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Hernán Guillermo Villamizar Maldonado, Bakk.rer.soc.oec.

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Abstract

To better comprehend the impact that inequality and redistribution have on intragenerational social mobility it is important to understand how they affect individual behaviour in competitive settings conducive to the increase of income. For instance, investments in education or a job promotion.

In the present thesis I use a rent-seeking contest to model those situations while accounting for two important characteristics of social mobility. Firstly, social mobility can be seen as a series of rent-seeking contests that are likely to be chained in a way that benefits the winner of previous contests. Secondly, inequality in the probabilities of winning within each contest is partly due to a difference in performance and is not entirely random.

Using that model, I designed and conducted a laboratory experiment in which participants decide how much to work and how much of their earnings they want to invest in a rent-seeking contest in order to increase their chances of obtaining an income above average in the next period. Furthermore, to analyze the impact of a scheme designed to reduce inequality in endowments, I introduced a taxation and redistribution scheme for one of the studied groups.

I found that, consistent with previous research, people over-invest when participating in a rent-seeking contest, although decreasingly so with each repetition. Subjects in the taxed groups invested relatively and nominally more. The main driver for this effect appears to be a combination of the income effect created through the more evenly distributed income and an investment heuristic based on a fixed share of available income.

In both treatments (the control group and the taxation and redistribution scenario), the number of participants with either very high or very low probabilities of winning increased with each round. Nevertheless, I found little evidence that this event is due to the advantage of previous winners. Instead, it was more likely due to a polarisation of the investments made with more participants making very small investments while others made even larger ones.

The obtained results suggest that repeated rent-seeking contests do not necessarily lead to a perpetuation of the winning status, as long as participants are always able to invest their optimal bid. Furthermore, the results from this study suggest that policies aimed at directly increasing available income for investment in human capital, such as student loans, might increase inefficiency and drive up the cost of education above its actual economic value.

Keywords: Social Mobility, Laboratory Experiment, Behavioral Economics, Tullock Contest

JEL Codes: C92 – Laboratory, Group Behavior; C72 - Noncooperative Games; J24 - Labor and Demographic Economics - Human Capital, Skills, Occupational Choice, Labor Productivity.

Abstract

Um die Auswirkungen von Ungleichheit und Umverteilung auf die soziale Intragenerationenmobilität besser zu erfassen, ist es wichtig zu verstehen, wie sich diese auf das individuelle Verhalten in einem Wettbewerbsumfeld auswirken, das der Erhöhung des Einkommens dient. Beispiele hierfür sind Investitionen in Bildung oder einen beruflichen Aufstieg.

In der vorliegenden Masterarbeit verwende ich einen rent-seeking Wettbewerb, um diese Situationen zu modellieren. Berücksichtigt werden dabei zwei wichtige Merkmale der sozialen Mobilität: Zum einen kann soziale Mobilität als eine Aneinanderreihung von rent-seeking Wettbewerben verstanden werden, welche wahrscheinlich so miteinander verknüpft sind, dass GewinnerInnen früherer Wettbewerbe begünstigt werden. Zum anderen ist die Ungleichheit innerhalb jedes Wettbewerbs zumindest teilweise auf einen Leistungsunterschied zurückzuführen, und nicht völlig zufällig.

Anhand dieses Modells entwarf und führte ich ein Laborexperiment durch, bei dem die TeilnehmerInnen entscheiden, wie viel sie arbeiten und welchen Teil ihres Verdienstes sie in einen rent-seeking Wettbewerb investieren wollen, um ihre Chancen auf ein überdurchschnittliches Einkommen in der nächsten Periode zu erhöhen. Darüber hinaus führe ich ein Besteuerungs- und Umverteilungsschema für eine der untersuchten Gruppen ein, um den Einfluss eines Programms zum Reduzieren von Ungleichheit bezüglich finanzieller Ausstattung zu analysieren.

In Übereinstimmung mit früheren Untersuchungen konnte ich feststellen, dass MitspielerInnen zu viel investieren, wenn sie an einem rent-seeking Wettbewerb teilnehmen, wenngleich dies mit jeder Wiederholung abnimmt. Die Subjekte in den besteuerten Gruppen investierten relativ und nominell mehr. Die Hauptursache für diesen Effekt scheint eine Kombination aus dem Einkommenseffekt, der durch das gleichmäßiger verteilte Einkommen entsteht, und einer Investitionsheuristik eines festen Anteils des verfügbaren Einkommens zu sein.

In beiden Treatments stieg mit jeder weiteren Runde die Anzahl der Teilnehmenden mit sehr kleiner oder sehr großer Gewinnwahrscheinlichkeit. Dennoch fand ich wenig Evidenz dafür, dass dieses Ereignis auf die Begünstigung früherer GewinnerInnen zurückzuführen ist. Vielmehr war es auf eine Polarisierung der getätigten Investitionen zurückzuführen, indem mehr Teilnehmende sehr kleine Investitionen tätigten, während andere sogar noch größere machten.

Die erzielten Ergebnisse deuten darauf hin, dass wiederholte rent-seeking Wettbewerbe nicht notwendigerweise zu einer langfristigen Beibehaltung des Siegerstatus führen, solange die TeilnehmerInnen stets in der Lage sind, ihr optimales Gebot zu investieren. Darüber hinaus deuten sie darauf hin, dass Maßnahmen, die darauf abzielen das verfügbare Einkommen für Investitionen in Humankapital, zum Beispiel Studiendarlehen, direkt zu erhöhen, die Ineffizienz steigern und die Kosten der Bildung über ihren tatsächlichen wirtschaftlichen Wert hinaus in die Höhe treiben könnten.

