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Three-player 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. Contrary to theory, we find no significant differences in intensity and fairness between the two match formats. The main reason is the behavior of the player acting in the final two matches in APA-tournaments. Rather than being severely discouraged when having to compete first against the loser of the first match, subjects try to exploit a perceived negative psychological momentum in such situations. This leads them into a dissipation trap: an effort-intense, final-like last match which significantly reduces their payoffs, but also levels the playing field for the other two players and thus enhances the fairness of APA-tournaments.

1. Introduction

Randomness, or luck, is an important element of most contests. Its role, though, varies from case to case. It may be influenced by, inter alia, the inherent 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 regime (e.g., the rules of the game). Clearly, some of the circumstances (e.g., the choice of the venue) and regulations (e.g., the use of video assistants in refereeing) can be chosen 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. The comparison of the APA and the LC has received considerable attention in the literature, both theoretically (see, e.g., Ellingsen, 1991, Che & Gale, 1997, Fang, 2002, Alcalde & 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 & Pratt, 1989, Davis & Reilly, 1998, Potters et al., 1998, and Dechenaux et al., 2015 for a survey). A central result is that the APA is more intense (i.e, induces higher aggregate effort) than the LC in static environments as long as contestants are not too heterogeneous; for large asymmetries, however, the LC may be more intense than the APA.

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

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[1] Szymanski (2003) discusses this relation particularly with regard to sports.

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(where each contestant is matched with every other contestant and the overall winner is the contestant who wins the most matches); Devriesere et al. (2025) provide a recent survey on tournament design from an operational research perspective. 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 (see, e.g., Konrad, 2012 for a theoretical treatment, Davis & Reilly, 1998, Zizzo, 2002, and Llorente-Saguer et al., 2023 for experimental evidence, and Malueg & Yates, 2010, Iqbal & Krumer, 2019, and Sonnabend, 2020 for empirical evidence).

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 sports. Examples include the major European soccer leagues (including the English Premier League) with up to 20 teams on a large scale and the first rounds (group or pool stages) of many major events in team sports on a small scale. In such tournaments like the FIFA World Cup (soccer), IHF Men's World Championship (handball), the FIBA Basketball World Cup, or the FIVB World Cup (volleyball), four teams per group are prevalent, but groups with only three teams have also been widely-used (e.g., in the first round of the FIFA World Cups in 1930 and 1950 and in the second round of the FIFA World Cup in 1982, in the first round of the IHF Men's World Championships in 1954 and 1961, in the first round of the FIBA Basketball World Cup in 1954 and the classification round of the FIBA Basketball World Cup in 1959, and in the first rounds of the FIVB World Cups in 1949, 1952, 1956, and 1969). Current instances of major tournaments with groups of three players/teams and a single prize (i.e., only the one who ranks first qualifies for the next stage)[2] include the finals of the Billie Jean King Cup (for female national tennis teams, formerly known as Fed(eration) Cup) in 2023 (with four groups of three teams) as well as its qualifiers (with six groups of three teams) and playoffs (with seven groups of three teams) in 2025, and the first round of the Olympic Badminton tournaments since 2012.

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 probability 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 is that pronounced asymmetries in intermediate continuation payoffs cause 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, because APAs induce stronger asymmetries than LCs, and stronger asymmetries generally reduce the intensity of contests, the aggregate expected effort of the tournament is higher with LC-matches than with APA-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 & 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. They focus on tournaments with matches organized as APAs and compare three different prize structures: a single first prize only, a second prize that equals the first prize, and a second prize that equals half of the first prize. They confirm many of the theoretical predictions by Laica et al. (2021), but also show that intensity is higher than predicted, especially in RRTs with a single prize. Moreover, they find that dynamic behavior is shaped not only by strategic considerations but is also subject to a psychological momentum.

In this paper, by contrast, we hold the prize-structure constant (considering a single prize) and study the role of luck: we experimentally test the impact of (the accuracy of) the CSF (APA or LC) on the intensity, fairness, and dynamics of a three-player RRT. Thereby, we contribute 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, 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. Second, there is also no significant difference in terms of fairness. Third, RRTs with APA-matches heavily disadvantage the player acting in the last two matches in terms of payoffs (but not winning probabilities). In RRTs with LC-matches, the player acting in the last two matches wins significantly more often than the two other players. Fourth, 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.

The last observation holds especially in RRTs with APA-matches where this player is predicted to provide zero effort in that match. Instead, subjects in this player-role seemingly try to exploit a negative psychological momentum of the first match loser and therefore choose a significantly higher effort than predicted.[3] 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. It also explains why we find no difference in fairness between our treatments either: The behavior of the player acting in the final two matches levels the playing field between the other two players and thus increases the fairness of RRTs with APA-matches as compared to the theoretical benchmark.

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] Vong (2017) considers a general model of multistage tournaments and shows that it is both necessary and sufficient to allow only the top-ranked player to qualify from each group to avoid the problem of strategic manipulation; the simulations by Csató (2025) confirm this theoretical result.

[3] 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 this sense, the loser of the first match may experience a negative psychological momentum that discourages her in view of the second match. For a recent experimental study on momentum in contests and its underlying behavioral mechanisms, see Kubitz et al. (2025).

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 Fig. 1 (henceforth game tree; see below). The seven nodes $k \in \{\mathrm{A}, \dots, \mathrm{F}\}$ of the game tree represent all combinations for which the ranking of the tournament has not yet been fully determined when the respective match starts. Notice, however, that match 3 is *strongly stakeless* at node C' (Csató et al., 2024): after two wins of Player 1, neither Player 2 nor Player 3 have any chance to be ranked first and win the prize.

If Player $i \in \{1,2,3\}$ meets Player $j \in \{1,2,3\}$, $i \neq j$, in the match of node k, she chooses effort x_i^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 $w_i^k \geq \ell_i^k \geq 0$. The probability p_i^k that Player i wins the match in node k against Player j is a function of the effort choices of both players and depends on how the matches are organized: in LC-tournaments, Player i's probability of winning the match in node k is defined by Skaperdas (1996), Tullock (1980)

$$p_i^k = \begin{cases} 1/2 & \text{if } x_i^k = x_j^k = 0, \\ \frac{x_i^k}{x_i^k + x_j^k} & \text{else,} \end{cases}$$

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

$$p_i^k = \begin{cases} 1 & \text{if} \quad x_i^k > x_j^k, \\ 1/2 & \text{if} \quad x_i^k = x_j^k, \\ 0 & \text{if} \quad x_i^k < x_j^k. \end{cases}$$

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.

To begin with, consider the behavior of the Players $i \in \{1,2,3\}$ and $j \in \{1,2,3\}$, $i \neq j$ who meet in the single match of node k. First notice that for $w_i^k = \ell_i^k$, the optimal effort choice is $x_i^k = 0$ for any $x_j^k \geq 0$. If $x_i^k = 0$ and $w_j^k > \ell_j^k$, Player j will have no best reply unless there is a smallest monetary unit $\varepsilon > 0$. As $\varepsilon \to 0$, in the limit, $x_j^k \to 0$ and $p_j^k \to 1$. Otherwise, the match in node k always has a unique Nash-equilibrium.

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

Table 1
Ex Ante expected SPE-Values.

	Tournament effort		Winning probability		Payoffs	
	LC	APA	LC	APA	LC	APA
Player 1	135.3	65.6	0.349	0.193	74.3	50
Player 2	125.6	159.7	0.307	0.683	58.7	250
Player 3	135.2	74.7	0.343	0.125	70.9	0
Aggregate	396.2	300				
Gini			0.028	0.371	0.051	0.557

Note: Gini $\hat{=}$ Gini coefficient.

For matches organized as lottery contests, 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

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

For matches organized as all-pay auctions, the Nash Equilibrium is in mixed strategies and has the following properties (Krumer et al., 2017): if we call the player with the weakly lower differential between continuation payoffs from winning and losing Player i, i.e., 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 entire tournament represents a dynamic game with three stages (the three consecutive matches) that can be solved by backward induction for its subgame perfect equilibrium (SPE), making repeatedly use of Eqs. (2)–(4) for LC-tournaments (Sahm, 2019) and Eqs. (5)–(7) for APA-tournaments (Krumer et al., 2017); see Appendix A for a detailed analysis of both types of tournaments. Table 1 contains the predictions for $R = 600$, the value of winning the prize (in points) that 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, which serves as the measure of *intensity*, and Gini coefficients, which serve as measures of fairness (with respect to ex-ante winning probabilities and expected payoffs). Fig. 1 presents the predicted (expected) efforts and winning probabilities in the individual matches along the potential courses of the RRT.

To understand why the equilibrium winning probabilities and expected payoffs of otherwise symmetric players differ due to their different positions in the schedule of the tournament, consider the first steps of the backward induction procedure for the APA-tournament: First, consider the match between Players 2 and 3 in node A (third stage), where Player 2 has won the first match and Player 3 has won the second

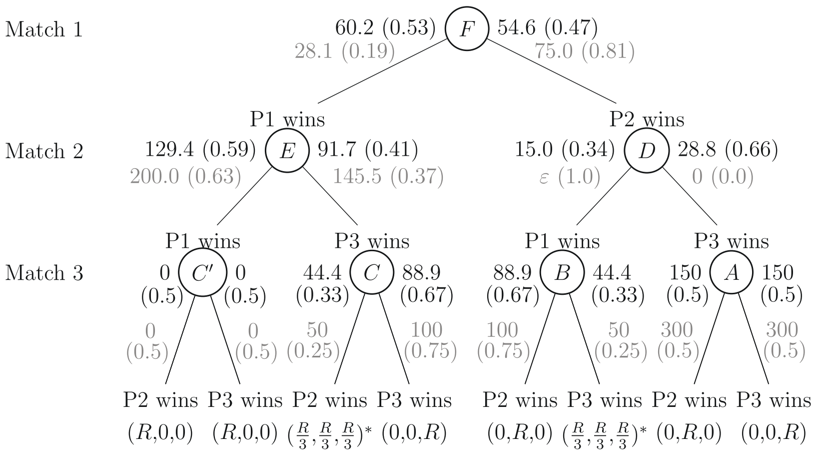

Fig. 1. Predicted efforts and winning probabilities in individual matches.
Note: Results are based on Krumer et al. (2017) and Sahm (2019). Numbers to the left (right) of a node and its downward edges denote the predicted effort and winning probability of the lower-(higher-)numbered player in the given match. Winning probabilities are in brackets. Black (gray) numbers denote predictions for the LC-(APA-)tournament. An asterisk indicates that the respective vector displays expected payoffs under random tie-breaking.

match. The winner of this match will thus win the entire tournament and receive the prize $R = 600$. Formally, we have a symmetric match with payoffs $w_2^A = w_3^A = 600$ from winning and $\ell_2^A = \ell_3^A = 0$ from losing and thus equal winning probabilities $p_2^A = p_3^A = 1/2$ and expected payoffs $E_2^A = E_3^A = 0$ according to Eqs. (6) and (7). Next, consider the match between Players 2 and 3 in node B (third stage), where Player 2 has won the first match, but Player 3 has lost the second match. If Player 2 wins that match, she will win the entire tournament and receive the prize $R = 600$; if Player 3 wins the match, the tournament will end in a tie and all players will win the prize with probability $1/3$ implying an expected payoff of $R/3 = 200$ for each of them. Formally, we have an asymmetric match with differing (expected) payoffs $w_2^B = 600$, $w_3^B = 200$ from winning and $\ell_2^B = 200$, $\ell_3^B = 0$ from losing and thus differing winning probabilities $p_2^B = 3/4$, $p_3^B = 1/4$ and expected payoffs $E_2^B = 400$, $E_3^B = 0$ according to Eqs. (6) and (7).

