there is no difference in intensity between our treatments.

The remainder of this paper is organized as follows: In Section 2, we briefly present the theoretical predictions and derive our hypotheses. In Section 3, we summarize our experimental design and procedures. The experimental results are presented in Section

4. Section 5 concludes.

2 Theory and Hypotheses

In this section, we formally introduce the game, sketch the theoretical findings , and derive our hypotheses. For a general theoretical analysis of round-robin tournaments see Laica et al. (2021).

2.1 The Game

We consider a RRT with three symmetric, risk-neutral players striving to win a single prize. In the RRT, each player is successively matched one-to-one with each other player in a sequence of three pairwise matches. Without loss of generality, we consider an exogenous sequence in which Player 1 meets Player 2 in the first match, Player 1 meets Player 3 in the second match, and Player 2 meets Player 3 in the third match. Apart from renaming players, this exogenous sequence is unique. Matches are either organized as LCs or as APAs and we refer to an RRT with LC-matches (APA-matches) as an *LC-tournament* (*APA-tournament*). The winner of the RRT depends on the final ranking which is determined according to the number of victories:[4] if there is a player with two victories, this player wins the prize; if there is a tie because each player has won one match, the prize is assigned randomly with equal probabilities of 1/3 for each player. For risk-neutral players, the tie-breaking rule is equivalent to sharing the prize equally. The value of winning the prize is identical for all players and given by $R > 0$.

The structure of the resulting sequential game with its $2^3 = 8$ potential courses is depicted in Figure 1 (henceforth game tree; see below). The seven nodes $k \in \{\text{A}, \ldots, \text{F}\}$ of the game tree represent all combinations for which the ranking of the tournament has not yet been determined when the respective match starts.

Player $i \in \{A, B\}$ chooses effort x_i^k in match k in order to maximize his expected payoff

$$E_i^k = p_i^k \left(w_i^k - x_i^k\right) + \left(1 - p_i^k\right) \left(\ell_i^k - x_i^k\right), \tag{1}$$

where w_i^k denotes Player i's expected continuation payoff from winning the match and ℓ_i^k denotes his expected continuation payoff from losing it, with $w_i^k \geq \ell_i^k \geq 0$ for $i \in \{A, B\}$. The probability p_i^k that Player $i \in \{A, B\}$ wins match k is a function of the effort choices of both players and depends on how the matches are organized: in LC-tournaments, Player A's probability of winning match k is defined by (Tullock, 1980; Skaperdas, 1996)

$$p_A^k = \begin{cases} 1/2 & \text{if } x_A^k = x_B^k = 0, \\ \frac{x_A^k}{x_A^k + x_B^k} & \text{else,} \end{cases}$$

and in APA-tournaments, it is defined by (Baye et al., 1996)

$$p_A^k = \begin{cases} 1 & \text{if } x_A^k > x_B^k, \\ 1/2 & \text{if } x_A^k = x_B^k, \\ 0 & \text{if } x_A^k < x_B^k. \end{cases}.$$

[4]As customary in the theoretical literature on contests, we abstract from draws. Indeed, many sports waive draws.

2.2 Subgame-Perfect Equilibria

In the following analysis, we recollect the theoretical predictions by Sahm (2019) for LC-tournaments and by Krumer et al. (2017) for APA-tournaments.

We note first that for $w_A^k = \ell_A^k$, the optimal choice in a single match is $x_A^k = 0$ for any $x_B^k \geq 0$. If $x_A^k = 0$ and $w_B^k > \ell_B^k$, Player B will have no best reply unless there is a smallest monetary unit $\epsilon > 0$. As $\epsilon \to 0$, in the limit, $x_B^k \to 0$ and $p_B^k \to 1$. Otherwise, in match k for $i, j \in \{A, B\}$ with $i \neq j$ and $w_i^k - \ell_i^k = \min\{w_A^k - \ell_A^k, w_B^k - \ell_B^k\}$, a unique Nash-equilibrium always exists.

In LC-tournaments, the Nash equilibrium is in pure strategies and has the following properties (Sahm, 2019): the equilibrium efforts are

$$x_i^k = \frac{(w_i^k - \ell_i^k)^2 (w_j^k - \ell_j^k)}{(w_i^k - \ell_i^k + w_j^k - \ell_j^k)^2}, \tag{2}$$

the equilibrium winning probabilities are

$$p_i^k = \frac{(w_i^k - \ell_i^k)}{(w_i^k - \ell_i^k) + (w_j^k - \ell_j^k)}, \tag{3}$$

and the expected equilibrium payoffs are

$$E_i^k = \ell_i + \frac{(w_i^k - \ell_i^k)^3}{(w_i^k - \ell_i^k + w_j^k - \ell_j^k)^2}. \tag{4}$$

In APA-tournaments, the Nash Equilibrium is in mixed strategies and has the following properties (Krumer et al., 2017): for $(w_i^k - \ell_i^k) \leq (w_j^k - \ell_j^k)$ the expected equilibrium efforts are

$$E(x_i^k) = \frac{(w_i^k - \ell_i^k)^2}{2(w_j^k - \ell_j^k)} \quad \text{and} \quad E(x_j^k) = \frac{w_i^k - \ell_i^k}{2}, \tag{5}$$

the equilibrium winning probabilities are

$$p_i^k = \frac{w_i^k - \ell_i^k}{2(w_j^k - \ell_j^k)} \quad \text{and} \quad p_j^k = 1 - p_i^k, \tag{6}$$

and the expected equilibrium payoffs are

$$E_i^k = \ell_i^k \quad \text{and} \quad E_j^k = w_j^k - (w_i^k - \ell_i^k). \tag{7}$$

The tournament represents a sequential game that can be solved by backward induction for its subgame perfect equilibrium (SPE), making repeatedly use of equations (2)-(4) for LC-tournaments and equations (5)-(7) for APA-tournaments; see Sahm (2019) and Krumer et al. (2017) for details.

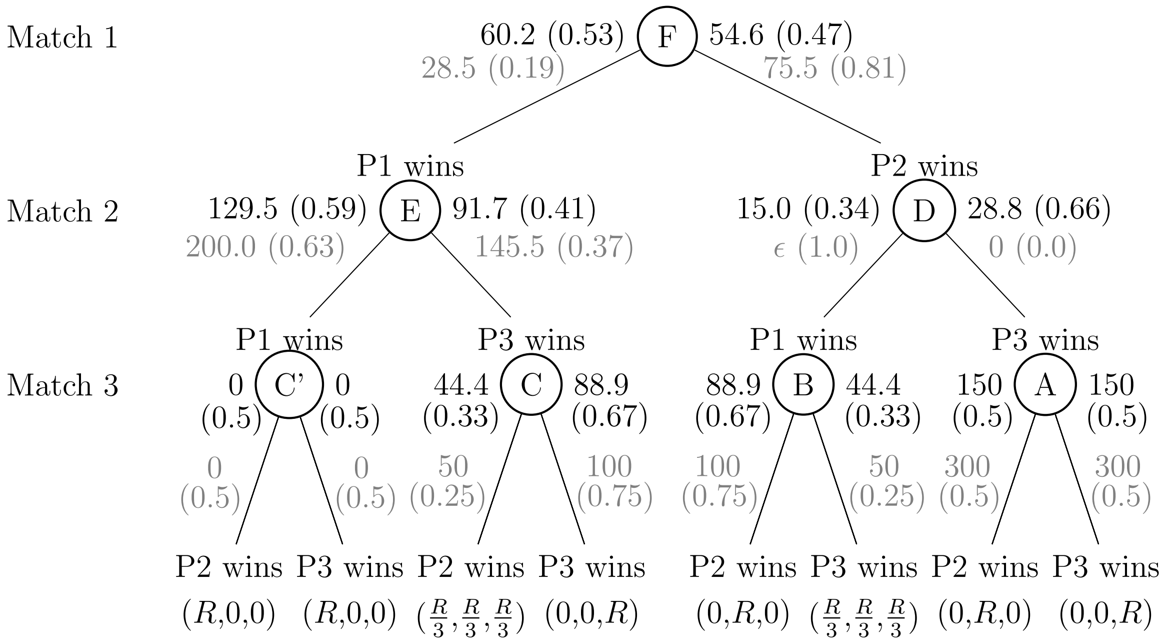
Table 1 contains the predictions for $R = 600$, the value (in points) we use in our experiment. The columns contain the equilibrium values of each player's ex-ante expected *tournament effort* (sum of effort across her two matches), winning probability for the entire RRT, and payoff for the LC- and the APA-tournament, respectively. Additionally, we report the corresponding sum of tournament efforts across players (*intensity*), relative standard deviations (*RSD*), and Gini coefficients. Figure 1 presents the predicted (expected) efforts and winning probabilities in the individual matches along the potential

Table 1: Ex Ante Expected SPE-Values

	Tournament Effort		Winning Probability		Payoffs	
	LC	APA	LC	APA	LC	APA
Player 1	135.3	67.1	0.349	0.193	74.3	49
Player 2	125.6	160.1	0.307	0.682	58.7	249
Player 3	135.2	74.9	0.344	0.125	70.9	0
Aggregate	396.1	302.0	1	1	203.9	298.0
RSD	0.035	0.418	0.056	0.744	0.099	1.084
Gini	0.016	0.205	0.028	0.371	0.051	0.557

Note: RSD$\triangleq$ relative standard deviation; Gini$\triangleq$ Gini coefficient.

courses of the RRT.