Contents

1. Introduction

Success depends, in most circumstances in life, not only on one's effort but on that of others. Take, for instance, patent races, litigation, military combat, or sports competitions, where the winner is – with varying degrees of luck involved – the one who exerted the most effort or spent the largest amount of money in comparison to the rest (Konrad, 2009). Competitions of this sort are commonly modelled in social sciences as rent-seeking contests, as first described by Tullock (1980) and expressed in a general form by Sheremeta and Chowdhury (2010).

Rent-seeking contests, also called Tullock contests, are contests in which the probability of winning is a function of the relative effort exerted. In their most basic form, two players compete for a prize that is of equal value to both. Participants can place a simultaneous, non-refundable investment. Each of the players is then assigned a probability of winning equal to their respective share of the total investments. This would mean that if both make the same investment, each will have a 50% chance of winning the prize. Yet, if one invests twice the amount of the other, he or she will have a 66.67% chance of winning.

In this thesis I use rent-seeking contests as the base model for an economic experiment in order to better understand how inequality affects competitive behaviour in human capital investments, and how it relates to the process of social mobility. In particular, I focus on whether this type of contest contributes to the perpetuation of inequalities and what the impact is on overall welfare.

With Tullock type contests, behavioral economists can model and analyze individual and social behavior in a competitive environment, and how it affects decision making. For instance, while an optimal investment strategy for this game exists, empirical examinations show that people tend to bid too much and therefore incur great efficiency losses with a median overbidding rate of 72% (Sheremeta, 2013; Chowdhury et al., 2014; Konrad, 2009; Dechenaux et al., 2015).

One of the several explanations for overbidding suggested in the literature on this topic is that winning itself has an inherent utility, separate from the utility of the prize. Sheremeta (2010) showed this in an experiment in which participants could invest and participate in the game, but winning did not carry a prize of positive monetary value. The prize was merely symbolic. In that study, 40% of players invested a positive amount of money to win the prize of value 0. Moreover, participants more likely to invest in that setting, were also more likely to over-invest when a prize of positive value was offered.

Another common explanation is bounded rationality. Participants can make mistakes, or be confused about the rules or strategy of the game. Sheremeta (2011) shows, using the *quantal response equilibrium* (QRE) developed by McKelvey and Palfrey (1995), that overbidding behaviour is consistent with bounded rationality. Subjects' bids are dependent on their initial endowment amounts, rather than on the stakes of the game. While keeping the award value constant, increasing or decreasing the endowment of participants also increases or reduces the efforts of the players.

The way in which information about other's investments and distribution levels influence a subject's investments during a rent-seeking contest was studied by Fallucchi et al. (2013). In their research they find that when given full information about their own and other's decisions, over-spending by participants decreases over time to around 13% above the optimum bid. In comparison, participants who only knew about their own efforts kept their investments high at approximately 63% over the optimal level.

Accounting for several of these explanations simultaneously, in one of his most recent studies, Sheremeta (2016) showed that while overbidding is correlated with bounded rationality, systematic biases, the utility of winning and relative payoff maximization, only impulsivity remains significant in a joint multivariate analysis. Impulsive behavior was measured using the Cognitive Reflection Test (CRT) developed by Frederick (2005). It aims to measure the tendency of a person to *stop and think* about a question with a seemingly trivial and intuitive, but ultimately incorrect, answer.[1]

1.1. Social Mobility as a Rent-Seeking Contest

Understanding the determining aspects of individual behaviour in rent-seeking contests allows us to model more complex dynamics in economics. Social mobility, for example, can be seen in many ways as a rent-seeking contest: in order to obtain a high salaried position, society members exert effort through work supply and investment in human capital. Given the limited nature of those positions, however, only a few are rewarded with the prize (Burkhauser et al., 2011).

The results listed above might lead us to think that people tend to invest too much in their education or put too much effort into their careers. Yet, there is one crucial way in which social mobility in real life differs from a Tullock contest: the outcome of the contest at a certain stage is likely to depend on the result of the previous stage. In other words, social mobility in practice is likely to be a series of contests in which those who have won previous stages are more likely to win the next. Illustrating this, it can be seen that alumni of respected schools are more likely to access the best universities, and alumni of those universities are more likely to obtain better jobs, thus creating in-

[1] A detailed description and its use in an experimental setting is given in section 3.2.3.

equalities that may appear insurmountable (Sewell, 1971).

A thorough understanding of how the inequality arising from a previous performance drives an individual's behavior is key to shaping redistribution and equality policies. Being two of the most important fields of research in economics, the literature on social mobility and inequality is, in equal parts, massive and diverse (Nolan et al., 2011; Atkinson and Bourguignon, 2015; Lipset and Bendix, 2018; Fields and Ok, 1999). In this thesis, I restrict myself to a model of intra-generational social mobility with only one high income position.

While there is extensive research on the effect of inequality on economic outcomes, such as productivity (Persson and Tabellini, 1994; Ku and Salmon, 2012), provision of public goods (Fehr and Schmidt, 1999) and growth (Ehrhart, 2009), there is limited literature on how inequality affects a single agent's behaviour in a competitive setting. Does, for instance, a worker with lower chances of obtaining a promotion reduce his or her output altogether and are they thus less likely to invest in human capital? Or does he or she invest *too much* given the expected earnings? In other words, how does inequality of opportunity affect work supply and social mobility in a competitive setting?