Now, we can use the results from nodes A and B to analyze the match between Players 1 and 3 in node D (second stage), where Player 2 has won the first match. Whereas Player 1 has a positive continuation payoff from winning and zero continuation payoff from losing ($w_1^D = p_3^B \cdot R/3 = 50 > 0 = \ell_1^D$), Player 3's continuation payoff in node D equals zero, regardless of whether she wins this match (and reaches node A) or loses it (and reaches node B): as calculated above, in both nodes, Player 3's expected payoff is zero ($w_3^D = E_3^A = 0 = E_3^B = \ell_3^D$). In this sense, Player 3 is fully discouraged, does not provide any effort ($x_3^D = 0$), and loses this match for sure ($p_3^D = 0$). Finally, the fact that Player 2 will win the match in node D for sure with (almost) no effort is anticipated and, therefore, provokes asymmetries also for the match between Players 1 and 2 in node F (first stage); see Appendix A for more details.

Table 1 and Fig. 1 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. As highlighted above, the main reason is the strong *discouragement effect* of Player 3 in node D of the APA-tournament where she invests nothing and thereby substantially less than in node E. 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).

Besides intensity and fairness, tournament design aims at avoiding (strongly) stakeless matches (like the one in node C') as they are unattractive to spectators and, consequently, sponsors (see, e.g. Chater et al., 2021; Csató & Gyimesi, 2026; Csató et al., 2024; Guyon, 2020; Stronka, 2024). The equilibrium probability of reaching the strongly stakeless match of node C' can easily be derived from Fig. 1 and equals $0.53 \cdot 0.59 \approx 0.31$ for the LC-tournament and $0.19 \cdot 0.63 \approx 0.12$ for the APA-tournament. Theory thus predicts that a higher accuracy (fewer random components) on the match-level helps avoiding such a stakeless final match.

2.3. Hypotheses

The above predictions give rise to the following testable hypotheses for three-player round-robin tournaments with a single prize.

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 favor Player 2, i.e., Player 2 wins more frequently and receives a larger payoff than the other players. In contrast, winning probabilities and payoffs do not differ significantly by player number in LC-tournaments.

Hypothesis 3. APA-tournaments are less fair than LC-tournaments where (un)fairness is measured by the Gini coefficient of the distribution of winning probabilities or payoffs across players.

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. These design choices aimed at facilitating learning by subjects, as learning effects are commonly found in contest experiments and are likely to depend on player numbers in our experiment.

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 (by giving each subject the same initial endowment per period, we intend to prevent endowment-related distortions in subjects' effort choices; see, e.g., Price & Sheremeta, 2011, 2015; Sheremeta, 2011). 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).

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.[5] Throughout the RRT (see Fig. 1 for the structure and the potential courses), 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).[6] 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. Appendix B.1 provides information on the demographic composition of our sample.

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 treatments. On average a session lasted 90 min. The experimental sessions were computerized using z-Tree (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 online in a separate document). 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 s to enter her 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. Subjects were then asked to fill out a short questionnaire at the computer consisting of some demographic questions and some questions related to the experiment. Concretely, we asked for age, gender, field of studies, the number of siblings, and self-assessments (on a Likert-scale from one to seven) of ambition, generosity, the frequency of playing board games and games of chance, and the importance assigned to winning the tournament and to the final payment. Finally, subjects collected 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

4.1. Efforts and intensity

Fig. 2 illustrates the evolution of the mean tournament effort across periods by player type. In both subfigures, 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 left (right) panel shows the results for treatment LC (APA).

The figure shows that subjects overinvest quite substantially relative to equilibrium predictions, and it reveals treatment- and player-specific learning effects. Whereas there is a clear downward trend of tournament efforts across the first periods in treatment APA, 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. To account for these learning effects, all the panel models we estimate to test our hypotheses include as control variables the inverse of the period number fully interacted with dummies for the treatment and the player number. A robustness check is provided in Section 4.4 and Appendix C.1.

[5] 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.

[6] 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.

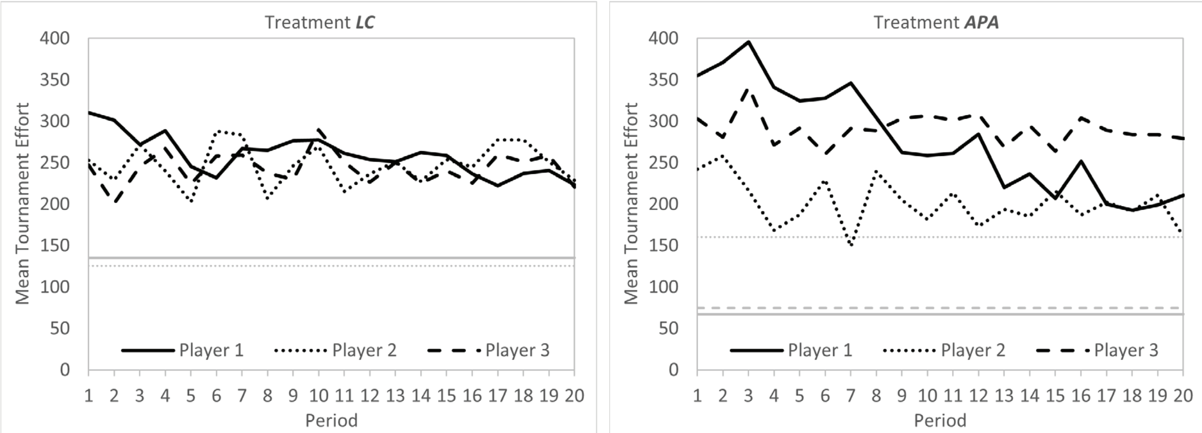

Fig. 2. Average effort per tournament.
Note: Gray lines depict the theoretical benchmarks. Note that the theoretical benchmarks of Player 1 and Player 3 are almost identical (135.3 vs. 135.2) in treatment LC.

Table 2
Overview of experimental results (Averages).

	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				
Gini			0.038	0.091	0.016	0.029

Note: Gini $\hat{=}$ Gini coefficient.

Table 3
Regression analysis of tournament intensity.

Dep. Variable	Tournament intensity			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	749.96***	(61.11)	737.97***	(65.35)
APA-Treatment	18.64	(102.00)	−17.34	(106.14)
1/Period			66.69*	(25.76)
1/Period × APA			200.01	(123.17)
Observations	920		920	
R^2	0.001		0.015	

Notes:
[1] The regression is conducted at the tournament level, i.e., there is one observation for each distinct tournament. This amounts to 20 periods · 138 subjects/3 subjects per RRT = 920 tournaments played overall.
[2] Standard errors are in parentheses, accounting for clustering at the session level.
[3] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

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.[7]

Table 2 suggests that (aggregate) effort levels in APA-tournaments and LC-tournaments are similar. To statistically test for differences in intensity between treatments, we pursue two avenues. First, we regress the sum of effort across matches and players for each tournament on a treatment dummy. The results are presented in Table 3 and show no significant treatment differences. The results also provide statistical evidence for the learning effects.

Second, we run panel regressions of the total tournament effort per player to also control for individual-level variables. The regressions include subject-specific random effects and treatment dummies fully interacted with the player role as explanatory variables. Further specifications also include additional controls collected in the final questionnaire. The results are presented in Table B.2 in the appendix and identify no treatment differences, either. This leads us to the following conclusion:

Result 1. *Contrary to theoretical predictions, 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 assign a higher importance to winning the tournament (their final earning) invest more (less).

4.2. Winning probabilities, payments, and fairness

Table 2 suggests that, contrary to theoretical predictions, LC-tournaments in the lab favor Player 3 and disadvantage Player 2 in terms of relative frequencies of winning and payments. Moreover, APA-tournaments in the lab seem to disadvantage 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 2 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. To account for dynamics across periods, we also incorporate the reverse of the period fully interacted with player and treatment dummies. 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 estimation results are provided in Tables B.3 and B.4 in the appendix. They show that Player 3 is significantly more likely to win the tournament than both Players 1 and 2 and receives a significantly higher payment than Player 2 (but not Player 1) in LC-tournaments (F tests reveal no significant differences between Players 1 and 2). 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 2:

Result 2. *APA-tournaments significantly disadvantage Player 3 compared to Players 1 and 2 in terms of payment (but not winning probability). LC-tournaments favor Player 3 over Players 1 and 2 in terms of winning probability and Player 3 over Player 2 in terms of payment.*

[7] In Section 4, we consistently use payments (payoffs including endowments) rather than payoffs to avoid negative values for the Gini coefficient.