Note: Numbers to the left (right) of a node and its downward edges denote the predicted effort and winning probability of the lower-(higher-)numbered player in the given match. Winning probabilities are in brackets. Black (gray) numbers denote predictions for the LC-(APA-)tournament.

Figure 1: Predicted Efforts and Winning Probabilities in Individual Matches

The table and figure illustrate several findings by Krumer et al. (2017) and Sahm (2019). First, the APA-tournament is highly discriminatory to the favor of Player 2. Whereas Player 2 expects to win more than two out of three RRTs and to earn 41% of the prize value, Player 3 expects to win rarely and to earn nothing. The main reason is a strong *discouragement effect* of Player 3 in node D of the APA-tournament where she invests substantially less than in node E. In fact, Player 3's expected continuation payoff is zero in node D and she invests no effort at all. In contrast, the LC-tournament is almost fair: Expected winning probabilities of all three players differ by less than five percentage points, and expected payoffs by less than three percent of the prize value. Indeed, Player 3 has an expected continuation payoff larger than zero in node D of the LC-tournament and, therefore, exerts positive effort. As a consequence, Sahm (2019) finds that intensity, i.e. expected aggregate effort measured by the sum of all players' expected effort, is higher for LC-tournaments (66 percent of the prize) than for APA-tournaments (50 percent of the prize).

2.3 Hypotheses

The above predictions give rise to the following testable hypotheses.

Hypothesis 1. *APA-tournaments are less intense than LC-tournaments where intensity is measured by the sum of efforts across players and matches.*

Hypothesis 2. *APA-tournaments are less fair than LC-tournaments where (un)fairness is measured by the dispersion of winnings and/or payoffs across players (e.g., via the relative standard deviation or the Gini coefficient).*

Hypothesis 3. *APA-tournaments favor Player 2, i.e. Player 2 wins more frequently and earns more than the other players. In contrast, winning probabilities and earnings do not differ significantly by player number in LC-tournaments.*

Hypothesis 4. *A win of Player 2 in the first match discourages Player 3 who invests less than after a win of Player 1. Discouragement is larger in the APA-tournament than in the LC-tournament.*

3 Experimental Design and Procedure

We test the hypotheses outlined in Section 2 with the help of a laboratory experiment. This enables us to investigate the influence of the sequential structure combined with the institutional character under controlled conditions. Below, we describe the design and the procedure of the experiment.

3.1 Design

We conduct an experiment with two treatments in a between-subject design. In each treatment, subjects play 20 independent repetitions (*periods* henceforth) of a sequential three-player RRT with a single prize of $R = 600$ points awarded either to the subject who wins both matches or randomly to one of the subjects if each wins one match. A subject's player number is randomly determined in the beginning and fixed across periods. Hence, a subject plays *each* RRT either as Player 1, Player 2, or Player 3. In contrast, each subject is randomly (re-)matched with two other subjects in each period.

Matches are organized as chosen-effort contests: In each repetition, each subject receives an initial endowment of $I = 600$ points which she can use to invest in her two matches.[5] Hence, in each RRT each subject can invest any integer number of points $Q_1 \in [0, 600]$ in her first match, and any integer number of the remaining points $Q_2 \in [0, 600 - Q_1]$ in her second match. Treatments differ with respect to the CSF applied in each match, which is either a lottery-contest (treatment LC) or an all-pay auction (treatment APA).

[5] An initial endowment per period which is equal for all subjects is supposed to not account for significant individual distortions in each subject's effort choices (see, e.g., Sheremeta, 2011; Price and Sheremeta, 2011, 2015).

The following feedback is provided to subjects: At the end of each match, the winner is announced to all three participants in the RRT, but the invested points are only revealed to the two participants in the given match.[6] Throughout the RRT, subjects are briefed on their current account of points, the results of previous matches, the points invested by both players in all previous matches they participated in, and the current standings. Player number, match plan and prize value are continuously displayed. At the end of a RRT, each subject learns her final payoffs and whether the winner of the RRT was univocal or determined by a random draw.

As individual characteristics of subjects, such as risk aversion or cognitive reflection, are known to influence behavior in contests, we attempt to control for these in our statistical analysis. Hence, each session (of each treatment) is segmented into three parts. In part 1, we elicit subjects' risk preferences following Holt and Laury (2002).[7] The RRTs are played in part 2. In part 3, we implement an incentivized cognitive reflection test (CRT) similar to Frederick (2005). Finally, subjects fill out a post-experimental questionnaire providing self-assessments on further characteristics, and demographics.

3.2 Procedures

Four sessions were conducted for each treatment. The sessions took place at the experimental laboratory of the department of social sciences at the University of Bamberg ("BLER") from November 2016 to May 2017. Participants were invited via the ORSEE recruitment system (Greiner, 2015). Either 15 or 18 subjects participated in a session; 138 subjects in total split equally between the two treaments. On average a session lasted 90 minutes. The experimental sessions were computerized using zTree (Fischbacher, 2007).

Upon arrival, subjects were randomly assigned to cubicles with a single computer that did not allow for any visual communication between them. Each cubicle contained a pen as well as a sheet with basic instructions informing subjects about the general rules of behavior, the show-up fee, and the point-to-cash conversion rate (the English translations of all instructions are provided in Appendix B). Once all participants were seated, the experimenters emphasized that no verbal communication between participants was permitted during the experiment.

Instructions for the first two experimental parts were distributed on paper at the beginning of the respective part. Subjects first had time to read them at their own pace before one of the experimenters read them aloud. Questions were permitted at all times during the instruction phases. The instructions for part 2 were followed by a short paper-based control questionnaire to verify the participants' full understanding of the instructions. Subjects had time to fill them out at their own pace. Afterwards, the experimenters revised each subject's answers individually and explained the correct answer if necessary. Instructions for part 3 were not distributed but only read out aloud by one of the experimenters at the beginning of the part. Each subject was then sequentially presented with three questions on her computer screen and received 40 seconds to enter her

[6] We do so to prevent players from exploiting budget constraints of other players. Equilibrium effort choices are not affected by this aspect. In practice, some intensity is never observable and perceived only as a participant.

[7] Each subject was presented with a table of ten ordered decisions between a safe amount of 180 points and a risky lottery yielding 400 points or 0 points. The probability to receive the 400 points increased across rows from 0.1 to 1.0 in steps of 0.1. Subjects were asked to submit their choices via the computer. Only one out of the ten decisions was paid. The payoff-relevant row as well as the payoff of the risky lottery were each randomly determined by the throw of a ten-sided dice at the end of the experiment.

answer. Subjects could earn EUR 0.50 per correct answer. A fourth question examined, how many of the questions had already been known to the subject before the experiment. Finally, subjects were asked to fill out a short questionnaire at the computer consisting of some demographic questions and some questions related to the experiment, before collecting their earnings.

Earnings consisted of (i) the points earned in one randomly selected decision from part 1 (determined by the throw of a ten-sided dice), (ii) the points earned in one randomly selected period from part 2 (determined by the throw of a 20-sided dice), with points converted into cash at the rate 1 Point = EUR 0.01, (iii) the cash earned in part 3, and (iv) a show-up fee of EUR 4.00. Average earnings were EUR 14.42 per subject.

4 Results

The presentation of our results closely follows the four hypotheses derived above. Before presenting our hypothesis tests in Subsections 4.2 to 4.5, however, we first investigate behavioral dynamics across periods to detect and account for potential learning effects.

4.1 Behavioral changes across periods

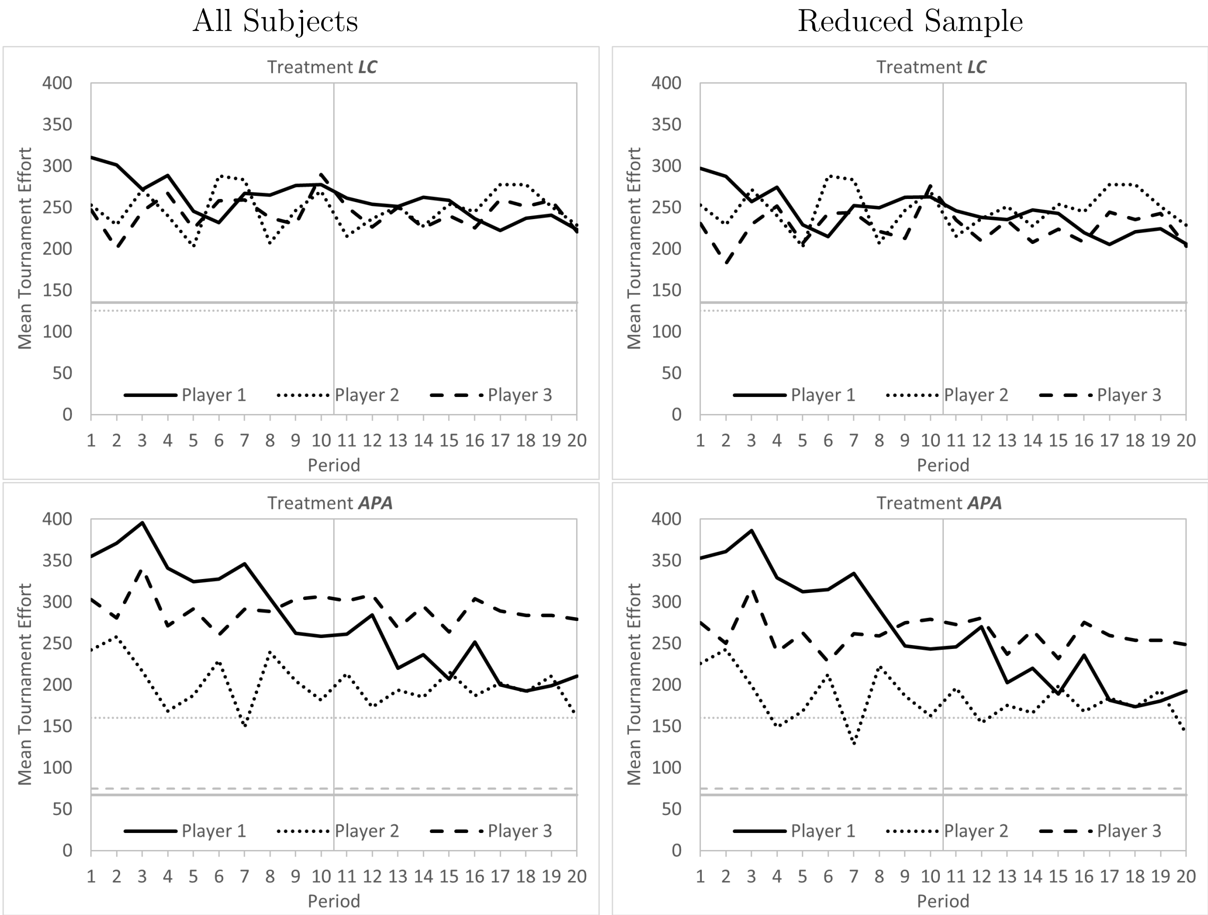
Figure 2 illustrates the evolution of the mean tournament effort across periods by player type. In each figure, the black solid (dotted; dashed) line depicts the mean tournament effort for Player 1 (2; 3), and the gray line of the same shape depicts the corresponding equilibrium prediction. The upper (lower) panel shows the results for treatment LC (APA). In addition, the right panel excludes six subjects (two in treatment LC, and four in treatment APA) who invest their entire endowment in at least 19 out of 20 periods. These subjects seem to not have understood the task, viewing it as one of optimally splitting the endowment between their two matches. The left panel of Figure 2 covers all subjects.