Fallucchi and Ramalingam (2017), in a laboratory setting, studied the efforts of participants of a Tullock contest in the presence of different sources of inequality: endowment, ability, and outcomes. In all treatments participants played 30 rounds of a lottery contest. At the beginning of each round, players received an endowment of tokens that they could trade for lottery tickets, the probability of winning the round being equal to their respective share of tickets bought. The prize in tokens – plus the tokens not used to buy tickets – were stored in a separate account and paid out at the end of the experiment.

The baseline was a contest in which players received 95 tokens of endowment, played for a prize of 80 tokens, and where each lottery ticket costed one token. In contrast, in the treatment scenario with *inequality of endowments* one of the contestants in the group received 120 tokens while the other received only 80. In the group with *inequality of ability* one of the players in each couple got one ticket per token, while the other received three. Finally, in the *inequality of outcomes* treatment, the prize was of 120 tokens for one of the subjects but 40 for the other. In each of the treatments, apart from the inequality parameters, all conditions remained constant.

In their study, Fallucchi and Ramalingam find evidence that the source of inequality determines the magnitude of competitive effort put in, with participants in groups with unequal abilities making larger investments when compared to the benchmarking case. Subjects in groups with unequal endowments or prizes, on the other hand, invested less than their counterparts in the control group. Most of these effects were driven by the disadvantaged subjects. Participants with *lower* ability displayed higher effort than advantaged players, and, while disadvantaged subjects in the *inequality of outcomes* treatment reduced their efforts, advantaged players did not increase theirs accordingly.

In the same manner, an investment gap was observed in the treatment with different endowments, even though theory would predict no difference.

Importantly, however, the source of inequality in Fallucchi and Ramalingam's experiment (2017) is exogenous. Participants are awarded more or less endowment or a higher or lower valuation at random. But one can argue that, in the case of social mobility, inequality arises at least in part from success in previous performance. More diligent students get better opportunities in the job market and better employees are awarded higher incomes. Luck still plays a role, of course, and people who put in less effort might still win the prize. But how does it affect overall performance if the source of inequality is at least, in theory, meritocratic? And does success have a tendency to perpetuate itself? In this present thesis, I aim to answer these questions by designing and conducting an experiment in which participants of a repeated rent-seeking contest can earn their endowments by solving a *real effort task*, and subsequently invest their earnings to increase their wages in the subsequent round of the task. The main manifestation of inequality studied here is the difference in winning probabilities between members of a group. Specifically, I pose the following research question:

Research Question 1: How does the distribution of winning probabilities in repeated rent-seeking contests develop over time when the endowments available for investment are determined by previous success and work supply?

Furthermore, assuming that inequality in endowments has a negative impact on the work supply and effort provision of participants, one might suggest an intervention designed to distribute those endowments more equally. To analyze the impact of such a scheme, the experiment I conducted includes a treatment which taxes and redistributes the income earned in the *real effort task* among the participants. The following research question thus complements the first:

Research Question 2: How does a taxation and redistribution scheme affect work supply and effort provision in rent seeking contests like those described in Research Question 1?

As I am aware that many factors play a role in how people behave in competitions and how that may impact the results, I designed the experiment and selected model parameters in a way that presents sensible benchmarks and allows future researchers to easily change values, extend the model and devise new interventions.

1.2. Rent-Seeking Contest as Prospect of Upward Mobility

To better illustrate the socio-economic implications of the research questions, it helps to see the process of social mobility modeled in the previous section as analogous to a simplified version of the Prospect of Upward Mobility (POUM): the probability of achieving (or staying with) an income above average in the following period, formalized by Benabou and Ok (2001). During the experiment presented in this thesis, subjects participate in several rent-seeking contests where the prize is a wage above average in the following round. The probability of a player of winning one of those contest is thus equal to his or her Prospect of Upward Mobility.

In their research, Benabou and Ok (2001) primarily focus on the influence that the POUM has on citizens' voting behaviour. They show, through theoretical considerations, that when individuals decide between taxation schemes, they not only consider their current social standing, but also their probability of obtaining a higher social position in the future. This helps to account for the seemingly contradictory behaviour of low-income citizens voting for a reduction of taxes for higher incomes and thus against redistribution as a whole.

According to Benabou and Ok, the extent to which citizens approve or disprove of redistribution depends in particular on the time validity of taxation and the shape of the social mobility probability function. Theorems 1 and 2 from their theoretical analysis best summarize their findings:

1. *Theorem 1:* The more concave the transition function is, the less support there is for redistribution among low income voters. The concavity of the transition function expresses the increasing odds of obtaining a higher income in the future with increasing current income, but at a decreasing rate.
2. *Theorem 2:* The more "sticky" taxation policy is, or the more forward-looking citizens are, the less support there is for redistribution.

Checchi and Filippin (2003) tested this idea in the laboratory and found strong support for it, especially the two theorems above, even after controlling idiosyncratic factors like risk and inequality-aversion. In their experiment, subjects were randomly placed into one of three income levels and had to decide on the taxation levels of future income based on the probability of going from one level of income to the other. Furthermore, depending on the treatment, the taxation chosen would be applicable to one, three, or five periods.

The results show that for longer periods of valid taxation, the average tax chosen by the participants declined, thus supporting the second theorem of Benabou and Ok. In the same manner, and in line with the first theorem, when subjects were confronted with a more mobile society, i.e. the probability of transition from a lower income level to a higher one increased, they were more likely to choose a lower taxation rate.