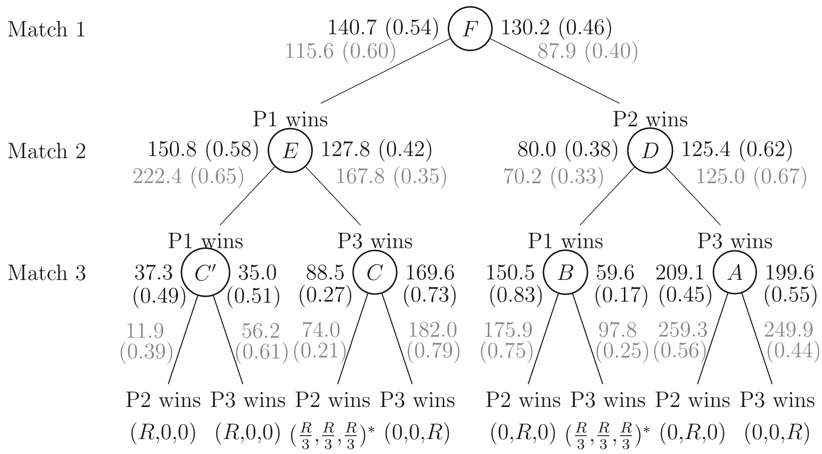

Fig. 3. Average efforts & relative frequencies of winning in individual matches.
Note: Numbers to the left (right) of a node and its downward edges denote the average effort and relative frequency of winning of the lower-(higher-)numbered player in the given match. Relative frequencies of winning are in brackets. Black (gray) numbers denote results for the LC-(APA-)tournament. An asterisk indicates that the respective vector displays expected payoffs under random tie-breaking.

With regard to tournament fairness, Table 2 suggests that winning probabilities in the lab are *more* dispersed in APA-tournaments than in LC-tournaments. By contrast, the estimation results of model (2) in Table B.3 yield almost equal probabilities of winning for the three players in APA-tournaments as $1/Period \rightarrow 0$ and at the means of the other variables, but a substantially higher winning probability for Player 3 (40%) than for the other two players in LC-tournaments. Indeed, a test for equality of the Gini coefficients calculated from the predicted winning probabilities reveals no significant treatment differences.[8]

To test Hypothesis 3 with regard to payments, we estimate panel regression models of a player's relative payment, i.e., her payment divided by the sum of payments obtained by all three players in the tournament. The models are set up similarly to the models for players' payments (see above) and their results are presented in Table B.5 in the appendix. We find that Player 2 (3) obtains the lowest (highest) payment share in LC-tournaments, and vice versa in APA-tournaments. Testing for equality of the absolute difference in payment shares between those two players in the two treatments as $1/Period \rightarrow 0$ – which is a test for equality of the Gini coefficients, as argued above – reveals no significant difference. We therefore conclude:

Result 3. *APA- and LC-tournaments are equally fair.*

4.3. 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 winning in the individual matches along the potential courses of the RRT. To that end, Fig. 3 represents the empirical counterpart of Fig. 1.

Fig. 3 shows that, barring overbidding, behavior and winning frequencies in individual matches closely track theoretical predictions in LC-tournaments, with the exception of efforts at the stakeless node C'. A similar pattern emerges for APA-tournaments, but with two important additional 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 provide no effort at all, because 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 67 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 (see Table B.6 in the appendix).

These observations suggest that no *discouragement effect* for Player 3 occurs in node D, at least not as strongly as theoretically predicted. Instead, Player 3 seemingly tries to exploit a negative psychological momentum by Player 1: Player 3 might consider Player 1 as a discouraged loser who is easy to beat after the loss in Match 1. 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 B.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 once control variables are included. 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.*

Fig. 3 also shows that *empirically* a higher accuracy (fewer random components) on the match level does not decrease the propensity to reach the unattractive stakeless match of node C'. Whereas the empirical propensity to reach node C' closely matches the theoretical prediction in the LC-tournament (it equals $0.54 \cdot 0.58 \approx 0.31$), it is more than three times higher in the APA-tournament (where it equals $0.60 \cdot 0.65 \approx 0.39$). We also note that average efforts in node C' are substantially larger than zero. As the match in node C' is strongly stakeless, any subject exerting positive effort in node C' may be considered

[8] For three individuals with values $y_1 < y_2 < y_3$ of the variable of interest, the Gini coefficient can be shown to equal $(2/3) \cdot (y_3 - y_1) / \sum_i y_i$. If winning probabilities are considered, $\sum_i y_i = 1$ which implies that the equality of the Gini coefficients in the two treatments is a linear hypothesis.

to be irrational. We identify 22 subjects who consistently exhibit such irrational behavior in node C'. Below, we report how excluding those subjects changes our results.

4.4. Robustness checks

To corroborate the robustness of the results presented above, we briefly describe our findings from statistical analyses performed on a more restricted number of observations. The corresponding tables are presented in Appendix C.

First, Appendix C.1 contains the results for the restricted dataset where the first five periods are excluded as an alternative way to account for potential learning effects. There are two differences to the results presented above: In LC-tournaments, the advantage of Player 3 over Players 1 and 2 in terms of winning probability and to Player 2 in terms of payments is no longer significant. In addition, a win of Player 2 in the first match significantly discourages Player 3 also in LC-tournaments.

Second, Appendix C.2 contains the results for the restricted dataset where all tournaments involving subjects who behave irrationally in node C' are excluded. This robustness check yields three differences to the results presented above: In LC-tournaments, Player 3 has a significantly larger probability of winning the tournament only in comparison to Player 2, but not Player 1. In APA-tournaments, Player 3's payment is no longer significantly lower than the payments of the other two players. And the difference in winning probabilities between Player 1 and Player 3 in node D of APA-tournaments is no longer significant.

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 also find no significant difference between LC- and APA-tournaments in terms of fairness.

One central result for static contests between two players is that all-pay auctions are more intense than lottery contests if the contestants are not too heterogeneous. The intuition for this result is based on two effects: On the one hand, less randomness implies a higher marginal impact of effort, which entails higher investments by both players. On the other hand, less randomness also implies better odds for the favorite, which entails a lower investment of the underdog and, as a strategic reaction, also by the favorite. If the players are not too heterogeneous, the first effect dominates.

The theory on (dynamic) round-robin tournaments, however, predicts larger intermediate asymmetries in continuation payoffs for APA-tournaments than for LC-tournaments, and in some matches these asymmetries are so strong that the second effect prevails. Therefore, APA-tournaments are predicted to be not only less fair but also less intense than LC-tournaments.

In our experiment, by contrast, we do not find significant differences between APA-tournaments and LC-tournaments in terms of fairness or intensity. The main reason is the behavior of subjects acting as Player 3 who have not taken part in the first match and meet the loser of the first match in the second match of the APA-tournament: they seem to ignore their low continuation payoff and invest much more than predicted, which not only increases the intensity but also levels the playing field.

Due to this behavior, we find, moreover, that APA-tournaments significantly disadvantage Player 3 in terms of payoffs: Instead of being discouraged after Player 2 has won the first match, 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 straightly into a *dissipation trap*: a cut-throat contest against Player 2 in the final match. As this also lowers winning chances and payments of Player 2, 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. Similarly, our findings suggest that the contest designer's choice of accuracy on the match-level (e.g., by adding or removing random components like the sudden-death rule or video assistant referees in sports) has not much impact on the overall intensity or fairness of round-robin tournaments with three players and a single prize. Moreover, the observation that a by then uninvolved third party (Player 3 in our setting) seemingly tries to exploit a perceived negative psychological momentum of another player (losing Player 1 in our setting) is, to the best of our knowledge, new and may serve as a testable prediction in many other dynamic contests.

This paper thus 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. An extension of the experiment to a round-robin tournament setting with multiple prizes suggests itself. Lauber et al. (2023) include, as a robustness check, a comparison of LC- and APA-tournaments in which the player who ranks second 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.

CRediT authorship contribution statement

Arne Lauber: Writing – original draft, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Christoph March:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Marco Sahm:** Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Conceptualization.

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Appendix A. Computation of the SPE

We compute the SPE of the RRT with three players and the respective equilibrium values quoted in Table 1 and Fig. 1.

A.1. Backward induction of the LC-tournament

Sahm (2019, Appendix A) provides the analysis of the LC-tournament with a prize of $R = 1$ making repeatedly use of Eqs. (2) to (4).

3rd stage: Player 2 vs. Player 3

In node A, Player 2 has won the first match and Player 3 has won the second match. Thus $w_2^A = w_3^A = 1$ and $\ell_2^A = \ell_3^A = 0$, which yields $x_2^A = x_3^A = 1/4$, $p_2^A = p_3^A = 1/2$, and $E_2^A = E_3^A = 1/4$.

In node B, Player 2 has won the first match and Player 1 has won the second match. Thus $w_2^B = 1$, $w_3^B = 1/3$, $\ell_2^B = 1/3$, and $\ell_3^B = 0$, which yields $x_2^B = 4/27$, $x_3^B = 2/27$, $p_2^B = 2/3$, $p_3^B = 1/3$, $E_2^B = 17/27$, and $E_3^B = 1/27$.

In node C, Player 1 has won the first match and Player 3 has won the second match. Thus $w_2^C = 1/3$, $w_3^C = 1$, $\ell_2^C = 0$, and $\ell_3^C = 1/3$, which yields $x_2^C = 2/27$, $x_3^C = 4/27$, $p_2^C = 1/3$, $p_3^C = 2/3$, $E_2^C = 1/27$, and $E_3^C = 17/27$.

In node C', Player 1 has won the first two matches. Thus $w_2^{C'} = w_3^{C'} = \ell_2^{C'} = \ell_3^{C'} = 0$, which yields $x_2^{C'} = x_3^{C'} = 0$, $p_2^{C'} = p_3^{C'} = 1/2$, $E_2^{C'} = E_3^{C'} = 0$.

2nd stage: Player 1 vs. Player 3

In node D, Player 2 has won the first match. Thus $w_1^D = \frac{1}{3}p_3^B = 1/9$, $w_3^D = E_3^A = 1/4$, $\ell_1^D = 0$, and $\ell_3^D = E_3^B = 1/27$, which yields $x_1^D = 92/3675$, $x_3^D = 529/11025$, $p_1^D = 12/35$, $p_3^D = 23/35$, $E_1^D = 48/3675$, and $E_3^D = 5689/44100$.

In node E, Player 1 has won the first match. Thus $w_1^E = 1$, $w_3^E = E_3^C = 17/27$, $\ell_1^E = \frac{1}{3}p_2^C = 1/9$, and $\ell_3^E = 0$, which yields $x_1^E = 1088/5043$, $x_3^E = 2312/15129$, $p_1^E = 24/41$, $p_3^E = 17/41$, $E_1^E = 6289/15129$, and $E_3^E = 4913/45387$.