The figure illustrates two important findings: First, there is a clear downward trend of tournament efforts across the first periods in treatment APA, whereas tournament efforts hardly change across periods in treatment LC. In treatment LC, the mean tournament effort across the first (last) ten periods of subjects in the respective role equals 273.4 (244.6) for Player 1, 249.0 (246.4) for Player 2, and 245.7 (240.7) for Player 3. In treatment APA, the corresponding means are 328.6 (226.2) for Player 1, 207.6 (193.4) for Player 2, and 293.8 (287.7) for Player 3.[8] Second, subjects overinvest quite substantially relative to equilibrium predictions (except for subjects acting as Player 2 in treatment APA).

To obtain statistical evidence for these observations, we estimate panel models of the total tournament effort with subject-specific random effects and robust standard errors clustered at the session level. As explanatory variables, we include a dummy for treatment APA, dummies for the player numbers, the inverse of the period number, and the full set of interactions between these variables. Further specifications also control for subjects' demographics and self-assessments.

The results are presented in Table A.1 in the appendix. They show that subjects in the role of Player 1 significantly decrease their total tournament effort across periods in both treatments, whereas changes of total tournament effort across periods are not significant for subjects in the other player roles in both treatments. In addition, Chi-square tests

[8] Unsurprisingly, mean tournament efforts in the reduced sample are lower by ten to twenty points for the affected player types, but show similar trends across periods.



Note: Gray lines depict the theoretical benchmarks.

Figure 2: Average effort per tournament

confirm that subjects overbid relative to the equilibrium predictions in both treatments, all periods, and all player roles.

Based on these results, we focus subsequently on decisions made by subjects in the reduced sample in the last ten periods.[9] Results for the complete dataset including all periods and subjects are presented in the appendix.

4.2 Intensity

Table 2 contains the average tournament effort, relative frequency of winning the tournament, and average payment in the experiment, separated by treatment and player role, in correspondence with Table 1.[10]

The table suggests that LC-tournaments are indeed more intense than APA-tournaments, but the difference is small and the order reverses once we take all periods and

[9]To assess how fast behavior stabilizes, we re-estimate the models and gradually exclude the first periods. The results are available from the authors upon request. The period trend becomes insignificant for all players in all treatments once we focus on the last 8 periods, but it is insignificant for all but one player when focusing on the last 11, 10, or 9 periods and the significance level for this player is ten percent. As a compromise, we decided to focus on the last ten periods.

[10]In Section 4, we consistently use payments (payoffs including endowments) rather than payoffs to avoid negative values for the inequality measures. In addition, the relative frequencies of winning the tournament in Table 2 are calculated only from tournaments won by subjects in the reduced sample; see the appendix for the corresponding table based on the complete dataset.

Table 2: Overview of Experimental Results (Averages)

	Total Effort		Rel. Winning Freq.		Payments	
	LC	APA	LC	APA	LC	APA
Player 1	228.5	209.2	0.326	0.393	562.4	611.7
Player 2	246.4	174.9	0.307	0.330	525.8	610.5
Player 3	224.4	257.9	0.367	0.277	591.1	505.0
Aggregate	699.3	642.0	1.0	1.0	1,679.3	1,727.2
RSD	0.041	0.159	0.076	0.143	0.048	0.087
Gini	0.021	0.086	0.040	0.078	0.026	0.041

Note: RSD$\triangleq$ relative standard deviation; Gini$\triangleq$ Gini coefficient.

subjects into account.

We pursue two avenues to statistically test for differences in intensity between treatments. First, we conduct a t-test of session averages and find no evidence of a statistically significant treatment difference (in a one-sided t-test for the equality of session averages, the p-value that session averages are larger in treatment LC equals 0.319). Second, we run panel regressions of the total tournament effort with subject-specific random effects and treatment dummies as explanatory variables. Further specifications also include the player role fully interacted with the treatment, and various controls. The results are presented in Table A.3 in the appendix and identify no treatment differences, either. This leads us to the following conclusion:

Result 1. *APA- and LC-tournaments are equally intense.*

As a side remark, we find no consistently significant impact of the player role, risk aversion, and cognitive reflection on total tournament effort. Subjects who are older or assign a higher importance to winning the tournament invest more. Subjects assigning a higher importance to their final earning invest less.

4.3 Fairness

Table 2 seems to indicate a higher fairness of LC-tournaments compared to APA-tournaments, as relative frequencies of winning and payments are more dispersed in the latter (when dispersion is measured by the relative standard deviation or the Gini coefficient). In treatment APA, subjects acting as Player 3 are the least successful, winning almost 12% less tournaments and getting paid more than 17% less than subjects acting as Player 1 (the most successful player role). In treatment LC, the difference between the least successful player role (Player 2) and the most successful player role (Player 3) is only 6% in terms of the relative frequency of tournaments won and 11% in terms of payments (earnings including endowment).

To formally test for a statistically significant treatment difference regarding fairness, we calculate for each session the relative frequency of winning and the average payment of each player and the RSD and the Gini coefficient of these session averages across players, and we compare treatments using a t-test on the session-specific values.

Table 3 contains the results showing that relative frequencies of winning and payments are more dispersed in treatment APA. The treatment, where the treatment difference is marginally significant for winning frequencies, and marginally insignificant for payments.

Table 3: Measures and Tests of Fairness of the Lab Tournaments

	Relative Winning Frequency			Payments		
	LC-mean	APA-mean	p-value	LC-mean	APA-mean	p-value
RSD	0.179	0.376	0.062	0.091	0.123	0.148
Gini	0.075	0.162	0.061	0.039	0.052	0.153

Note: RSD$\triangleq$ relative standard deviation; Gini$\triangleq$ Gini coefficient. p-values stem from a one-sided t-test of equality of means against the alternative hypothesis, that the APA-mean is larger.

However, we also obtain significance for payments at the 5% significance level if we include all observations (see Table A.5 in the appendix; significance for winning frequencies remains marginal for the RSD and disappears for the Gini coefficient). We therefore tentatively conclude:

Result 2. *LC-tournaments are marginally fairer than APA-tournaments.*

4.4 Winning Probabilities and Payments

Regarding Hypothesis 3, Table 2 already indicates marked deviations from theoretical predictions: Contrary to predictions, LC-tournaments in the lab seem to favor Player 3 and disfavor Player 2 in terms of relative frequencies of winnings and payments. Moreover, APA-tournaments in the lab seem to strongly disfavor Player 3, while Players 1 and 2 achieve similar payments (though Player 1 seems to win more frequently, she also invests more).

We statistically test Hypothesis 3 by estimating logit panel models of players' probabilities to win the tournament, and panel regression models of players' payments. The models include as explanatory variables dummies for the player number (with Player 3 as the baseline) fully interacted with treatment dummies and account for subject-specific random effects. Further specification also incorporate our control variables. Finally, the panel regression models account for the possible clustering of standard errors at the session level. The results are provided in Table 4.