An important implication of the POUM Theorem in the context of this thesis is that once a taxation scheme is in place, the POUM might be altered after redistribution if the probability of improving one's social standing depends on the redistribution result. Imagine, for instance, a scenario in which the ability to invest in the training needed to increase your income depends on your previous income. If the distribution of income changes with each period, voting in favor or against redistribution will change accordingly, mitigating or aggravating inequality. Furthermore, if for some subjects the probability of achieving a given status becomes easier with each passing period while it becomes more difficult for others, a poverty trap can arise through complacency or resignation at the extremes of the income distributions (Ceroni, 2001; Ku and Salmon, 2012).

* * *

To recapitulate: in this thesis I design and conduct an experiment based on rent-seeking contests to study the effect of inequality on work supply and investment in human capital within an imperfectly meritocratic society. Inequality, expressed as the difference in the Prospect of Upward Mobility within a group, is made endogenous to the model by way of work supply in a real effort task, and monetary investments in a Tullock contest. Furthermore, I study how the implementation of a taxation and redistribution scheme promotes or suppresses the observed behaviour.

In a nutshell, the process of social mobility, as modelled and implemented in the experiment, is as follows: subjects work for an endowment they can invest in a rent-seeking contest. The contest grants the winner a higher wage for the following period of the real effort task, thus granting a higher endowment in case of constant work supply. In the intervened group the incomes from solving the *real effort task* were taxed and redistributed within the group, making the endowments for investment more equally distributed.

This thesis is presented in six parts. This introductory chapter outlined the study and offered an overview of previous research, upon which this thesis builds. Additionally, it postulated the research questions. Chapter 2 maps out the theoretical foundation of the experiment with a formal model that generalizes Koch (2017), and derives mathematical predictions that build the base of the hypotheses in section 3.3. Chapter 3 presents the design and procedure of the experimental sessions, while chapter 4 deals with the results and their analysis. Finally, chapters 5 and 6 conclude with policy implications, suggestions for extended research, and a short summary.

2. The Contest Success Function

The model my experiment builds upon is inspired by Koch (2017) and aims to simulate a process by which the effort of a subject determines his or her likelihood to obtain a higher wage in the subsequent period. Koch (2017) proposes a Tullock contest in which the relative work supply determines the probability of winning a higher income in the following period and it is described by the Contest Success Function (CSF):

$$p(x_i, x_{-i}) = \begin{cases} \frac{1}{n}, & \text{if } x_i = x_{-i} = 0 \\ \frac{x_i}{x_i + \sum_{j \neq i}^{n} x_j}, & \text{otherwise} \end{cases} \tag{2.1}$$

Where x_i is the work supplied by participant i and n the total number of participants. So, if a participant provides, for instance, one fourth of the total work supply of the group, she will have a 25 percent chance of obtaining the high income in the following round.

Koch's model, however, has several drawbacks. Most notably, that the probability of winning depends only on work supply and therefore a redistribution scheme would have no impact on the likelihood of obtaining a higher wage. Also, since the level of optimal work supply depends on the utility function and it, in turn, on the expected wage for the following round, the best response function, and therefore the optimization problem, increases in complexity with each round and is not analytically solvable (Koch, 2017).

To address those issues, I consider a model where the contest success function is dependant on an individual's relative investment in human capital — similar to investment in private education.

To be precise, at the end of period t, an individual i has the opportunity to invest an amount I of her available income to increase her chances of winning a high income in the next period. Her available income is the income obtained from work after taxation and redistribution. Analogously to the case above, the Contest Success Function (CSF) is therefore defined by:

$$p_t(I_i, I_{-i}) = \begin{cases} \frac{1}{n}, & \text{if } I_i = I_{-i} = 0 \\ \frac{I_i}{I_i + \sum_{j \neq i}^{n} I_j}, & \text{otherwise} \end{cases} \tag{2.2}$$

To see how a rational participant would go about deciding her optimal investment, let us consider the most simple case of a game with two periods where the share of total investment at the end of the first period determines the probability of obtaining the prize of a high wage in the second according to the CSF.

In the second period, the last in this case, exactly one participant will have a high wage w_h while all others will work with a low wage w_l. That means that a participant i's prize, or valuation $\mathbb{V}$ of the game, is equal to the difference in earnings between what she would earn with the high versus with the low wage. At the end of the first period, participant i has to then choose how much to invest in order to maximize the chances of obtaining the prize $\mathbb{V}$.

Thus, in period 1, a participant wants to maximize his or her expected profit $\mathbb{E}\Pi_i$ according to the optimization problem:

$$\max_{I_i} \quad \mathbb{E}\Pi_i(I_i, I_j) = \frac{I_i}{I_i + \sum_{j \neq i}^{n} I_j}\mathbb{V} - I_i \tag{2.3}$$

Assuming risk-neutrality and that the valuation $\mathbb{V}$ of the higher wage is equal for all participants and therefore that $I_i^* = I_{-i}^* = I^*$ it can be easily shown that the optimal investment amount is:[1]

$$I^* = \frac{n-1}{n^2}\mathbb{V} \tag{2.4}$$

The optimal amount of investment in the first round will hence depend inversely on the number of participants and will be directly proportional to the value of the prize.

2.1. Ensuring Opportunity: The Budget Constraint

Whilst this may be straightforward, it is interesting to question what happens if there are several consecutive rounds. In the present design, the probability of obtaining the high income in the next period is independent from the previous period only if the optimal investment amount is higher than the available income. In other words, if a participant who has not won the high wage cannot afford the optimal investment, he would have an increased interest to earn the high wage in previous periods. The budget constraint $\frac{n-1}{n^2}\mathbb{V} \leqslant \pi(w_l)$ is thus violated whenever $\frac{\pi(w_h)-\pi(w_l)}{\pi(w_l)} > \frac{n^2}{n-1}$.