1st stage: Player 1 vs. Player 2

In node F, $w_1^F = E_1^E = 6289/15129$, $w_2^F = p_1^D E_2^B + p_3^D E_2^A = 1437/3780$, $\ell_1^F = E_1^D = 48/3675$, and $\ell_2^F = p_3^E E_2^C = 17/1107$, which yields

$$x_1^F = \frac{74509559596323332}{742030627722770505} \approx 0.1004,$$
$$x_2^F = \frac{141134045423761}{1551283542277569} \approx 0.0910,$$

$$p_1^F = \frac{6887964}{13128779} \approx 0.5246,$$
$$p_2^F = \frac{6240815}{13128779} \approx 0.4754,$$
$$E_1^F = \frac{1256345899995116512}{10141085245544530235} \approx 0.1239,$$
$$E_2^F = \frac{24878271356200861}{254410500933521316} \approx 0.0978.$$

Moreover, Player 3's expected payoff equals

$$E_3^F = p_1^F E_3^E + p_2^F E_3^D = \frac{3284432699741}{27807541648740} \approx 0.1181$$

and the players' ex-ante winning probabilities are given by

$$P_1 = p_1^F(p_1^E + \frac{1}{3}p_3^E p_2^C) + \frac{1}{3}p_2^F p_1^D p_3^B = \frac{564207880}{1614839817} \approx 0.3494,$$
$$P_2 = \frac{1}{3}p_1^F p_3^E p_2^C + p_2^F[p_1^D(p_2^B + \frac{1}{3}p_3^B) + p_3^D p_2^A] = \frac{991897217}{3229679634} \approx 0.3071,$$
$$P_3 = p_1^F p_3^E(\frac{1}{3}p_2^C + p_3^C) + p_2^F(\frac{1}{3}p_1^D p_3^B + p_3^D p_3^A) = \frac{1109366657}{3229679634} \approx 0.3435.$$

Multiplying the expected effort levels and payoffs by $R = 600$ yields the equilibrium values quoted in Table 1 and Fig. 1.

A.2. Backward induction of the APA-tournament

We summarize the analysis of the APA-tournament with a prize of $R = 1$ by Krumer et al. (2017, Section 2), making repeatedly use of Eqs. (5) to (7).

3rd stage: Player 2 vs. Player 3

In node A, Player 2 has won the first match and Player 3 has won the second match. Thus $w_2^A = w_3^A = 1$ and $\ell_2^A = \ell_3^A = 0$, which yields $E(x_2^A) = E(x_3^A) = 1/2$, $p_2^A = p_3^A = 1/2$, and $E_2^A = E_3^A = 0$.

In node B, Player 2 has won the first match and Player 1 has won the second match. Thus $w_2^B = 1$, $w_3^B = 1/3$, $\ell_2^B = 1/3$, and $\ell_3^B = 0$, which yields $E(x_2^B) = 1/6$, $E(x_3^B) = 1/12$, $p_2^B = 3/4$, $p_3^B = 1/4$, $E_2^B = 2/3$, and $E_3^B = 0$.

In node C, Player 1 has won the first match and Player 3 has won the second match. Thus $w_2^C = 1/3$, $w_3^C = 1$, $\ell_2^C = 0$, and $\ell_3^C = 1/3$, which yields $E(x_2^C) = 1/12$, $E(x_3^C) = 1/6$, $p_2^C = 1/4$, $p_3^C = 3/4$, $E_2^C = 0$, and $E_3^C = 2/3$.

In node C', Player 1 has won the first two matches. Thus $w_2^{C'} = w_3^{C'} = \ell_2^{C'} = \ell_3^{C'} = 0$, which yields $x_2^{C'} = x_3^{C'} = 0$, $p_2^{C'} = p_3^{C'} = 1/2$, $E_2^{C'} = E_3^{C'} = 0$.

2nd stage: Player 1 vs. Player 3

In node D, Player 2 has won the first match. Thus $w_1^D = \frac{1}{3}p_3^B = 1/12$, $w_3^D = E_3^A = 0$, $\ell_1^D = 0$, and $\ell_3^D = E_3^B = 0$, which yields $x_1^D = \varepsilon$, $x_3^D = 0$, $p_1^D = 1$, $p_3^D = 0$, $E_1^D = 1/12$, and $E_3^D = 0$.

In node E, Player 1 has won the first match. Thus $w_1^E = 1$, $w_3^E = E_3^C = 2/3$, $\ell_1^E = \frac{1}{3}p_2^C = 1/12$, and $\ell_3^E = 0$, which yields $E(x_1^E) = 1/3$, $E(x_3^E) = 8/33$, $p_1^E = 7/11$, $p_3^E = 4/11$, $E_1^E = 1/3$, and $E_3^E = 0$.

1st stage: Player 1 vs. Player 2

In node F, $w_1^F = E_1^E = 1/3$, $w_2^F = p_1^D E_2^B + p_3^D E_2^A = E_2^B = 2/3$, $\ell_1^F = E_1^D = 1/12$, and $\ell_2^F = p_1^E E_2^{C'} + p_3^E E_2^C = 0$, which yields $E(x_1^F) = \frac{3}{64}$, $E(x_2^F) = \frac{1}{8}$, $p_1^F = \frac{3}{16}$, $p_2^F = \frac{13}{16}$, $E_1^F = \frac{1}{12}$, and $E_2^F = \frac{5}{12}$. Moreover, Player 3's expected payoff equals $E_3^F = p_1^F E_3^E + p_2^F E_3^D = 0$ and the players' ex-ante winning probabilities are given by

$$P_1 = p_1^F(p_1^E + \frac{1}{3}p_3^E p_2^C) + \frac{1}{3}p_2^F p_1^D p_3^B = \frac{407}{2112} \approx 0.193,$$
$$P_2 = \frac{1}{3}p_1^F p_3^E p_2^C + p_2^F[p_1^D(p_2^B + \frac{1}{3}p_3^B) + p_3^D p_2^A] = \frac{721}{1056} \approx 0.683,$$
$$P_3 = p_1^F p_3^E(\frac{1}{3}p_2^C + p_3^C) + p_2^F(\frac{1}{3}p_1^D p_3^B + p_3^D p_3^A) = \frac{263}{2112} \approx 0.125.$$

Multiplying the expected effort levels and payoffs by $R = 600$ yields the equilibrium values quoted in Table 1 and Fig. 1.

Appendix B. Additional tables

B.1. Demographic composition of the sample

We note first that most participants were students at the University of Bamberg. However, ten non-students (retirees, high-school students, non-university employees) also participated. Table B.1 provides a breakdown of subjects' key characteristics by treatment and player number.

Pairwise t-tests among the different sub-groups reveal no significant differences except for a slightly larger fraction of females assigned to the role of Player 1 in treatment LC compared to Player 2 in treatment LC as well as Player 1 and Player 2 in treatment APA ($p = 0.039$ in a one-sided t-test). Treatment differences across player roles are not significant.

Table B.1
Overview of demographics by treatment and player role.

	Females (Fraction)	Age	Students of Econ. (Fract.)	Number of siblings
All Subjects	0.507	26.9	0.580	1.40
Treatment LC	0.551	25.6	0.609	1.43
Player 1	0.696	25.9	0.652	1.52
Player 2	0.435	25.0	0.652	1.30
Player 3	0.522	25.8	0.522	1.48
Treatment APA	0.464	28.2	0.551	1.36
Player 1	0.435	25.7	0.609	1.48
Player 2	0.435	29.7	0.435	1.26
Player 3	0.522	29.4	0.609	1.35

B.2. Estimation of total tournament effort by player

See Table B.2.

Table B.2
Panel estimations of total tournament effort by player.

Dep. variable	Total effort			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	245.03***	(23.227)	267.21**	(69.284)
Player 2	2.83	(21.893)	29.76	(25.582)
Player 3	0.05	(40.177)	23.83	(35.826)
APA × Player 1	−0.96	(52.803)	3.96	(50.617)
APA × Player 2	−56.22	(28.173)	13.68	(27.692)
APA × Player 3	42.73	(54.353)	87.19	(46.854)
$(1/Period)$ × LC × Player 1	77.79**	(16.895)	77.79**	(16.932)
$(1/Period)$ × LC × Player 2	−0.86	(36.986)	−0.86	(37.067)
$(1/Period)$ × LC × Player 3	−10.24	(43.758)	−10.24	(43.854)
$(1/Period)$ × APA × Player 1	185.23**	(47.861)	185.30**	(47.790)
$(1/Period)$ × APA × Player 2	64.96	(45.256)	65.07	(45.388)
$(1/Period)$ × APA × Player 3	16.51	(68.765)	16.64	(68.684)
Number of Correct CRT Answers			−2.75	(6.80)
Number of Safe Choices			−11.51	(10.44)
Age			3.59	(1.61)
Female			24.88	(20.38)
Econ			12.99	(17.08)
Number of Siblings			−16.46	(12.01)
Propensity to Play Risk Games			7.33	(14.21)
Propensity to Play Games of Chance			−17.07*	(6.36)
Ambition			7.48	(6.19)
Generosity			2.23	(8.60)
Importance Payment			−25.41*	(8.55)
Importance Winning			39.22***	(4.76)
Observations	2760		2760	
Subjects	138		138	
R^2	0.027		0.256	

Notes:
[1] Robust standard errors in parentheses, clustered at the session level.
[2] All models include a subject-specific random effects error structure.
[3] Coefficients of interactions are displayed w/o an omitted category, i.e., the coefficient of "APA × Player k" is the estimated treatment effect for subjects assigned to the role of Player k, and the coefficient of "1/Period × Tr × Player k" is the estimated effect of the reverse period for subjects assigned to the role of Player k in treatment Tr.
[4] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

B.3. Estimation of winning probabilities

See Table B.3.

B.4. Estimation of payments

See Table B.4.

B.5. Estimation of payment shares

See Table B.5.

B.6. Panel regression of winning frequency in node D

See Table B.6.

B.7. Panel regression of efforts in the second match

See Table B.7.

Appendix C. Robustness checks

C.1. Results for the last 15 periods

In this subsection, we present the results of our main analyses when tournaments played in the first five periods are excluded. We follow the order in which the results are referred to in the main text, regardless of whether the corresponding figure or table is presented in the main text or in Appendix B.

There are two differences to the results presented in the main text: In LC-tournaments, the advantage of Player 3 over Players 1 and 2 in terms of winning probability and to Player 2 in terms of payments is no longer significant. In addition, a win of Player 2 in the first match significantly discourages Player 3 also in LC-tournaments (see Fig. C.1 and Tables C.1–C.8.).