The estimation results show that Player 3 is significantly more likely to win the tournament and earns significantly more than Player 2 in LC-tournaments whereas Player 1's winning probability and payment are in between and do not differ significantly from those of the other players (comparison between Players 1 and 2 are based on a Chi-square test). In APA-tournaments, there are no significant differences in the probability to win between players, but Player 3 earns significantly less than the other two players (who earn almost the same). We therefore conclude, in contrast to Hypothesis 3:

Result 3. *APA-tournaments significantly disfavor Player 3 compared to the other players in terms of payment (but not winning probability). LC-tournaments favor Player 3 over Player 2 in terms of winning probability and payment.*

4.5 Tournament dynamics

To understand why the distribution of winning probabilities and payments across players differs so markedly from theoretical predictions, especially in APA-tournaments, and to test our final hypothesis, we consider effort choices and resulting relative frequencies of

Table 4: Panel Estimations for Winning Probabilities and Payments

Dep. Variable	Winning Probability		Payment	
Model Type	(Logit Panel Model)		(Linear Panel Model)	
Model	(1)	(2)	(3)	(4)
Constant	-0.679***	-0.108	591.05***	591.90***
	(0.237)	(0.748)	(25.185)	(79.066)
APA-Treatment	-0.491	-0.359	-86.10*	-89.62**
	(0.346)	(0.318)	(46.626)	(43.051)
LC × Player 1	-0.165	-0.367	-28.62	-31.57
	(0.334)	(0.311)	(37.432)	(45.898)
LC × Player 2	-0.360	-0.539*	-65.28**	-71.447**
	(0.334)	(0.311)	(28.596)	(30.745)
APA × Player 1	0.552	0.221	106.73***	105.81***
	(0.345)	(0.329)	(25.387)	(24.305)
APA × Player 2	0.224	0.362	105.59***	95.162***
	(0.349)	(0.319)	(33.751)	(27.636)
Control Variables	No	Yes	No	Yes
Observations	1,320	1,320	1,320	1,320
Subjects	132	132	132	132
Log-likelihood	-796.7	-777.9		
R^2			0.025	0.059

Note: Standard errors in parentheses, accounting for clustering at the session level in models (3) and (4). All models include a subject-specific random effects error structure.
Significance level: *** (1%), ** (5%), * (10%)

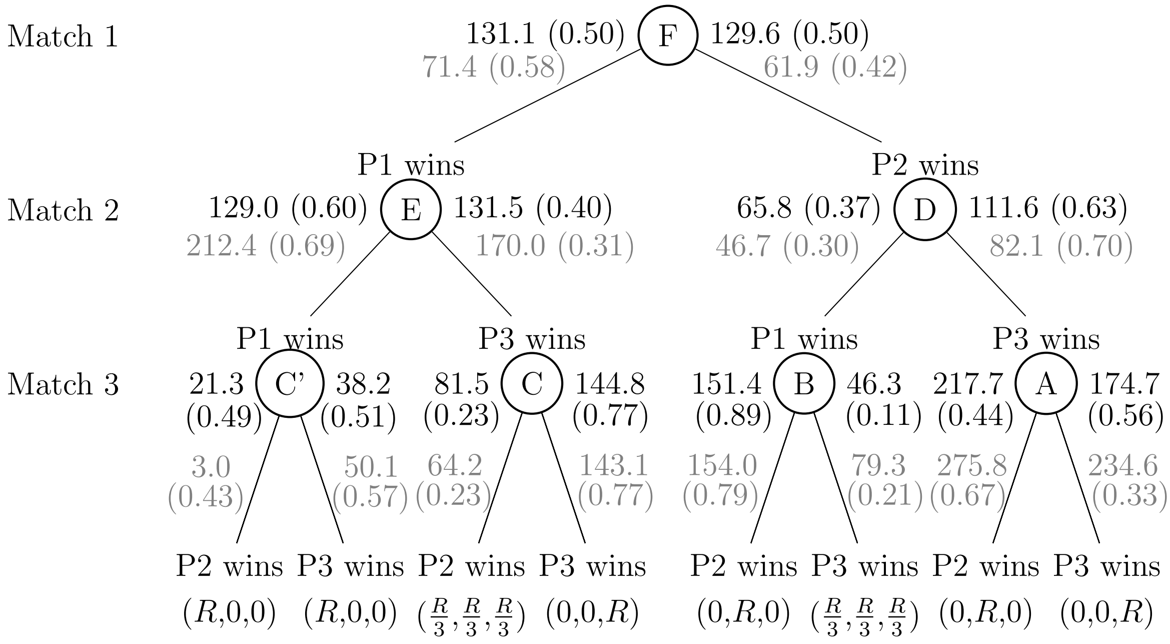
winning in the individual matches along the potential courses of the RRT. To that end, Figure 3 represents the empirical counterpart of Figure 1.[11]

The figure shows that, barring overbidding, behavior and winning frequencies in individual matches closely track theoretical predictions in LC-tournaments. The same holds for the majority of possible matches in APA-tournaments, but with two important exceptions: The first match (node F in the figure) and the second match after a win by Player 2 (node D in the figure). In the latter situation, theory predicts a strong discouragement of Player 3. Indeed, Player 3 is predicted to effectively drop out of the tournament as a win against Player 1 would lead to a cut-throat competition in the final match against Player 2, leaving Player 3 with nothing to gain in node D. In sharp contrast to this prediction, subjects in the role of Player 3 invest substantially in this situation, outbidding Player 1 almost two-to-one and winning in 70 percent of those matches. A panel regression of the propensity to win in node D on a player dummy confirms that Player 3 is significantly more likely to win than Player 1.[12]

These observations clearly suggest that no *discouragement effect* for Player 3 occurs in node D, at least not as strongly as theoretically predicted. Instead, Player 3 seemingly

[11] Average efforts are, as before, based on the choices of subjects in the reduced sample made in the last ten periods. Relative frequencies of winning are, in addition, based on only those matches in which both players belong to the reduced sample since otherwise the probabilities of a node's leaving edges could sum to less than one (with the remaining matches won by excluded subjects). Results for the complete dataset are presented in the appendix.

[12] The results are available upon request.



Note: Numbers to the left (right) of a node and its downward edges denote the average effort and relative frequency of winning of the lower-(higher-)numbered player in the given match. Relative frequencies of winning are in brackets. Black (gray) numbers denote results for the LC-(APA-)tournament.

Figure 3: Average Efforts and Relative Frequencies of Winning in Individual Matches

tries to exploit a negative psychological momentum by Player 1.[13] As a consequence of this backward-looking behavior, subjects in the role of Player 3 frequently end up in a *dissipation-trap*: an effort-intense, final-like last match against Player 2 (node A in the figure).

We statistically test for the absence of a discouragement effect (i.e., Hypothesis 4) by estimating panel regression models of Player 3's effort choice in the second match. The models include as explanatory variables a dummy for the stage fully interacted with treatment dummies and account for subject-specific random effects as well as robust standard errors clustered at the session level. Further specifications also incorporate our control variables. The results are provided in Table A.7 in the appendix. They show that subjects acting as Player 3 in APA-tournaments invest significantly less in stage 2 after a loss of Player 1 in the first match (i.e., in node D versus E). Efforts of subjects acting as Player 3 in LC-tournaments are also smaller in node D than E, but the significance is marginal and disappears in the complete sample. We therefore cannot reject Hypothesis 4:

Result 4. *A win of Player 2 in the first match discourages Player 3 in APA-tournaments but not in LC-tournaments. However, the discouragement in APA-tournaments is substantially weaker than predicted by theory.*

[13] As stated by Cohen-Zada et al. (2017), a "psychological momentum is the tendency of an outcome to be followed by a similar outcome not caused by any strategic incentive of the player". In our case, Player 3 might consider Player 1 as a discouraged loser who experiences negative psychological momentum after the loss in Match 1.

5 Conclusion

Our study is the first to examine the impact of the contest success function on the intensity and fairness of sequential round-robin tournaments with three symmetric players in a controlled laboratory environment. We identify no significant impact of the CSF on tournament intensity, in contrast to experimental findings on static contests with symmetric players, in which lottery contests are usually less intense than all-pay auctions. Moreover, we confirm that LC-tournaments are marginally fairer than APA-tournaments.

Most noteworthy, we find that APA-tournaments strongly and significantly disfavor Player 3 in terms of payoffs. This stems from the absence of the predicted discouragement effect on Player 3 after Player 2 has won the first match. Instead, subjects acting as Player 3 seemingly try to exploit a perceived negative psychological momentum of the losing Player 1 in this situation, neglecting that this leads them straight into a *dissipation trap*: a cut-throat contest against Player 2 in the final match. Yet, we cannot confirm the theoretical predictions by Krumer et al. (2017) suggesting a major advantage for Player 2. For LC-tournaments, our results are closely in line with the theoretical predictions by Sahm (2019).

Our experimental results indicate that independent of the actual institutional character, i.e. whether, e.g., a sports contest inherently contains some source of randomness or not, the model with matches organized as lottery contests yields better predictions for the empirical outcome of a round-robin tournament.

This paper acts as a benchmark for further experimental investigations on round-robin tournaments and on the influence of the contest success function's discriminatory power in dynamic contests in general. Obvious is the extension of the experiment to a round-robin tournament setting with multiple prizes. Lauber et al. (2023) includes, as a robustness check, a comparison of LC- and APA-tournaments in which the second-best player[14] wins a prize that is half as high as the prize for the tournament winner. They find that LC-tournaments are more intense but less fair than APA-tournaments for this prize structure, though results are not significant due to a small number of sessions. Still, the results suggest an interesting interaction between the contest success function and the prize structure, especially regarding fairness.

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References

Alcalde, J. and Dahm, M. (2010). Rent seeking and rent dissipation: A neutrality result. *Journal of Public Economics*, 94(1):1–7.

Baye, M. R., Kovenock, D., and de Vries, C. G. (1996). The all-pay auction with complete information. *Economic Theory*, 8(2):291–305.

Che, Y.-K. and Gale, I. (1997). Rent dissipation when rent seekers are budget constrained. *Public Choice*, 92(1/2):109–126.