Pilot sessions have shown that in a game with three participants, a high wage of approximately five times the low wage will make it impossible for a low wage participant

[1]A step-by-step derivation can be found in Appendix A.

to invest the optimal amount. I take this into account for the current experimental design and make the high wage only twice as large.

2.2. Theoretical Predictions

Regardless of the repetitions of the game, the expected profit maximizing investment for a given player is constant, as shown in equation 2.4 since, first, the valuation of the game is constant across periods, and, second, the invested amount only affects the winning probabilities in the subsequent period. In other words, the amount of money invested in the contest should not be dependent on the wage of the player, nor on the history of wins and losses.

Furthermore, since work supply does not enter the CSF and participants can always afford to invest their optimum, as explained in section 2.1, there is no incentive to work more than the profit maximizing amount.

3. Experimental Design

To empirically answer the questions posed in the introductory chapter and to test the theoretical statements of the model described in chapter 2, I designed and conducted a laboratory experiment. The current chapter explains the experimental design and begins with a general overview in section 3.1. It then addresses the considerations going into the selection, design and parametrization of the Real Effort Task (RET) in section 3.1.1, and details in section 3.2 each element of the experiment. In order to make explicit which information was available to players at each stage of the procedure, each component of the experiment is shown with its respective screenshots in the chronological order in which they were presented to participants.

The treatment intervention is explained in subsection 3.2.2, while the hypotheses derived from the research questions proposed in the introduction chapter are laid out formally in the context of this specific design in section 3.3.

3.1. General Structure of the Experiment

The general goal in the experiment is to let players invest their earnings from solving a Real Effort Task to increase their individual chances of winning a contest that awards the double wage in the following round, as explained in the theoretical model of section 2. This process is repeated several times in groups that remain constant throughout the trial.

The experiment is roughly divided into three sections as shown in Figure 3.1.[1] The first is an introductory section where the principal components of the experiment, including the RET, are explained in great detail to the participants. In this first section, participants are also asked several control questions to test their understanding of the task.

Within the introductory section, participants complete two rounds of the RET, once with the low payment per task and once with the high payment per task (the wages subjects will receive if they respectively lose or win the Tullock contests later on). Both the high and the low wage are equal to the respective wages paid during the competition stage. This is used later as a baseline against which the performances in the competitive rounds are compared.

[1]Table B.1 in the appendix lists a detailed breakup of the three main sections and its contents.

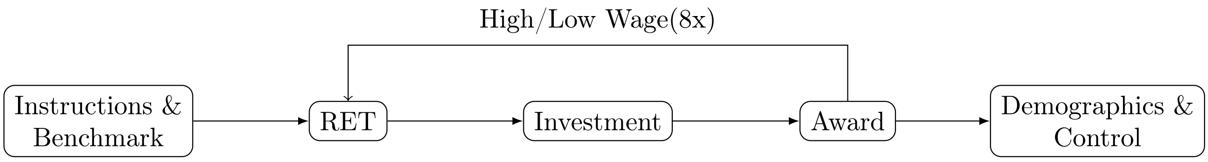


Figure 3.1.: Basic Structure of Experiment

The second section is the Tullock competition and it is the core of the experiment. During this stage, by solving the real effort tasks, participants earn money that they can subsequently invest to win a higher piece rate in the following round.

Finally, in the third section, participants answer several questions regarding their demographics, their cognitive reflection, and their risk aversion. A selection of screenshots in appendix C expands upon the sample images in this chapter.

The experiment was programmed using oTree (Chen et al., 2016) and was conducted at the *Vienna Center for Experimental Economics*. Participants were not allowed to communicate, nor use their cellphones. The instructions were presented to all participants on-screen and were also read aloud to let them know that everyone had the same information. In addition, to ensure comprehension at every step during the reading of instructions, participants were actively asked if they had any questions and we only proceeded once any questions had been answered. Lastly, participants were paid anonymously at the end of the session, in private, and in cash.

3.1.1. Real Effort Task

The RET which players perform in order to earn tokens to invest in the rent-seeking contest is inspired by Rey-Biel et al. (2016) and Giusti (2014). Participants are asked to count the occurrences of the letter “a” in a random string of characters. Figure 3.2 gives an example of such a string which in the experiment is called a *sequence*. Once a sequence is solved, another one appears. The strings of characters are generated pseudo-randomly but each iteration is identical for every participant in the session, thus ensuring equal difficulty for everyone. A fact of which all participants are made aware. In each round of the RET, participants have 180 seconds to solve as many sequences as possible with each correct guess awarding one token. At the end of the session, each token is exchanged for EUR 0.1.