C.2. Results without tournaments involving irrational players in node C'

In this subsection, we present the results of our main analyses taking into account the behavior of subjects in node C'. As the match in node C' is strongly stakeless, any subject exerting positive effort in node C' may therefore be considered to be irrational. Out of 92 subjects acting as Players 2 or 3, 47 exert a positive effort in node C' at least once. Note however that subjects may derive a positive utility (or, "joy") of winning even if the expected payoff from winning is zero (see, e.g., Sheremeta, 2010). We therefore employ a slightly extended definition of rationality: 14 out of the 47 subjects who sometimes invest in node C' never invest more than five points, and 11 do so once or twice, but invest zero in all other instances. This leaves 22 subjects who we classify as irrational in node C'. Below, we present the results of our main analyses when tournaments involving at least one of these irrational subjects are excluded (this applies to 400 out of 920 tournaments). As in the previous subsection, the results are presented in the order they are referred to in the main text.

There are three differences to the results presented in the main text: In LC-tournaments, Player 3 has a significantly larger probability of winning the tournament only in comparison to Player 2, but not Player 1. In APA-tournaments, Player 3's payment is no longer significantly lower than the payments of the other two players. And the difference in winning probabilities between Player 1 and Player 3 in node D of APA-tournaments is no longer significant (see Fig. C.2 and Tables C.9–C.16).

Table B.3
Logit panel estimations for winning probabilities.

Dep. variable	Winning probability			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	−0.491*	(0.231)	0.022	(0.613)
APA-Treatment	−0.483	(0.329)	−0.349	(0.283)
LC × Player 1	−0.378	(0.324)	−0.644*	(0.282)
LC × Player 2	−0.500	(0.326)	−0.639*	(0.285)
APA × Player 1	0.484	(0.326)	0.064	(0.288)
APA × Player 2	−0.096	(0.334)	0.065	(0.287)
$(1/Period)$ × LC × Player 1	0.956*	(0.458)	0.946*	(0.456)
$(1/Period)$ × LC × Player 2	0.117	(0.483)	0.116	(0.481)
$(1/Period)$ × LC × Player 3	−1.299*	(0.559)	−1.290*	(0.556)
$(1/Period)$ × APA × Player 1	0.420	(0.457)	0.423	(0.460)
$(1/Period)$ × APA × Player 2	−0.617	(0.561)	−0.622	(0.562)
$(1/Period)$ × APA × Player 3	0.032	(0.500)	0.028	(0.503)
Number of Correct CRT Answers			0.079	(0.074)
Number of Safe Choices			−0.093	(0.056)
Age			0.011	(0.007)
Female			0.063	(0.165)
Econ			0.221	(0.154)
Siblings			−0.181*	(0.075)
Propensity to Play Games of Chance			0.064	(0.063)
Propensity to Play Board Games			−0.121**	(0.046)
Ambition			0.004	(0.060)
Generosity			−0.072	(0.061)
Importance Payment			−0.100	(0.052)
Importance Winning			0.300***	(0.043)
Observations	2760		2760	
Subjects	138		138	
Log-likelihood	−1656.1		−1624.0	

Notes:
[1] Standard errors in parentheses.
[2] All models include a subject-specific random effects error structure.
[3] In interactions between treatment and player dummies, Player 3 is the omitted category for player, but there is no omitted category for the treatment, i.e., the coefficient of "Tr × Player k" is the estimated difference between Player k and Player 3 in treatment Tr.
[4] Coefficients of interactions with the reverse of the period are displayed w/o an omitted category for the treatment and the player, i.e., the coeff. of "$1/Period$ × Tr × Player k" is the estimated effect of the reverse period for subjects assigned to the role of Player k in treatment Tr.
[5] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table B.4
Panel estimations for payments.

Dep. variable	Payment			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	592.07***	(18.40)	572.34***	(51.27)
APA-Treatment	−91.33*	(34.98)	−100.80**	(31.45)
LC × Player 1	−50.50**	(11.13)	−53.51*	(22.87)
LC × Player 2	−63.68**	(16.48)	−81.22**	(24.53)
APA × Player 1	91.84***	(13.47)	91.72***	(16.66)
APA × Player 2	85.31*	(31.35)	79.61*	(31.21)
$(1/Period)$ × LC × Player 1	45.05	(38.46)	45.05	(38.55)
$(1/Period)$ × LC × Player 2	14.47	(34.24)	14.47	(34.32)
$(1/Period)$ × LC × Player 3	−126.21**	(28.99)	−126.21***	(29.05)
$(1/Period)$ × APA × Player 1	−130.34*	(40.50)	−130.51**	(40.50)
$(1/Period)$ × APA × Player 2	−123.37	(73.69)	−123.68	(73.91)
$(1/Period)$ × APA × Player 3	−13.00	(87.97)	−13.36	(87.77)
Number of Correct CRT Answers			7.49	(7.80)
Number of Safe Choices			3.92	(4.67)
Age			−2.43*	(0.98)
Female			−25.60	(18.67)
Econ			10.56	(12.41)
Siblings			−1.55	(7.09)
Propensity to Play Games of Chance			−1.93	(6.52)
Propensity to Play Board Games			4.07	(3.84)
Ambition			−4.47	(4.36)
Generosity			−6.96	(8.20)
Importance Payment			16.30**	(5.68)
Importance Winning			−8.38	(4.41)
Observations	2760		2760	
Subjects	138		138	
R^2	0.016		0.050	

Notes:
[1] Robust standard errors in parentheses, clustered at the session level.
[2] All models include a subject-specific random effects error structure.
[3] In interactions between treatment and player dummies, Player 3 is the omitted category for player, but there is no omitted category for the treatment, i.e., the coefficient of "Tr × Player k" is the estimated difference between Player k and Player 3 in treatment Tr.
[4] Coefficients of interactions with the reverse of the period are displayed w/o an omitted category for the treatment and the player, i.e., the coeff. of "$1/Period$ × Tr × Player k" is the estimated effect of the reverse period for subjects assigned to the role of Player k in treatment Tr.
[5] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table B.5
Panel estimations for payment shares.

Dep. variable	Payment share			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	0.362***	(0.007)	0.378***	(0.027)
APA-Treatment	−0.060***	(0.011)	−0.063**	(0.013)
LC × Player 1	−0.041**	(0.009)	−0.046**	(0.012)
LC × Player 2	−0.047*	(0.014)	−0.056**	(0.015)
APA × Player 1	0.043*	(0.013)	0.040*	(0.013)
APA × Player 2	0.049	(0.021)	0.048	(0.023)
$(1/Period)$ × LC × Player 1	0.030	(0.022)	0.030	(0.022)
$(1/Period)$ × LC × Player 2	0.044	(0.030)	0.044	(0.030)
$(1/Period)$ × LC × Player 3	−0.074*	(0.030)	−0.074*	(0.030)
$(1/Period)$ × APA × Player 1	−0.018	(0.014)	−0.018	(0.014)
$(1/Period)$ × APA × Player 2	−0.019	(0.056)	−0.019	(0.056)
$(1/Period)$ × APA × Player 3	0.037	(0.042)	0.036	(0.042)
Number of Correct CRT Answers			0.009*	(0.004)
Number of Safe Choices			0.001	(0.002)
Age			−0.001*	(0.000)
Female			−0.008	(0.009)
Econ			0.006	(0.008)
Siblings			−0.001	(0.004)
Propensity to Play Games of Chance			−0.001	(0.003)
Propensity to Play Board Games			−0.001	(0.003)
Ambition			−0.005	(0.004)
Generosity			−0.004	(0.004)
Importance Payment			0.006	(0.003)
Importance Winning			−0.001	(0.002)
Observations	2760		2760	
Subjects	138		138	
R^2	0.011		0.027	

Notes:
[1] Robust standard errors in parentheses, accounting for clustering at the session level.
[2] All models include a subject-specific random effects error structure.
[3] In interactions between treatment and player dummies, Player 3 is the omitted category for player, but there is no omitted category for the treatment, i.e., the coefficient of "Tr × Player k" is the estimated difference between Player k and Player 3 in treatment Tr.
[4] Coefficients of interactions with the reverse of the period are displayed w/o an omitted category for the treatment and the player, i.e., the coefficient of "1/Period × Tr × Player k" is the estimated effect of the reverse period for subjects assigned to the role of Player k in treatment Tr.
[5] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table B.6
Panel estim. of winning freq. in node D in the APA-Treatm.

Dep. Variable	Indicator of winning in node D			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	0.309***	(0.021)	−0.073	(0.499)
Player 3	0.401**	(0.032)	0.433*	(0.099)
$1/Period$ × Player 1	0.211	(0.130)	0.250	(0.145)
$1/Period$ × Player 3	−0.204	(0.114)	−0.216	(0.118)
Number of Correct CRT Answers			0.025	(0.022)
Number of Safe Choices			−0.042	(0.031)
Age			0.010*	(0.002)
Female			−0.019	(0.062)
Econ			−0.080*	(0.025)
Siblings			−0.098*	(0.029)
Propensity to Play Games of Chance			0.001	(0.018)
Propensity to Play Board Games			0.042*	(0.011)
Ambition			0.039	(0.022)
Generosity			0.054	(0.023)
Importance Payment			−0.002	(0.039)
Importance Winning			0.030*	(0.006)
Observations	366		366	
Subjects	45		45	
R^2	0.130		0.249	

Notes:
[1] Robust standard errors in parentheses, accounting for clustering at the session level.
[2] All models include a subject-specific random effects error structure.
[3] Coefficients of interactions are displayed w/o an omitted category, i.e., the coefficient of "1/Period × Player k" is the estimated effect of the reverse period for subjects assigned to the role of Player k.
[4] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table B.7
Panel estimation for effort choices of Player 3 in Match 2.