[14]This is the player who has won one match, if another player has two wins, or a randomly selected player, if each player has won and lost exactly one match.

Cohen-Zada, D., Krumer, A., and Shtudiner, Z. (2017). Psychological momentum and gender. *Journal of Economic Behavior & Organization*, 135:66–81.

Davis, D. D. and Reilly, R. J. (1998). Do too many cooks always spoil the stew? an experimental analysis of rent-seeking and the role of a strategic buyer. *Public Choice*, 95(1/2):89–115.

Dechenaux, E., Kovenock, D., and Sheremeta, R. M. (2015). A survey of experimental research on contests, all-pay auctions and tournaments. *Experimental Economics*, 18(4):609–669.

Deutscher, C., Sahm, M., Schneemann, S., and Sonnabend, H. (2022). Strategic Investment Decisions in Multi-stage Contests with Heterogeneous Players. *Theory and Decision*, 93:281–317.

Ellingsen, T. (1991). Strategic Buyers and the Social Cost of Monopoly. *American Economic Review*, 81(3):648–657.

Epstein, G. S., Mealem, Y., and Nitzan, S. (2011). Political culture and discrimination in contests. *Journal of Public Economics*, 95(1):88–93.

Epstein, G. S., Mealem, Y., and Nitzan, S. (2013). Lotteries vs. all-pay auctions in fair and biased contests. *Economics & Politics*, 25(1):48–60.

Fang, H. (2002). Lottery versus all-pay auction models of lobbying. *Public Choice*, 112(3/4):351–371.

Fischbacher, U. (2007). z-tree: Zurich toolbox for ready-made economic experiments. *Experimental Economics*, 10(2):171–178.

Fornwagner, H. (2019). Incentives to lose revisited: The NHL and its tournament incentives. *Journal of Economic Psychology*, 75:102088.

Franke, J., Kanzow, C., Leininger, W., and Schwartz, A. (2014). Lottery versus all-pay auction contests: A revenue dominance theorem. *Games and Economic Behavior*, 83:116–126.

Frederick, S. (2005). Cognitive reflection and decision making. *Journal of Economic Perspectives*, 19(4):25–42.

Greiner, B. (2015). Subject pool recruitment procedures: organizing experiments with orsee. *Journal of the Economic Science Association*, 1(1):114–125.

Holt, C. A. and Laury, S. K. (2002). Risk aversion and incentive effects. *American Economic Review*, 92(5):1644–1655.

Iqbal, H. and Krumer, A. (2019). Discouragement effect and intermediate prizes in multi-stage contests: Evidence from Davis Cup. *European Economic Review*, 118:364–381.

Konrad, K. A. (2009). *Strategy and dynamics in contests*. LSE perspectives in economic analysis. Oxford University Press, Oxford and New York.

Konrad, K. A. (2012). Dynamic contests and the discouragement effect. *Revue d'économie politique*, 122(2):233–256.

Krumer, A. and Lechner, M. (2017). First in first win: Evidence on schedule effects in round-robin tournaments in mega-events. *European Economic Review*, 100(C):412–427.

Krumer, A., Megidish, R., and Sela, A. (2017). First-mover advantage in round-robin tournaments. *Social Choice and Welfare*, 48(3):633–658.

Laica, C., Lauber, A., and Sahm, M. (2021). Sequential Round-Robin Tournaments with Multiple Prizes. *Games and Economic Behavior*, 129:421–448.

Lauber, A., March, C., and Sahm, M. (2023). Optimal and fair prizing in sequential round-robin tournaments: Experimental evidence. *Games and Economic Behavior*, 141:30–51.

Llorente-Saguer, A., Sheremeta, R. M., and Szech, N. (2019). Designing Contests Between Heterogeneous Contestants: An Experimental Study of Tie-Breaks and Bid-Caps in All-Pay Auctions. CESifo Working Paper Series 5955, CESifo.

Malueg, D. A. and Yates, A. J. (2010). Testing contest theory: Evidence from best-of-three tennis matches. *Review of Economics & Statistics*, 92(3):689–692.

Millner, E. L. and Pratt, M. D. (1989). An experimental investigation of efficient rent-seeking. *Public Choice*, 62(2):139–151.

Potters, J., de Vries, C. G., and van Winden, F. (1998). An experimental examination of rational rent-seeking. *European Journal of Political Economy*, 14(4):783–800.

Price, C. R. and Sheremeta, R. M. (2011). Endowment effects in contests. *Economics Letters*, 111(3):217–219.

Price, C. R. and Sheremeta, R. M. (2015). Endowment origin, demographic effects, and individual preferences in contests. *Journal of Economics & Management Strategy*, 24(3):597–619.

Sahm, M. (2019). Are sequential round-robin tournaments discriminatory? *Journal of Public Economic Theory*, 21(1):44–61.

Sheremeta, R. M. (2011). Contest design: An experimental investigation. *Economic Inquiry*, 49(2):573–590.

Skaperdas, S. (1996). Contest success functions. *Economic Theory*, 7(2):283–290.

Sonnabend, H. (2020). On discouraging environments in team contests: Evidence from top-level beach volleyball. *Managerial and Decision Economics*, 41(6):986–997.

Szymanski, S. (2003). The economic design of sporting contests. *Journal of Economic Literature*, 41(4):1137–1187.

Taylor, B. A. and Trogdon, J. G. (2002). Losing to Win: Tournament Incentives in the National Basketball Association. *Journal of Labor Economics*, 20(1):23–41.

Tullock, G. (1980). Efficient rent seeking. In Buchanan, J. M., Tollison, R. D., and Tullock, G., editors, *Toward a theory of the rent-seeking society*, pages 97–112. Texas A & M University, College Station.

Zizzo, D. J. (2002). Racing with uncertainty: A patent race experiment. *International Journal of Industrial Organization*, 20(6):877–902.

Appendix

A Additional Figures and Tables

A.1 Panel Estimation of Behavioral Changes Across Periods

Table A.1: Panel estimations for changes of efforts across periods

Dep. Variable	Total Effort			
Sample	Full Sample		Reduced Sample	
Model	(1)	(2)	(3)	(4)
Constant	245.03***	267.21***	228.89***	278.02***
	(23.227)	(69.284)	(23.612)	(96.037)
Player 2	2.83	29.76	18.96	36.64
	(21.893)	(25.582)	(14.211)	(30.430)
Player 3	0.05	23.83	0.06	24.41
	(40.177)	(35.826)	(38.316)	(42.306)
APA × Player 1	-0.96	3.96	-1.97	2.91
	(52.803)	(50.617)	(42.734)	(51.886)
APA × Player 2	-56.22**	13.68	-58.78**	17.41
	(28.173)	(27.692)	(27.694)	(35.746)
APA × Player 3	42.73	87.19*	29.12	79.58
	(42.727)	(46.854)	(64.314)	(68.005)
$(1/Period)\times$				
LC × Player 1	77.79***	77.79***	81.32***	81.32***
	(16.895)	(16.932)	(17.248)	(17.286)
LC × Player 2	-0.86	-0.86	-0.86	-0.86
	(36.986)	(37.067)	(36.989)	(37.074)
LC × Player 3	-10.24	-10.24	-10.70	-10.70
	(43.758)	(43.854)	(45.889)	(45.994)
APA × Player 1	185.23***	185.30***	201.51***	201.44***
	(47.861)	(47.790)	(34.764)	(34.744)
APA × Player 2	64.96	65.07	67.91	67.79
	(45.256)	(45.388)	(47.758)	(47.812)
APA × Player 3	16.51	16.64	18.09	17.94
	(68.765)	(68.684)	(75.757)	(75.705)
Control Variables	No	Yes	No	Yes
Observations	2,760	2,760	2,640	2,640
Subjects	138	138	132	132
R^2	0.027	0.256	0.029	0.253

Note: Robust standard errors in parentheses, clustered at the session level. All models include a subject-specific random effects error structure. Significance level: *** (1%), ** (5%), * (10%)

A.2 Summary Statistics for Complete Dataset

Table A.2: Overview of Experimental Results (Averages): Complete Dataset

	Total Effort		Rel. Freq.(Winning)		Payments	
	LC	APA	LC	APA	LC	APA
Player 1	259.0	277.4	0.348	0.411	549.7	569.1
Player 2	247.7	200.5	0.298	0.274	531.0	563.9
Player 3	243.2	290.7	0.354	0.315	569.4	498.4
Aggregate	750.0	768.6	1.0	1.0	1,650.0	1,631.4
RSD	0.027	0.155	0.076	0.172	0.028	0.059
Gini	0.014	0.078	0.038	0.091	0.016	0.029

Note: RSD$\triangleq$ relative standard deviation; Gini$\triangleq$ Gini coefficient.

A.3 Panel Estimation of Differences in Intensity

Table A.3: Panel Estimations of Tournament Effort: Reduced Sample

Dep. Variable	Total Tournament Effort			
Model	(1)	(2)	(3)	(4)
Constant	233.29***	238.74***	228.48***	251.08**
	(20.029)	(86.601)	(27.765)	(98.488)
APA-Treatment	-19.96	3.04	-19.25	-17.85
	(37.405)	(43.442)	(40.578)	(46.957)
Player 2			17.92	22.62
			(20.343)	(37.359)
× APA			-52.24	5.03
			(34.926)	(47.656)
Player 3			-4.07	15.45
			(36.322)	(36.613)
× APA			52.75	66.36
			(55.285)	(61.656)
Control Variables	No	Yes	No	Yes
Observations	1,320	1,320	1,320	1,320
Subjects	132	132	132	132
R^2	0.003	0.233	0.019	0.247

Note (for both tables): Robust standard errors in parentheses, clustered at the session level and corrected for the finite number of clusters. All models include a subject-specific random effects error structure. Significance level: *** (1%), ** (5%), * (10%).