This particular task was chosen as it fulfills several requirements of my design. First, the main research questions address the effects of inequality on performance measures, like output and efficiency. To be able to observe changes in those measures it is important to ensure that participants are not simply always doing as much as time allows, i.e. a corner solution, but that they choose an optimum based on their personal preferences. A corner solution would be particularly risky if players have a significant intrinsic motivation, or if no incentive is offered to stop solving tasks (Frey, 1997). An example of

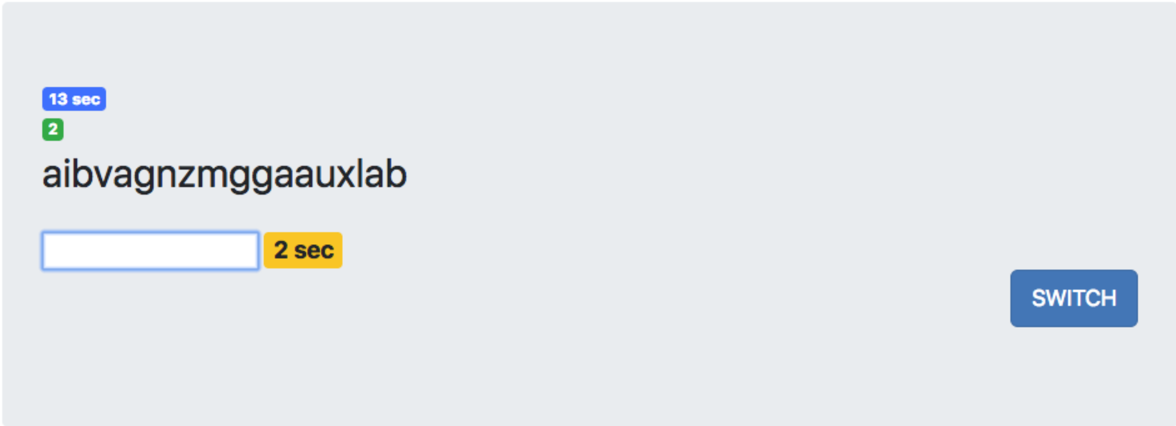


Figure 3.2.: Sample Screen of the Letter Counting Task

a task with a high intrinsic motivation would be any fun game, such as Tetris, for instance. The Letter Counting Task is tedious and repetitive without being effortless and therefore is a particularly revealing exercise to determine effort exerted due to monetary incentives (Cerasoli et al., 2014).

Furthermore, the task is easy to explain and is not mathematical, which has been shown to induce a gender gap in a competitive setting not linked to skill (Niederle and Vesterlund, 2010).

Incentivised Leisure

Missing incentives for non-work might also lead to a corner solution and thus difficult the identification of differences in work supply among subjects. In real life, leisure has an intrinsic motivation which, in economics, is quantified by the opportunity costs of not working. In the laboratory, however, due to the short time frame, implicit peer pressure and possible experimenter demand effects, participants might be reluctant or even opposed to reducing their work input and spending time in leisure. To address this issue, a fundamental feature of my design is, following Sausgruber et al., the monetary incentivisation of leisure time.

In my experiment, participants have, at any point while solving the RET, the opportunity to change to a leisure mode where they are paid per time unit and do not need to work. In this leisure mode, that was called "switch" mode to avoid any stigma on shirking (Rey-Biel et al., 2016; Eriksson et al., 2009), players spend the remaining time of the 180 seconds in the round and obtain 1 token each 10 seconds. A confirmation screen is shown to ensure that participants do not enter the "switch" mode by mistake as once they enter it, they cannot go back to solving sequences.

Increasing Difficulty and Optimality

Depending on a participant's ability, there must exist a rate of payment per time unit for which she or he is indifferent about offering work – solving the task – or spending time in leisure mode. Assume, for instance, that a participant needs one second to solve a sequence of given length and earns one monetary unit for that. If he or she would also earn one monetary unit per second in the leisure mode, they would stay in the "switch" mode given the disutility of labor. However, if he or she needs less than one second, they would prefer to solve the sequence as they would then earn more. Between those two points, and according to the transitivity and continuity axioms of choice, there must be a point where they were indifferent.

In my design, and following the procedure used by Sausgruber et al., the Letter Counting Task starts at a level so easy that any participant would earn more by solving the task than by spending time in "switch" mode. The sequence then increases in length by four characters. With each iteration it becomes more difficult to count the number of "a"s in the sequence. Depending on their abilities, each player will come at a task in which he or she would earn more by staying in the "switch" mode. By observing the times taken to solve each task, it is possible to determine the point at which any given participant should have changed to the leisure mode.

This difficulty increasing feature is also one of the reasons why I chose the Letter Counting Task. The random sequence is easily generated while the difficulty increase (the length increase) can be easily and quantifiably changed. In fact, it allows for several parameter changes for future research. For instance the speed of increase, the change rate between "switch" and task, or the letters that are to be counted.

To ensure that the solution to the subsequent sequence is not just the number of letters in the last sequence plus a small number, for each generated sequence a new sample from a new population with a different distribution is drawn. This makes it unviable to just guess the number of "a"s in the sequence by starting at the count of the last one.

3.1.2. Learning Effects

Since the experiment consists of several benchmarking and competition rounds, it was important to have a task that would present little increase in performance after each repetition. Otherwise, it would have been difficult to compare the outcomes of the baseline and the competition rounds for the same participants.