Dep. variable	Effort of player 3 in Match 2			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	117.70***	(20.070)	209.53*	(84.187)
APA-Treatment	−6.33	(26.474)	35.43*	(14.207)
LC × Node E	15.85	(9.605)	15.88	(9.835)
APA × Node E	64.71*	(26.214)	65.16*	(26.483)
$1/Period$	33.50*	(12.008)	32.67*	(11.395)
$1/Period$ × Node E	−53.25	(27.317)	−52.04	(28.166)
$1/Period$ × APA	21.85	(52.147)	22.27	(52.261)
$1/Period$ × APA × Node E	−33.41	(59.702)	−34.94	(61.196)
Number of Correct CRT Answers			12.127	(7.433)
Number of Safe Choices			−10.533	(10.592)
Age			3.217*	(0.934)
Female			49.362	(30.501)
Econ			−44.525**	(11.155)
Siblings			−18.980	(8.602)
Propensity to Play Games of Chance			−47.695	(21.075)
Propensity to Play Board Games			−11.025	(8.021)
Ambition			−8.633	(9.604)
Generosity			10.058	(15.694)
Importance Payment			−11.500	(8.740)
Importance Winning			39.842***	(4.561)
Observations	920		920	
Subjects	46		46	
R^2	0.026		0.427	

Notes:
[1] Robust standard errors in parentheses, accounting for clustering at the session level.
[2] All models include a subject-specific random effects error structure.
[3] For interactions between the treatment dummies and the dummy for Node E, there is no omitted category for the treatment, i.e., the coefficient of "Tr × Node E" is the estimated difference between Player 3's effort in node E and D in treatment Tr. In contrast, treatment LC is the omitted category for the treatment and Node D is the omitted category for the node in interactions with the reverse of the period.
[4] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table C.1
Average efforts, winning frequencies, and payments.

	Total effort		Rel. Freq.(Winning)		Payments	
	LC	APA	LC	APA	LC	APA
Player 1	250.9	250.7	0.336	0.394	550.8	585.8
Player 2	250.5	195.8	0.293	0.293	525.1	579.8
Player 3	245.4	288.4	0.371	0.313	577.2	499.4
Aggregate	746.8	735.0				
Gini			0.052	0.068	0.021	0.035

Note: Gini $\triangleq$ Gini coefficient.

Table C.2
Regression analysis of tournament intensity.

Dep. variable	Tournament intensity			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	746.85***	(64.24)	702.09***	(108.22)
APA-Treatment	−11.89	(105.86)	−86.40	(128.30)
$1/Period$			510.80	(607.85)
$1/Period$ × APA			850.35	(790.18)
Observations	690		690	
R^2	0.0003		0.0109	

Notes:
[1] The regression is conducted at the tournament level, i.e., there is one observation for each distinct tournament. This amounts to 15 periods · 138 subjects/3 subjects per RRT = 690 tournaments played overall.
[2] Robust standard errors are in parentheses, accounting for clustering at the session level.
[3] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table C.3
Panel estimations of total tournament effort by player.

Dep. variable	Total effort			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	233.14***	(42.03)	242.92*	(75.63)
Player 2	3.12	(17.41)	27.45	(31.98)
Player 3	−0.46	(51.81)	23.24	(41.84)
APA × Player 1	−91.93	(53.64)	−87.44	(50.42)
APA × Player 2	−50.42	(42.59)	16.47	(42.99)
APA × Player 3	58.60	(63.14)	99.32	(64.83)
$(1/Period)$ × LC × Player 1	202.58	(211.23)	202.58	(211.85)
$(1/Period)$ × LC × Player 2	162.89	(334.40)	162.89	(335.38)
$(1/Period)$ × LC × Player 3	145.33	(211.36)	145.33	(211.98)
$(1/Period)$ × APA × Player 1	1,249.41**	(276.12)	1,249.93**	(277.53)
$(1/Period)$ × APA × Player 2	149.42	(223.41)	150.32	(223.91)
$(1/Period)$ × APA × Player 3	−37.68	(202.40)	−36.64	(203.28)
Number of Correct CRT Answers			−1.37	(5.69)
Number of Safe Choices			−7.68	(10.75)
Age			3.53	(1.60)
Female			14.50	(22.73)
Econ			13.37	(17.21)
Siblings			−21.54	(13.53)
Propensity to Play Games of Chance			9.65	(12.84)
Propensity to Play Board Games			−18.62*	(6.39)
Ambition			9.14	(6.12)
Generosity			0.37	(7.05)
Importance Payment			−24.47*	(9.89)
Importance Winning			39.68***	(5.91)
Observations	2070		2070	
Subjects	138		138	
R^2	0.025		0.261	

Notes:
1 Robust standard errors in parentheses, clustered at the session level.
2 All models include a subject-specific random effects error structure.
3 Coefficients of interactions are displayed w/o an omitted category, i.e. the coefficient of "APA × Player k" is the estimated treatment effect for subjects assigned to the role of Player k, and the coefficient of "1/Period × Tr × Player k" is the estimated effect of the reverse period for subjects assigned to the role of Player k in treatment Tr.
4 Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

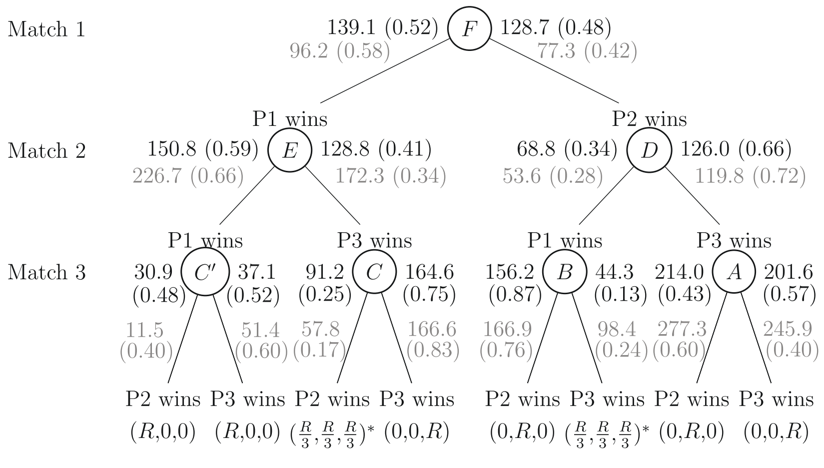

Fig. C.1. Average efforts & relative frequencies of winning in individual matches.
Note: Numbers to the left (right) of a node and its downward edges denote the average effort and relative frequency of winning of the lower-(higher-)numbered player in the given match. Relative frequencies of winning are in brackets. Black (gray) numbers denote results for the LC-(APA-)tournament. An asterisk indicates that the respective vector displays expected payoffs under random tie-breaking.

Table C.4
Logit panel estimations for winning probabilities.

Dep. variable	Total effort			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	−0.522	(0.380)	0.025	(0.739)
APA-Treatment	−0.666	(0.550)	−0.577	(0.529)
LC × Player 1	−0.224	(0.539)	−0.503	(0.520)
LC × Player 2	−0.599	(0.545)	−0.786	(0.526)
APA × Player 1	0.479	(0.545)	0.100	(0.531)
APA × Player 2	0.622	(0.570)	0.815	(0.551)
$(1/Period)$ × LC × Player 1	−0.181	(3.559)	−0.179	(3.539)
$(1/Period)$ × LC × Player 2	1.394	(3.616)	1.385	(3.604)
$(1/Period)$ × LC × Player 3	−1.139	(3.534)	−1.135	(3.527)
$(1/Period)$ × APA × Player 1	2.481	(3.417)	2.470	(3.436)
$(1/Period)$ × APA × Player 2	−5.929	(3.970)	−6.027	(3.986)
$(1/Period)$ × APA × Player 3	2.462	(3.674)	2.408	(3.694)
Number of Correct CRT Answers			0.090	(0.081)
Number of Safe Choices			−0.088	(0.062)
Age			0.013	(0.008)
Female			−0.023	(0.183)
Econ			0.258	(0.171)
Siblings			−0.149	(0.083)
Propensity to Play Games of Chance			0.109	(0.070)
Propensity to Play Board Games			−0.093	(0.051)
Ambition			−0.013	(0.067)
Generosity			−0.095	(0.067)
Importance Payment			−0.123*	(0.058)
Importance Winning			0.293***	(0.047)
Observations	2070		2070	
Subjects	138		138	
Log-likelihood	−1250.7		−1224.9	

Notes:
[1] Standard errors in parentheses.
[2] All models include a subject-specific random effects error structure.
[3] In interactions between treatment and player dummies, Player 3 is the omitted category for player, but there is no omitted category for the treatment, i.e. the coefficient of "Tr × Player k" is the estimated difference between Player k and Player 3 in treatment Tr.
[4] Coefficients of interactions with the reverse of the period are displayed w/o an omitted category for the treatment and the player, i.e. the coeff. of "$1/Period$ × Tr × Player k" is the estimated effect of the reverse period for subjects assigned to the role of Player k in treatment Tr.
[5] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

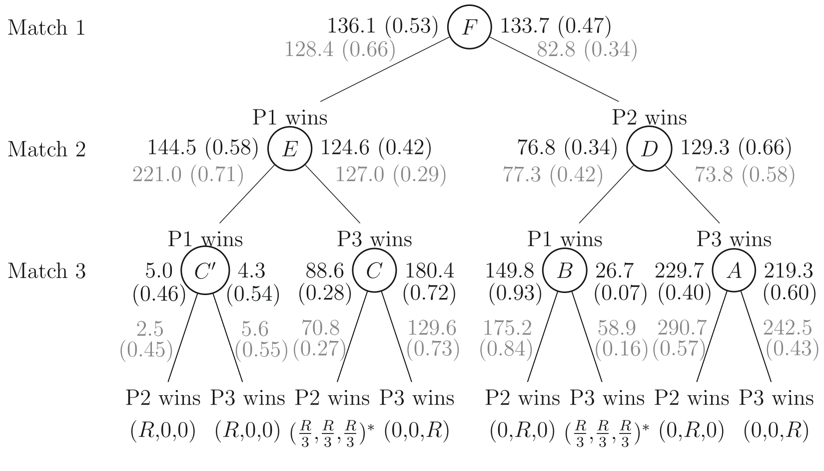

Fig. C.2. Average efforts & relative frequencies of winning in individual matches.
Note: Numbers to the left (right) of a node and its downward edges denote the average effort and relative frequency of winning of the lower-(higher-)numbered player in the given match. Relative frequencies of winning are in brackets. Black (gray) numbers denote results for the LC-(APA-)tournament. An asterisk indicates that the respective vector displays expected payoffs under random tie-breaking.

Table C.5
Panel estimations for payments.