Table A.4: Panel Estimations of Tournament Effort: Complete Dataset

Dep. Variable	Total Tournament Effort			
Model	(1)	(2)	(3)	(4)
Constant	249.99***	271.28***	259.02***	281.11***
	(20.363)	(61.099)	(21.514)	(68.257)
APA-Treatment	6.21	29.78	18.36	23.46
	(33.986)	(34.964)	(45.719)	(43.472)
Player 2			-11.32	15.44
			(25.092)	(27.542)
× APA			-65.57	-27.15
			(58.979)	(39.559)
Player 3			-15.78	8.43
			(29.453)	(25.781)
× APA			29.12	44.50
			(58.560)	(39.330)
Control Variables	No	Yes	No	Yes
Observations	2,760	2,760	2,760	2,760
Subjects	138	138	138	138
R^2	0.0002	0.239	0.019	0.248

A.4 Comparison of Session Average for Differences in Fairness

Table A.5: Measures and Tests of Fairness of the Lab Tournaments: Complete Dataset

	Rel. Freq.(Winning)			Payments		
	LC-mean	*APA*-mean	p-value	*LC*-mean	*APA*-mean	p-value
RSD	0.223	0.358	0.097	0.056	0.086	0.049
Gini	0.096	0.145	0.121	0.024	0.037	0.051

Note: RSD$\triangleq$ relative standard deviation; Gini$\triangleq$ Gini coefficient. p-values stem from a one-sided t-test of equality of means against the alternative hypothesis, that the *APA*-mean is larger.

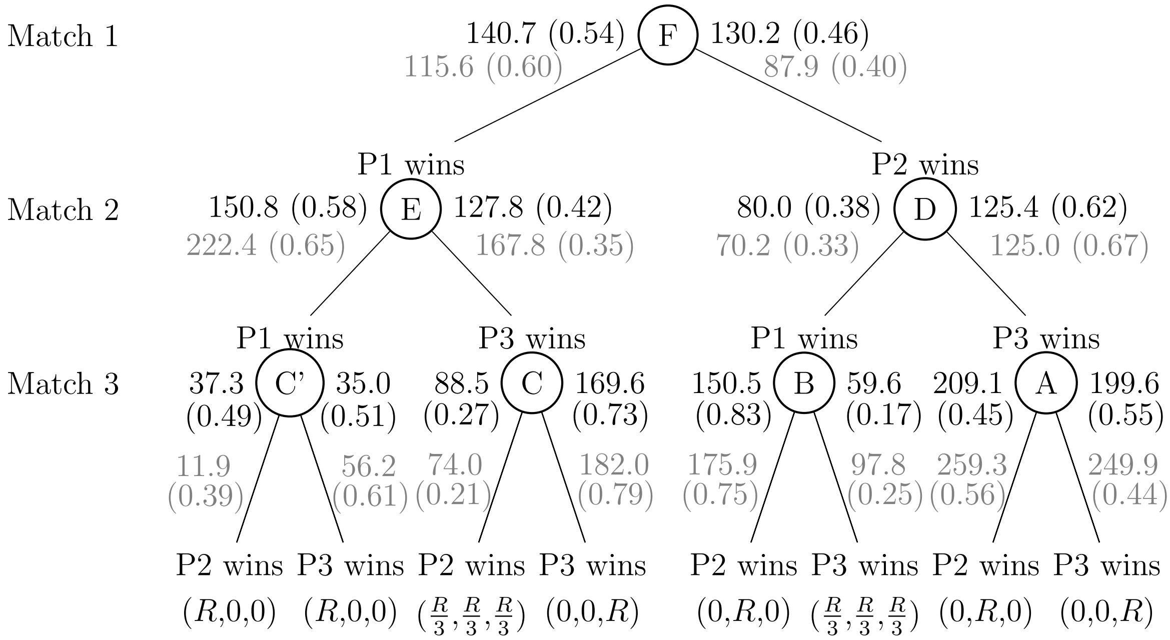
A.5 Panel Estimation of Differences in Winnings and Payments

Table A.6: Panel Estimations for Winnings and Payments: Complete Dataset

Dep. Variable	Winning Probability		Payment	
Model Type	(Logit Panel Model)		(Linear Panel Model)	
Model	(1)	(2)	(3)	(4)
Constant	-0.712***	-0.196	569.37***	549.55***
	(0.212)	(0.604)	(21.699)	(51.449)
APA-Treatment	-0.256	-0.123	-70.96**	-80.44***
	(0.302)	(0.252)	(35.305)	(26.590)
LC × Player 1	0.019	-0.248	-19.69	-22.60
	(0.297)	(0.252)	(12.209)	(19.600)
LC × Player 2	-0.257	-0.397	-38.37**	-55.77***
	(0.300)	(0.254)	(15.473)	(20.520)
APA × Player 1	0.553*	0.136	70.73***	70.65***
	(0.300)	(0.259)	(21.208)	(21.902)
APA × Player 2	-0.209	-0.049	65.45***	59.72***
	(0.306)	(0.254)	(12.994)	(13.588)
Control Variables	No	Yes	No	Yes
Observations	2,760	2,760	2,760	2,760
Subjects	138	138	138	138
Log-likelihood	-1,662.4	-1,630.2		
R^2			0.010	0.044

Note: Standard errors in parentheses, accounting for clustering at the session level in models (3) and (4). All models include a subject-specific random effects error structure.
Significance level: *** (1%), ** (5%), * (10%)

A.6 Efforts and Wins along the Course of the Tournament



Note: Numbers to the left (right) of a node and its downward edges denote the average effort and relative frequency of winning of the lower-(higher-)numbered player in the given match. Relative frequencies of winning are in brackets. Black (gray) numbers denote results for the LC-(APA-)tournament.

Figure A.1: Average Efforts & Relative Winning Freq. in Individual Matches: Complete Dataset

A.7 Panel Regression of Efforts in the Second Match

Table A.7: Panel Estimation for Effort Choices of Player 3 in Match 2

Dep. Variable	Last 10 Periods, Reduced Sample		Complete Dataset	
Model	(1)	(2)	(3)	(4)
Constant	114.12***	252.13**	123.06***	211.31**
	(18.525)	(109.706)	(19.364)	(85.720)
APA-Treatment	-29.31	10.51	-1.69	40.21**
	(30.101)	(17.258)	(27.226)	(15.653)
LC × Node E	15.25*	15.02*	6.67	6.92
	(8.345)	(8.445)	(4.896)	(4.961)
APA × Node E	83.29***	83.55***	48.86***	49.269***
	(18.610)	(18.819)	(18.199)	(18.289)
Control Variables	No	Yes	No	Yes
Observations	430	430	920	920
Subjects	43	43	46	46
R^2	0.064	0.462	0.021	0.424

Note: Robust errors in parentheses, clustered at the session level.
Significance level: *** (1%), ** (5%), * (10%)

B Experimental Instructions

General Instructions

This is an experiment in strategic decision-making. Thank you for your participation.
To compensate you for showing up on time you will receive

$\boxed{\text{4 Euro}}$

If you follow these instructions, you can earn additional money depending on your own decisions, the decisions of the other participants, and chance. At the end of the experiment the total amount of money that you have earned will be paid out to you privately in cash.

From now on, we ask you to remain seated quietly at your computer desk. You may use the computer only for the experiment. Please do not communicate with other participants during the experiment. If you have any questions during the experiment, please raise your hand and wait for an experimenter to come to you. Participants who intentionally violate these rules will be asked to leave the experiment without being financially compensated.

During the experiment your decisions determine a score expressed in points. At the end of the experiment, the points you have earned in some of your decisions will determine your earnings according to the following rule:

$\boxed{\text{1 Point = 1 Cent}}$ $\boxed{\text{100 Points = 1 Euro}}$

The experiment consists of 3 parts and a questionnaire at the end. On the next pages you initially receive detailed information on the first part of the experiment. Once part 1 is finished additional information on the second part follows. After part 2 is finished, you receive instructions for the third part.

Instructions for Part 1

In the first part of the experiment, your earnings only depend on your own decisions and chance. You have to submit **10 decisions** in this part. These are listed in the following table:

	Option S	Option L		Your
Choice	Points	Points	Dice Score	Choice
1	**180**	**400**, if **0**, if	1 2, 3, 4, 5, 6, 7, 8, 9, 10	*S* *L*
2	**180**	**400**, if **0**, if	1, 2 3, 4, 5, 6, 7, 8, 9, 10	*S* *L*
3	**180**	**400**, if **0**, if	1, 2, 3 4, 5, 6, 7, 8, 9, 10	*S* *L*
4	**180**	**400**, if **0**, if	1, 2, 3, 4 5, 6, 7, 8, 9, 10	*S* *L*
5	**180**	**400**, if **0**, if	1, 2, 3, 4, 5 6, 7, 8, 9, 10	*S* *L*
6	**180**	**400**, if **0**, if	1, 2, 3, 4, 5, 6 7, 8, 9, 10	*S* *L*
7	**180**	**400**, if **0**, if	1, 2, 3, 4, 5, 6, 7 8, 9, 10	*S* *L*
8	**180**	**400**, if **0**, if	1, 2, 3, 4, 5, 6, 7, 8 9, 10	*S* *L*
9	**180**	**400**, if **0**, if	1, 2, 3, 4, 5, 6, 7, 8, 9 10	*S* *L*
10	**180**	**400**, if **0**, if	1, 2, 3, 4, 5, 6, 7, 8, 9, 10 - - -	*S* *L*

In each decision, you have a choice between two options, Option S and Option L:

- Option S yields a secure final score of 180 points.
- The final score of option L depends on the throw of a 10-sided dice. For example, in the first decision option L yields 400 points, if the dice result is 1, and it yields 0 points if the result is 2, 3, 4, 5, 6, 7, 8, 9, or 10. For the other decisions, the final score of option L is determined analogously, with the probability of receiving 400 points increasing as you move down the table. Indeed, in the last decision option L yields a secure final score of 400 points.