To reduce the impact of learning on the number of tasks solved as the experiment progresses, the task and design selected allow for enough repetition and learning even before the measurements of work supply and investment start. After doing it a couple of times, there does not seem to be much room for improvement in recognizing "a"s. Figure 3.3 shows the average time participants of the experiment needed to solve the first 16 tasks across the 8 competitive rounds. Although there is an increase in variance as the task becomes more difficult (going from the top left to the bottom right box), there is no visible decrease in the average time needed by participants to solve each task across rounds (going from left to right in each box).[2]

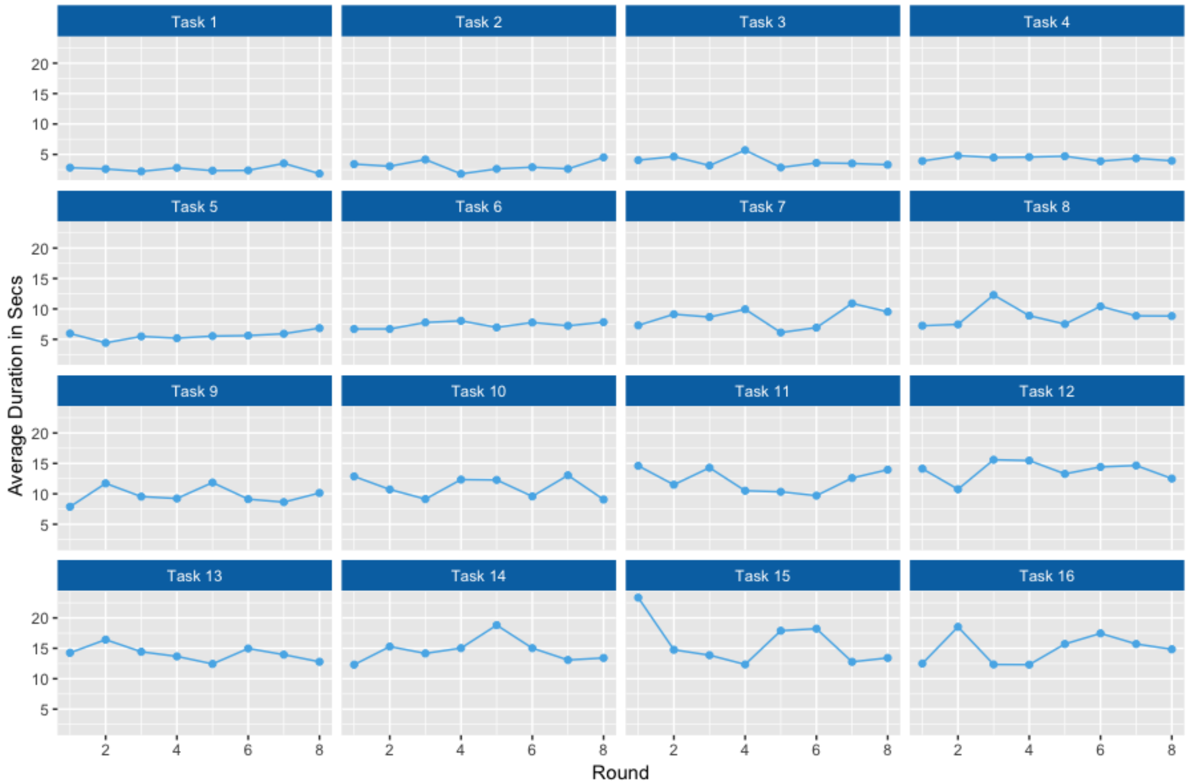


Figure 3.3.: Average Time in Seconds Needed to Solve the First 16 Tasks Across Rounds

3.1.3. Benchmarking

To identify the levels of performance in a non-competitive environment, two rounds of the RET are played during the introductory section of the experiment. In the first round, participants receive what will be the low piece rate (the payment per sequence if they do not win the previous contest), while in the second they receive the high piece rate (the payment per sequence if they are declared the winner of a period). The latter piece rate was, in my case, double the low piece rate so that a participant would optimally take up to twenty seconds solving a sequence before switching to the leisure mode. The order of the benchmark rounds – first low, then high piece rate – was selected to make the difference in earnings more noticeable and significant.

[2]Note that this assumes similar learning effects across individuals.

3.1.4. Help and Feedback

During solving of the Real Effort Task (RET) a summarized version of the instructions is shown at the bottom of the page and a mouseover display explains all relevant elements if needed. Once a participant goes into the “switch” mode, a counter shows in real time how many tokens he or she earns with each passing second and informs him or her about the number of sequences solved.

Finally, a feedback screen shows how many sequences were solved, how much time was spent in the “switch” mode, and the total earnings for the round. In the second round of the baseline setting RET, another table informs the participant about the earnings in the previous round to make the difference in earnings, between the high and the low piece rate, more obvious.[3]

3.2. Experiment Walkthrough

To start, the introductory section welcomes the participants and informs them about the functioning of the experiment and the RET.

Real Effort Task Instructions and Trial Round

After a short welcome to the experiment, participants are told the main goal of the RET (counting “a”s) and how they submit their answers by typing the correct number in the input field and pressing “enter” (see section 3.1.1 for more detail). They then have the opportunity to test the task five times with five different sequences that were chosen to show the variability of the sequences. Some were long and some were short, some had many “a”s and some had few. When a correct answer is submitted, the next sequence is shown and the current timer is restarted.

The screen also featured an annotated tour that explained every part of the RET screen: the sequence, the input field, and a timer counting the number of seconds needed to solve the current and the previous sequence.

“Switch” Mode Instructions

Once participants complete the trial round, they are introduced to the leisure mode, the payment scheme, and the increasing difficulty mechanism of the RET. As explained in more detail in section 3.1.1, the incentivised leisure mode is a core feature of my experiment. As aforementioned, during the experiment it is called “switch’ mode to avoid any stigma on shirking.

Remember, participants are paid one token per correctly solved sequence, with one token being converted to EUR 0.1 at the end of the session. While in the “switch” mode,

[3] See appendix C for an example of the feedback screen.