Dep. variable	Payment			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	601.98***	(49.76)	606.59***	(63.56)
APA-Treatment	−129.71	(67.16)	−139.70	(64.84)
LC × Player 1	−31.50	(42.60)	−37.29	(46.09)
LC × Player 2	−76.52	(71.32)	−98.08	(72.06)
APA × Player 1	195.19**	(46.06)	194.74**	(46.92)
APA × Player 2	172.33*	(63.53)	168.85*	(59.02)
$(1/Period)$ × LC × Player 1	−224.04	(346.02)	−224.04	(347.04)
$(1/Period)$ × LC × Player 2	−3.87	(377.97)	−3.87	(379.07)
$(1/Period)$ × LC × Player 3	−282.89	(397.23)	−282.89	(398.40)
$(1/Period)$ × APA × Player 1	−931.59	(432.21)	−934.58	(437.94)
$(1/Period)$ × APA × Player 2	−739.01	(336.90)	−744.26	(337.73)
$(1/Period)$ × APA × Player 3	309.45	(237.53)	303.45	(230.14)
Number of Correct CRT Answers			7.96	(7.61)
Number of Safe Choices			0.29	(4.60)
Age			−2.08	(1.08)
Female			−23.05	(19.75)
Econ			14.68	(11.90)
Siblings			6.97	(8.61)
Propensity to Play Games of Chance			1.60	(6.18)
Propensity to Play Board Games			9.07**	(2.14)
Ambition			−8.99	(4.93)
Generosity			−8.79	(9.95)
Importance Payment			12.37	(6.34)
Importance Winning			−9.53	(5.55)
Observations	2070		2070	
Subjects	138		138	
R^2	0.020		0.054	

Notes:
[1] Robust standard errors in parentheses, clustered at the session level.
[2] All models include a subject-specific random effects error structure.
[3] In interactions between treatment and player dummies, Player 3 is the omitted category for player, but there is no omitted category for the treatment, i.e., the coefficient of "Tr × Player k" is the estimated difference between Player k and Player 3 in treatment Tr.
[4] Coefficients of interactions with the reverse of the period are displayed w/o an omitted category for the treatment and the player, i.e., the coeff. of "$1/Period$ × Tr × Player k" is the estimated effect of the reverse period for subjects assigned to the role of Player k in treatment Tr.
[5] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table C.6
Panel estimations for payment shares.

Dep. variable	Payment share			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	0.363***	(0.024)	0.395***	(0.038)
APA-Treatment	−0.110*	(0.037)	−0.115*	(0.035)
LC × Player 1	−0.029	(0.027)	−0.035	(0.024)
LC × Player 2	−0.061	(0.052)	−0.072	(0.047)
APA × Player 1	0.122*	(0.045)	0.121*	(0.046)
APA × Player 2	0.120*	(0.045)	0.120*	(0.043)
$(1/Period)$ × LC × Player 1	−0.061	(0.170)	−0.061	(0.171)
$(1/Period)$ × LC × Player 2	0.167	(0.304)	0.167	(0.305)
$(1/Period)$ × LC × Player 3	−0.106	(0.195)	−0.106	(0.195)
$(1/Period)$ × APA × Player 1	−0.323	(0.351)	−0.327	(0.356)
$(1/Period)$ × APA × Player 2	−0.237	(0.127)	−0.243	(0.125)
$(1/Period)$ × APA × Player 3	0.560	(0.297)	0.552	(0.289)
Number of Correct CRT Answers			0.010	(0.004)
Number of Safe Choices			0.001	(0.002)
Age			−0.001	(0.000)
Female			−0.009	(0.008)
Econ			0.008	(0.007)
Siblings			0.004	(0.006)
Propensity to Play Games of Chance			0.001	(0.004)
Propensity to Play Board Games			0.001	(0.002)
Ambition			−0.008	(0.004)
Generosity			−0.007	(0.005)
Importance Payment			0.004	(0.003)
Importance Winning			−0.002	(0.003)
Observations	2760		2760	
Subjects	138		138	
R^2	0.018		0.034	

Notes:
[1] Robust standard errors in parentheses, accounting for clustering at the session level.
[2] All models include a subject-specific random effects error structure.
[3] In interactions between treatment and player dummies, Player 3 is the omitted category for player, but there is no omitted category for the treatment, i.e. the coefficient of "Tr × Player k" is the estimated difference between Player k and Player 3 in treatment Tr.
[4] Coefficients of interactions with the reverse of the period are displayed w/o an omitted category for the treatment and the player, i.e. the coefficient of "1/Period × Tr × Player k" is the estimated effect of the reverse period for subjects assigned to the role of Player k in treatment Tr.
[5] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table C.7
Panel estim. of winning freq. in node D in the APA-Treatm.

Dep. variable	Indicator of winning in node D			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	0.318*	(0.074)	−0.323	(0.593)
Player 3	0.413	(0.147)	0.510*	(0.136)
$1/Period$ × Player 1	−0.350	(1.118)	−0.033	(1.271)
$1/Period$ × Player 3	−0.216	(1.009)	−0.794	(0.821)
Number of Correct CRT Answers			0.002	(0.021)
Number of Safe Choices			−0.041	(0.036)
Age			0.009*	(0.002)
Female			−0.036	(0.051)
Econ			−0.124**	(0.013)
Siblings			−0.094	(0.044)
Propensity to Play Games of Chance			0.003	(0.016)
Propensity to Play Board Games			0.055*	(0.012)
Ambition			0.076*	(0.018)
Generosity			0.064	(0.023)
Importance Payment			0.004	(0.032)
Importance Winning			0.022	(0.009)
Observations	288		288	
Subjects	45		45	
R^2	0.185		0.304	

Notes:
[1] Robust standard errors in parentheses, accounting for clustering at the session level.
[2] All models include a subject-specific random effects error structure.
[3] Coefficients of interactions are displayed w/o an omitted category, i.e. the coefficient of "1/Period × Player k" is the estimated effect of the reverse period for subjects assigned to the role of Player k.
[4] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table C.8
Panel estimation for effort choices of Player 3 in Match 2.

Dep. variable	Effort of player 3 in Match 2			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	107.49**	(22.89)	215.39	(91.67)
APA-Treatment	−30.83	(33.24)	11.28	(24.70)
LC × Node E	42.29*	(13.03)	41.29*	(13.75)
APA × Node E	109.15*	(38.52)	109.85*	(38.24)
$1/Period$	165.78	(92.98)	159.09	(93.81)
$1/Period$ × Node E	−363.03	(175.30)	−349.85	(181.30)
$1/Period$ × APA	247.17	(259.26)	245.08	(257.14)
$1/Period$ × APA × Node E	−140.00	(372.43)	−154.55	(372.37)
Number of Correct CRT Answers			12.252	(5.655)
Number of Safe Choices			−10.274	(12.549)
Age			3.134*	(0.995)
Female			47.183	(33.560)
Econ			−42.295*	(13.517)
Siblings			−23.778	(11.215)
Propensity to Play Games of Chance			−45.905*	(19.339)
Propensity to Play Board Games			−12.867	(9.519)
Ambition			−8.084	(10.956)
Generosity			7.364	(15.980)
Importance Payment			−12.695	(9.596)
Importance Winning			41.972***	(5.496)
Observations	690		690	
Subjects	46		46	
R^2	0.032		0.463	

Notes:
[1] Robust standard errors in parentheses, accounting for clustering at the session level.
[2] All models include a subject-specific random effects error structure.
[3] For interactions between the treatment dummies and the dummy for Node E, there is no omitted category for the treatment, i.e., the coefficient of "Tr × Node E" is the estimated difference between Player 3's effort in node E and D in treatment Tr. In contrast, treatment LC is the omitted category for the treatment and Node D is the omitted category for the node in interactions with the reverse of the period.
[4] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table C.9
Average efforts, winning frequencies, and payments.

	Total effort		Rel. Freq.(Winning)		Payments	
	LC	APA	LC	APA	LC	APA
Player 1	248.5	300.4	0.340	0.488	555.3	592.7
Player 2	250.7	180.0	0.290	0.260	523.3	575.8
Player 3	241.0	192.5	0.370	0.252	581.1	558.7
Aggregate	740.2	706.8				
Gini			0.053	0.158	0.023	0.013

Note: Gini $\hat{=}$ Gini coefficient.

Table C.10
Regression analysis of tournament intensity.

Dep. variable	Tournament intensity			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	740.23***	(66.93)	736.74***	(83.16)
APA-Treatment	−67.37	(116.11)	−83.88	(130.89)
$1/Period$			19.31	(89.41)
$1/Period$ × APA			91.99	(201.77)
Observations	520		520	
R^2	0.010		0.013	

Notes:
[1] The regression is conducted at the tournament level, i.e., there is one observation for each distinct tournament. The sample involves 520 distinct tournaments.
[2] Robust standard errors are in parentheses, accounting for clustering at the session level.
[3] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table C.11
Panel estimations of total tournament effort by player.

Dep. variable	Total effort			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	243.63***	(28.08)	258.18*	(68.32)
Player 2	1.17	(43.35)	17.94	(39.37)
Player 3	−12.76	(47.64)	12.18	(41.93)
APA × Player 1	12.16	(59.96)	7.52	(55.57)
APA × Player 2	−63.33	(35.64)	17.00	(30.79)
APA × Player 3	−52.35	(64.69)	19.72	(56.39)
$(1/Period)$ × LC × Player 1	70.65	(39.53)	70.03	(40.47)
$(1/Period)$ × LC × Player 2	−33.731	(48.39)	−33.56	(48.49)
$(1/Period)$ × LC × Player 3	−7.77	(41.36)	−8.66	(41.43)
$(1/Period)$ × APA × Player 1	188.45*	(77.67)	185.07*	(77.14)
$(1/Period)$ × APA × Player 2	−4.02	(50.64)	−2.60	(51.69)
$(1/Period)$ × APA × Player 3	−34.77	(99.65)	−34.49	(99.92)
Number of Correct CRT Answers			4.30	(9.68)
Number of Safe Choices			−7.75	(10.46)
Age			1.83	(2.12)
Female			−11.47	(11.72)
Econ			0.88	(20.53)
Siblings			−16.75	(13.57)
Propensity to Play Games of Chance			5.20	(10.05)
Propensity to Play Board Games			−17.01*	(7.13)
Ambition			9.14	(3.88)
Generosity			0.88	(7.83)
Importance Payment			−22.75**	(5.43)
Importance Winning			40.12**	(7.85)
Observations	1560		1560	
Subjects	116		116	
R^2	0.046		0.237	

Notes:
[1] Robust standard errors in parentheses, clustered at the session level.
[2] All models include a subject-specific random effects error structure.
[3] Coefficients of interactions are displayed w/o an omitted category, i.e. the coefficient of “APA × Player k” is the estimated treatment effect for subjects assigned to the role of Player k, and the coefficient of “1/Period × Tr × Player k” is the estimated effect of the reverse period for subjects assigned to the role of Player k in treatment Tr.
[4] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$)

Table C.12
Logit panel estimations for winning probabilities.