Only one of the 10 decisions will count towards your final earnings. To determine your earnings for the first part of the experiment, one of the participants will throw a 10-sided dice twice at the end of the experiment. The result of the first throw determines the number of the decision which counts towards your earnings. Your earnings for the first part are then determined as follows:

- If you have chosen option S in the selected decision, you earn the money equivalent of 180 points.
- If you have chosen option L in the selected decision, your earnings depend on the result of the second throw of the dice. You earn the money equivalent of the points related to the result.

Please remain quiet until all participants have finished reading the instructions. An experimenter will then read them aloud. Afterwards, the first part of the experiment will begin.

Instructions for Part 2

In the second part of the experiment you participate as a player in 20 independent tournaments. For each single tournament you are randomly allocated into groups of three. On that point you are randomly assigned a player from 1 to 3, i.e. you are either Player 1, Player 2, or Player 3. Your player number remains the same across all 20 tournaments. Within a tournament you sequentially interact with every other player (opponent)in your group. The sequence is the following:

MATCH 1:	Player 1 vs. Player 2
MATCH 2:	Player 1 vs. Player 3
MATCH 3:	Player 2 vs. Player 3

In those matches the participating players make decisions, for each decision you have 35 seconds. In the meantime the non-participating player pauses but has to confirm with a click on 'OK'. Once all matches in a group are completed and consequently the tournament is finished, a new tournament, independent from the previous tournament, starts. For that, you are again randomly assigned with your player number into new composed groups of three. The players interact all over again in the illustrated sequence.

Your decisions in each tournament

You and your opponent compete in matches for a *tournament prize* which equals

$$\boxed{R = 600 \text{ Punkte.}}$$

At the beginning of each tournament, that means after each group allocation, each of you receives, independently of the outcomes of previous tournaments, an *initial endowment* of

$$\boxed{I = 600 \text{ Punkten.}}$$

You can use this endowment to submit it in matches with your opponent. For this purpose you can submit any number of positive integer points Q_1 between 0 and your initial endowment of 600. In your second match you can submit any number of positive integer points Q_2 between 0 and your remaining endowment of $600 - Q_1$.

The winner...

LC-treatment

...of a match: After you and your opponent have made your decisions the winner will determined in the as follows. If neither you nor your opponent submitted any points, a computerized fair coin toss determines the winner. Otherwise, the computer randomly draws an integer number bewteen 1 and the total number of points submitted by yourself and your opponent. Each of those numbers is equally likely to be drawn. You receive the prize,

- if you possess the *lower* player number and the drawn number is at most as large as the number of points submitted by yourself.
- if you possess the *higher* player number and the drawn number is larger than the number of points submitted by your opponent.

APA-treatment

...of a match: After you and your opponent have made your decisions the winner will determined in the as follows. You win the match, if you submitted a larger number of points than your opponent. In case you and your opponent have submitted an identical number of points, a computerized fair coin toss determines the winner.

...of a tournament: Tournament winner is the player who has the most wins in matches, i.e. overall 2 wins. In case that all players in one group have won the same number of matches (1 win per player), the computer randomly draws a tournament winner. That means, each player's probability to win the tournament is identical.

Your final score at the end of a tournament

The points you have submitted in match are deducted from your endowment irrespective of the outcome of the match and of the tournament. You keep the remaining endowment. Your final score at the end of a tournament therefore equals

$$\boxed{finalscore = \begin{cases} I - Q_1 - Q_2 + R, & \text{if you win the tournament.} \\ I - Q_1 - Q_2, & \text{if you do not win the tournament.} \end{cases}}$$

At the end of each match, as a *participating* player your are informed about (i) the number of points you and your opponent submitted, (ii) the winner of the match, (iii) your total number of wins in matches,(iv) your current endowment. As a *non-particiapting* player you are only informed which of the participating player has won the match. Generally, the display is updated such that you are always informed about (i) your current endowment, (ii) the outcomes in previous matches, (iii) the standings. Exemplary, Figure B.2 shows a input-screen and Figure B.3 (Figure B.4) shows an outcome-screen. At the end of each tournament you are informed if you have won the tournament and about your final score.