Dep. Variable	Winning probability			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	−0.526	(0.310)	−0.145	(0.841)
APA-Treatment	−0.839	(0.468)	−0.676	(0.417)
LC × Player 1	−0.282	(0.421)	−0.713	(0.381)
LC × Player 2	−0.547	(0.443)	−0.883*	(0.400)
APA × Player 1	1.176**	(0.450)	0.577	(0.401)
APA × Player 2	0.043	(0.472)	0.314	(0.421)
$(1/Period)$ × LC × Player 1	0.968	(0.625)	0.957	(0.621)
$(1/Period)$ × LC × Player 2	−0.111	(0.659)	−0.113	(0.653)
$(1/Period)$ × LC × Player 3	−0.920	(0.713)	−0.968	(0.713)
$(1/Period)$ × APA × Player 1	0.494	(0.628)	0.344	(0.625)
$(1/Period)$ × APA × Player 2	0.151	(0.747)	0.195	(0.752)
$(1/Period)$ × APA × Player 3	−0.706	(0.851)	−0.720	(0.859)
Number of Correct CRT Answers			0.169	(0.100)
Number of Safe Choices			−0.079	(0.079)
Age			0.008	(0.014)
Female			−0.100	(0.220)
Econ			0.287	(0.209)
Siblings			−0.142	(0.096)
Propensity to Play Games of Chance			0.080	(0.086)
Propensity to Play Board Games			−0.070	(0.061)
Ambition			−0.058	(0.080)
Generosity			−0.182*	(0.081)
Importance Payment			−0.088	(0.070)
Importance Winning			0.395***	(0.060)
Observations	1560		1560	
Subjects	116		116	
Log-likelihood	−910.2		−886.6	

Notes:
[1] Standard errors in parentheses.
[2] All models include a subject-specific random effects error structure.
[3] In interactions between treatment and player dummies, Player 3 is the omitted category for player, but there is no omitted category for the treatment, i.e. the coefficient of “Tr × Player k” is the estimated difference between Player k and Player 3 in treatment Tr.
[4] Coefficients of interactions with the reverse of the period are displayed w/o an omitted category for the treatment and the player, i.e. the coeff. of “$1/Period$ × Tr × Player k” is the estimated effect of the reverse period for subjects assigned to the role of Player k in treatment Tr.
[5] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table C.13
Panel estimations for payments.

Dep. Variable	Payment			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	603.22***	(11.59)	561.34***	(72.78)
APA-Treatment	−40.79	(27.31)	−76.51**	(20.96)
LC × Player 1	−50.11	(48.61)	−65.85	(50.24)
LC × Player 2	−79.20*	(29.63)	−106.24**	(26.24)
APA × Player 1	54.60	(36.74)	79.23	(35.89)
APA × Player 2	11.77	(20.47)	32.30	(17.45)
$(1/Period)$ × LC × Player 1	57.07	(156.68)	58.90	(159.13)
$(1/Period)$ × LC × Player 2	11.03	(57.19)	9.96	(58.16)
$(1/Period)$ × LC × Player 3	−89.44	(56.40)	−89.92	(56.38)
$(1/Period)$ × APA × Player 1	−128.63*	(53.74)	−126.84*	(52.65)
$(1/Period)$ × APA × Player 2	25.88	(36.83)	21.31	(36.63)
$(1/Period)$ × APA × Player 3	−13.28	(106.51)	−13.93	(105.93)
Number of Correct CRT Answers			8.09	(9.54)
Number of Safe Choices			4.93	(6.00)
Age			−0.78	(1.48)
Female			−11.06	(15.99)
Econ			32.64	(17.12)
Siblings			1.43	(9.66)
Propensity to Play Games of Chance			5.69	(7.83)
Propensity to Play Board Games			9.51	(6.38)
Ambition			−10.61	(6.33)
Generosity			−16.66*	(6.10)
Importance Payment			14.69**	(3.83)
Importance Winning			−2.70	(4.94)
Observations	1560		1560	
Subjects	116		116	
R^2	0.012		0.038	

Notes:
[1] Robust standard errors in parentheses, clustered at the session level.
[2] All models include a subject-specific random effects error structure.
[3] In interactions between treatment and player dummies, Player 3 is the omitted category for player, but there is no omitted category for the treatment, i.e., the coefficient of "Tr × Player k" is the estimated difference between Player k and Player 3 in treatment Tr.
[4] Coefficients of interactions with the reverse of the period are displayed w/o an omitted category for the treatment and the player, i.e., the coeff. of "$1/Period$ × Tr × Player k" is the estimated effect of the reverse period for subjects assigned to the role of Player k in treatment Tr.
[5] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table C.14
Panel estimations for payment shares.

Dep. variable	Payment			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	0.368***	(0.015)	0.365***	(0.039)
APA-Treatment	−0.040	(0.017)	−0.051*	(0.015)
LC × Player 1	−0.048	(0.030)	−0.060	(0.028)
LC × Player 2	−0.054*	(0.021)	−0.065**	(0.019)
APA × Player 1	0.016	(0.026)	0.020	(0.018)
APA × Player 2	0.004	(0.011)	0.017	(0.012)
$(1/Period)$ × LC × Player 1	0.037	(0.087)	0.040	(0.089)
$(1/Period)$ × LC × Player 2	0.012	(0.055)	0.010	(0.056)
$(1/Period)$ × LC × Player 3	−0.050	(0.050)	−0.051	(0.050)
$(1/Period)$ × APA × Player 1	−0.060***	(0.006)	−0.063***	(0.009)
$(1/Period)$ × APA × Player 2	0.059	(0.048)	0.056	(0.047)
$(1/Period)$ × APA × Player 3	0.000	(0.047)	0.000	(0.047)
Number of Correct CRT Answers			0.010	(0.005)
Number of Safe Choices			0.003	(0.003)
Age			0.000	(0.001)
Female			−0.003	(0.010)
Econ			0.021*	(0.008)
Siblings			0.001	(0.007)
Propensity to Play Games of Chance			0.000	(0.005)
Propensity to Play Board Games			0.002	(0.004)
Ambition			−0.010	(0.005)
Generosity			−0.008*	(0.003)
Importance Payment			0.004	(0.003)
Importance Winning			0.004	(0.003)
Observations	1560		1560	
Subjects	116		116	
R^2	0.011		0.032	

Notes:
[1] Robust standard errors in parentheses, accounting for clustering at the session level.
[2] All models include a subject-specific random effects error structure.
[3] In interactions between treatment and player dummies, Player 3 is the omitted category for player, but there is no omitted category for the treatment, i.e. the coefficient of "Tr × Player k" is the estimated difference between Player k and Player 3 in treatment Tr.
[4] Coefficients of interactions with the reverse of the period are displayed w/o an omitted category for the treatment and the player, i.e. the coefficient of "1/Period × Tr × Player k" is the estimated effect of the reverse period for subjects assigned to the role of Player k in treatment Tr.
[5] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table C.15
Panel estim. of winning freq. in node *D* in the APA-Treatm.

Dep. Variable	Indicator of winning in node D			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	0.360**	(0.045)	−0.079	(0.399)
Player 3	0.279	(0.092)	0.353	(0.168)
$1/Period$ × Player 1	0.451	(0.243)	0.546	(0.253)
$1/Period$ × Player 3	−0.342	(0.235)	−0.292	(0.282)
Number of Correct CRT Answers			0.060	(0.031)
Number of Safe Choices			−0.036	(0.031)
Age			0.014*	(0.004)
Female			0.010	(0.077)
Econ			−0.254*	(0.058)
Siblings			−0.073	(0.037)
Propensity to Play Games of Chance			0.022	(0.030)
Propensity to Play Board Games			0.025*	(0.007)
Ambition			0.026	(0.018)
Generosity			0.082	(0.033)
Importance Payment			0.019	(0.028)
Importance Winning			0.021	(0.010)
Observations	176		176	
Subjects	37		37	
R^2	0.057		0.199	

Notes:
[1] Robust standard errors in parentheses, accounting for clustering at the session level.
[2] All models include a subject-specific random effects error structure.
[3] Coefficients of interactions are displayed w/o an omitted category, i.e. the coefficient of "1/Period × Player *k*" is the estimated effect of the reverse period for subjects assigned to the role of Player *k*.
[4] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Table C.16
Panel estimation for effort choices of Player 3 in Match 2.

Dep. variable	Effort of player 3 in Match 2			
Model	(1)		(2)	
Variable	Coef.	SE	Coef.	SE
Constant	113.12***	(19.59)	73.51	(123.87)
APA-Treatment	−63.13	(30.12)	2.45	(20.14)
LC × Node E	8.69	(12.938)	8.49	(12.97)
APA × Node E	88.90*	(35.18)	89.01*	(35.48)
$1/Period$	29.80	(17.76)	26.92	(14.85)
$1/Period$ × Node E	−18.88	(33.62)	−15.73	(34.47)
$1/Period$ × APA	64.20	(104.42)	65.96	(104.70)
$1/Period$ × APA × Node E	−161.07	(69.05)	−164.18	(69.59)
Number of Correct CRT Answers			15.903	(8.687)
Number of Safe Choices			−2.340	(11.150)
Age			−4.157	(2.740)
Female			34.351	(21.179)
Econ			−42.968	(23.847)
Siblings			−11.360	(8.553)
Propensity to Play Games of Chance			−27.179	(19.304)
Propensity to Play Board Games			−6.970	(9.588)
Ambition			−3.546	(10.578)
Generosity			17.573	(13.226)
Importance Payment			−11.706	(10.687)
Importance Winning			35.698**	(7.102)
Observations	520		520	
Subjects	33		33	
R^2	0.030		0.448	

Notes:
[1] Robust standard errors in parentheses, accounting for clustering at the session level.
[2] All models include a subject-specific random effects error structure.
[3] For interactions between the treatment dummies and the dummy for Node E, there is no omitted category for the treatment, i.e., the coefficient of "Tr × Node E" is the estimated difference between Player 3's effort in node E and D in treatment Tr. In contrast, treatment LC is the omitted category for the treatment and Node D is the omitted category for the node in interactions with the reverse of the period.
[4] Significance levels: *** ($p < 0.001$), ** ($p < 0.01$), * ($p < 0.05$).

Data availability

We have shared data on https://data.mendeley.com/datasets/j6wjzgd8sr/1.

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