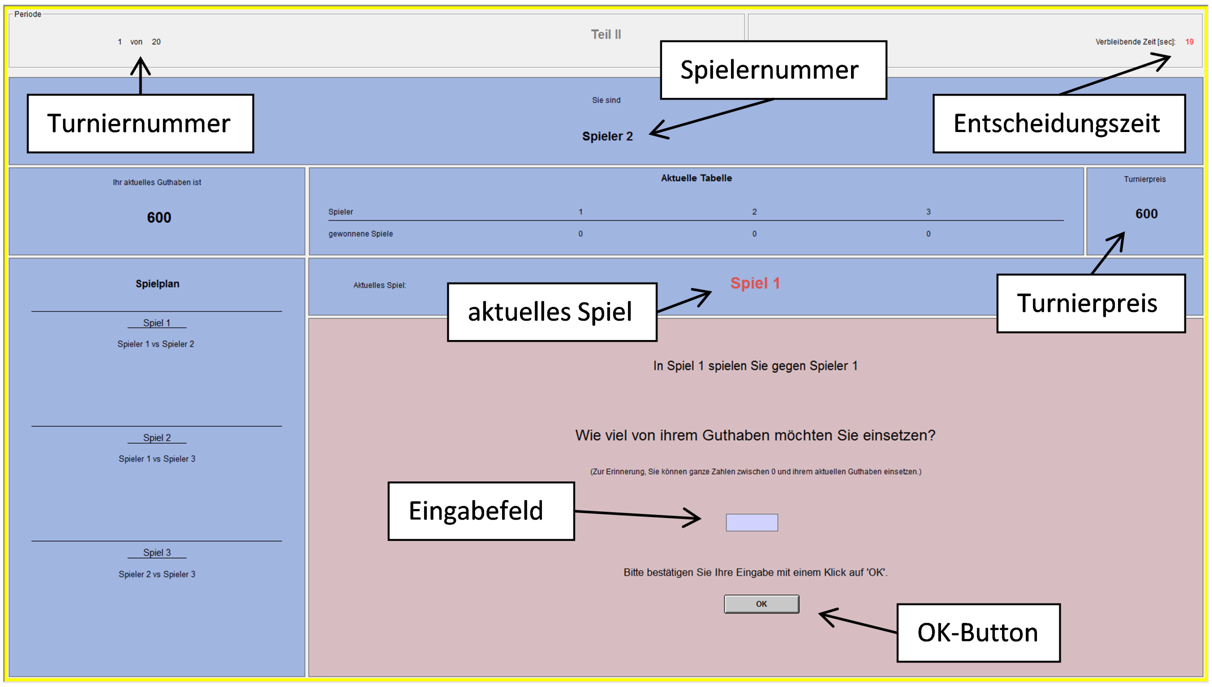


Figure B.2: Input-screen

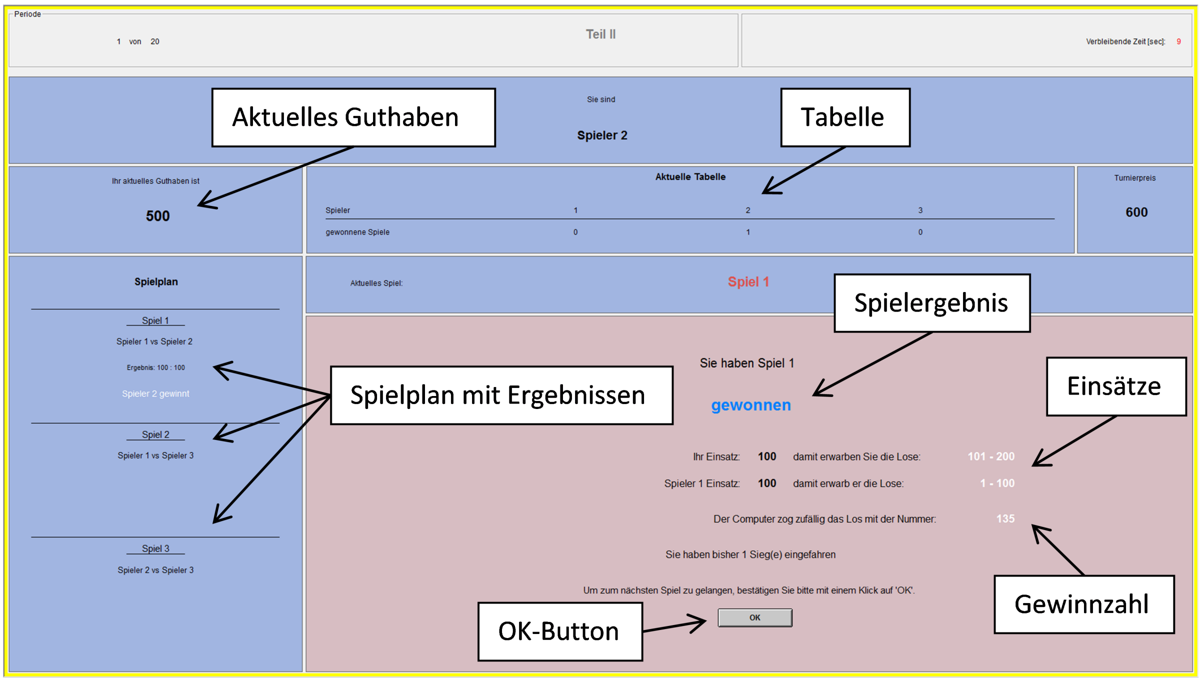


Figure B.3: LC-treatment Outcome-screen

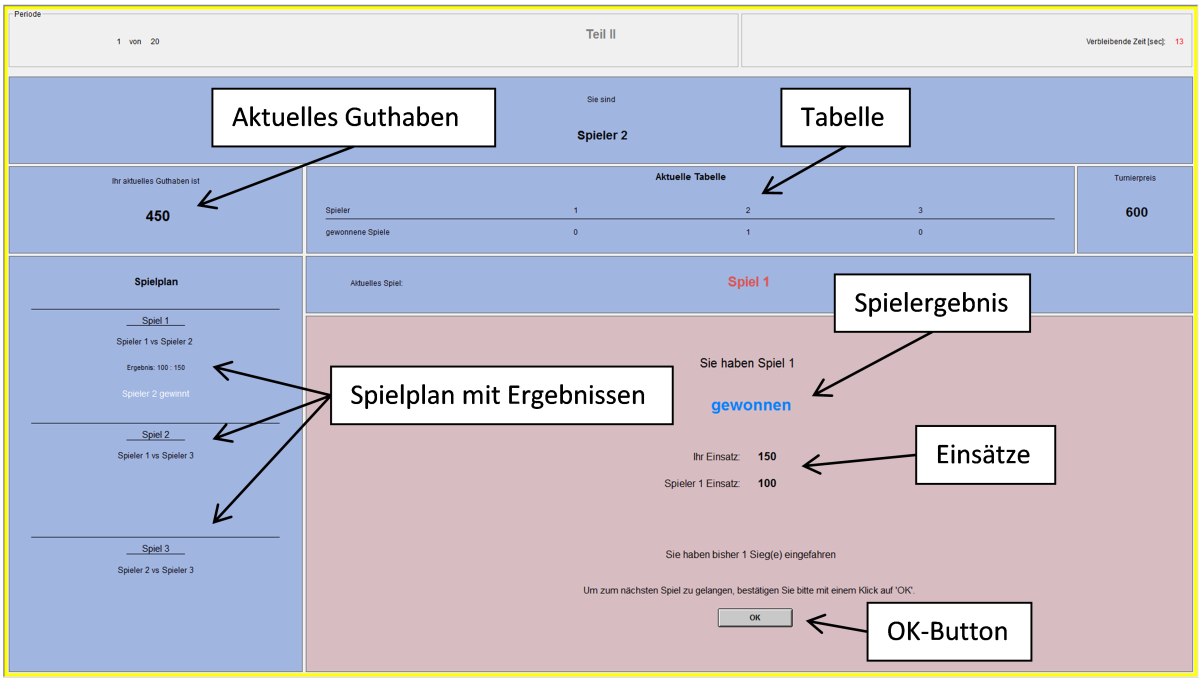


Figure B.4: APA-treatment Outcome-screen

Example

The following tables illustrate the decision situation in the second part of the experiment with the help of a fictious example.

LC-treatment

Match	Player	Submitted Points	Winning numbers	Drawn number	Winner	Current Endowment
1	Player 1 Player 2	100 100	1,2,...,100 101,102,...,200	135	Player 2	$600 - 100 = 500$ $600 - 100 = 500$
2	Player 1 Player 3	200 100	1,2,...,200 201,102,...,300	269	Player 3	$500 - 200 = 300$ $600 - 100 = 500$
3	Player 2 Player 3	200 100	1,2,...,200 201,102,...,300	47	Player 2	$500 - 200 = 300$ $500 - 100 = 400$

Player	Wins	Finalscore
1	0	$600 - 100 - 200 = 300$
2	$\boxed{\mathbf{2}}$	$600 - 100 - 200 + 600 = 900$
3	1	$600 - 100 - 100 = 400$

APA-treatment

Match	Player	Submitted Points	Winner	Current Endowment
1	Player 1 Player 2	100 150	Player 2	$600 - 100 = 500$ $600 - 150 = 450$
2	Player 1 Player 3	200 100	Player 1	$500 - 200 = 300$ $600 - 100 = 500$
3	Player 2 Player 3	200 100	Player 2	$450 - 200 = 250$ $500 - 100 = 400$

Consequently the standings, with each player's final score and Player 2 as a winner due to two wins in matches, yield as follows.

Player	Wins	Finalscore
1	1	$600 - 100 - 200 = 300$
2	$\boxed{\mathbf{2}}$	$600 - 150 - 200 + 600 = 850$
3	0	$600 - 100 - 100 = 400$

Your earnings in the second part

At the end of the 20 tournaments one tournament will be selected. Only the finalscore of this tournament determines your earnings in the second part of the experiment. To deterimene this tournament, one randomly selected participant will throw a 20-sided dice once. The score of this throw determines the tournament relevant for the earnings.

Control Questions

The following questions are intended to ensure that you have understood the instructions. Please answer to the best of your knowledge and raise your hand once you are finished. An experimenter will then come to you and peruse the answers with you.

LC-treatment

1. Which of the following statements is true?
   □ For every torunament you are the same player and you play in the same group.
   □ For every torunament you are the same player and you are newly drawn to a random group.
   □ For every torunament you are a newly drawn a random player number and you play in the same group.
   □ For every torunament you are a newly drawn a random player number and you are newly drawn to a random group.

2. What is your likelihood of winning a match, if you submit exactly half as many points as your opponent?
   □ 0 □ 1/2 □ 1/3

3. Who wins the match, if you obtain the lower player number, you and your opponent have each submitted 93 points, and the computer randomly draws the number 97?
   □ You. □ Your opponent.

4. Who wins the match, if you submit 0 points abd your opponent submits 1 point?
   □ You for sure.
   □ Your opponent for sure.
   □ Depending on the random draw of the computer, either of us my win.

5. Is it possible to win a tournament with one win in matches?
   □ Yes. □ No.

6. What is your final score, if you submit your entire endowment in a tournament and you do not win in the tournament?
   □ 0 points. □ 600 points.

7. If you won a tournament and you have submitted 300 points. How large is your endowment in the next tournament?
   □ 1200 points. □ 900 points. □ 600 points.

8. And if you lost it with a submission of 300 points?
   □ 600 points. □ 300 points. □ 0 points.

APA-treatment

1. Which of the following statements is true?
   □ For every torunament you are the same player and you play in the same group.
   □ For every torunament you are the same player and you are newly drawn to a random group.
   □ For every torunament you are a newly drawn a random player number and you play in the same group.
   □ For every torunament you are a newly drawn a random player number and you are newly drawn to a random group.

2. What is your likelihood of winning a match, if you submit exactly half as many points as your opponent?
☐ 0 ☐ 1/2 ☐ 1/3

3. Is it possible to win a tournament with one win in matches?
☐ Yes. ☐ No.

4. What is your final score, if you submit your entire endowment in a tournament and you do not win in the tournament?
☐ 0 points. ☐ 600 points.

5. If you won a tournament and you have submitted 300 points. How large is your endowment in the next tournament?
☐ 1200 points. ☐ 900 points. ☐ 600 points.

6. And if you lost it with a submission of 300 points?
☐ 600 points. ☐ 300 points. ☐ 0 points.

C Experiment

Part 3

Please answer the following questions. For each question you have 40 seconds to respond. For the first three questions you recieve EUR 0.50 per correct answer additionally to your final score. The last question in not relevant for the earnings but ask you to answer to the best of your knowledge.

(1) A pencil and an eraser cost EUR 1.10 in total. The pencil costs EUR 1.00 more than the eraser. How much does the eraser cost? ____________ cents

(2) It takes 5 machines 5 minutes to make 5 widgets. How long does it take 100 machines to make 100 widgets? ____________ minutes

(3) In a lake, there is a patch of lily pads. Every day, the patch doubles in size. It takes 48 days for the patch to cover the entire lake. How long does it take for the patch to cover half of the lake? ____________ days

Across how many of these questions you had come already before this experiment?
☐ 0 ☐ 1 ☐ 2 ☐ 3

Questionnaire [extract of Experiment related questions]

Q1. How do you describe yourself as a person in terms of willing to take risks from 1 (not willing to take risks at all) to 7 (very willing to take risks)?

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

Q2. How often do you participate in gambling (e.g. lotteries, casinos, online betting) from 1 (never) to 7 (very often)?

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

Q3. How much do you like playing parlor games (e.g. Chess, Monopoly, cards) from 1 (not at all) to 7 (very much)?

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

Q4. How ambitious are you from 1 (not ambitious at all) to 7 (highly ambitious)?

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

Q5. How do you describe your money management from 1 (very spare) to 7 (very generous)?

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

Q6. How important was it to you that you achieve earnings as high as possible from 1 (not important at all) to 7 (very important)?

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

Q7. How important was it to you that you win as many tournaments as possible from 1 (not important at all) to 7 (very important)?

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

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