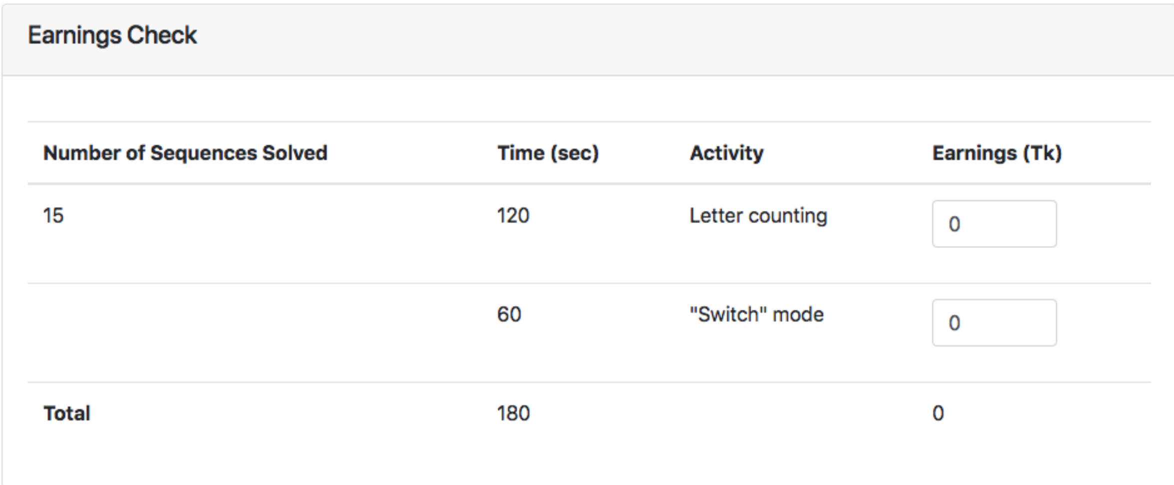
they earn 0.1 tokens per second spent in it. On this screen, I go to great effort to let participants know that, in terms of payment, the ideal point to switch is when he or she takes longer than 10 seconds to solve a sequence, regardless of how much time is left or how many sequences they have solved thus far. However, I do not explicitly define that as the optimum since in the competition rounds it might be advisable to solve more sequences to increase the chances of a higher piece-rate.

On this screen, an illustrative example of possible earnings is presented, participants can try the RET several times, and an annotated tour introduces the new elements (a counter showing the total solved sequences, a time countdown, and the switch button).

Control Questions

On this page, participants are asked two sets of questions to ensure that they have understood the instructions. Participants can only advance if they respond correctly to all the control questions.

In the first set, participants are asked how much a fictional player would have earned given an amount of solved sequences and time spent in the "switch" mode (Fig. 3.4). The numbers were chosen so they would not offer an obvious anchor point,[4] while still being easy to calculate.



Earnings Check

Number of Sequences Solved	Time (sec)	Activity	Earnings (Tk)
15	120	Letter counting	0
	60	"Switch" mode	0
Total	180		0

Figure 3.4.: Control Question: Earnings

In the second set (Fig. 3.5), participants were asked to select the switching point of a fictional player aiming at maximizing her payoff. Once again, the times were selected in such a form so that a tendency to infer an anchoring point would be minimized. Similarly, instead of giving examples of actual sequences, only a visualization with bars is given.

[4]An anchor point is an amount of time or number of sequences solved that a participant is supposed to aim for while solving the RET.

"Switch" Check

The following table lists how much time three fictional participants needed to solve nine consecutive sequences. Please select for each participant the sequence after which she/he should have stopped solving sequences and changed to the "switch mode" if she/he was interested in maximizing her/his **total** earnings in that round.

Sequence	Time Needed by Participant "X" (seconds)	Time Needed by Participant "Y" (seconds)	Time Needed by Participant "Z" (seconds)
||||	4 ○	1 ○	5 ○
||||||||	5 ○	2 ○	9 ○
||||||||||||	8 ○	4 ○	8 ○
||||||||||||||||	9 ○	7 ○	10 ○
||||||||||||||||||||	8 ○	5 ○	13 ○
||||||||||||||||||||||||	10 ○	9 ○	12 ○
||||||||||||||||||||||||||||||||	13 ○	9 ○	14 ○
||||||||||||||||||||||||||||||||||||	15 ○	10 ○	14 ○
||||||||||||||||||||||||||||||||||||||||	18 ○	13 ○	18 ○

Figure 3.5.: Control Question: "Switch" Mode

Instructions and control questions were shown before both the low and high piece rate paying benchmarking rounds. In the control questions before the high wage benchmark round, I chose the possible answers such that selecting the correct answer for the low wage benchmark round would be possible, so forcing participants to think why there was a change in the maximizing time to solve sequences.

3.2.1. Competition Section

At the beginning of the competition section, participants are informed that they were randomly placed into groups of three people and that each person was assigned a label A, B or C, but that their identity and that of all other participants will remain anonymous both to all other participants as well as to the experimenters.[5] I chose groups of three people for the experiment as the group dynamics are more interesting and revealing in the case of three players when compared to two, and this did not increase the modelling complexity too much. With three players it is possible, for instance, to compare competitive behavior between losers in subsequent rounds. Most importantly, it allows me to make a distinction between players *without the highest* possibility of winning and those *with the least* possibility of winning.

At the beginning of the competition section, participants in the treatment sessions are further informed about the taxation and redistribution scheme (see section 3.2.2).[6]

Tullock Contest

Next, players are informed about the contest proper. In eight rounds, each participant will have the opportunity to earn money by solving the Letter Counting Task or by spending time in the "switch" mode. Money earned through work[7] can then be invested to increase the higher piece rate in the following round. Only one person per round is awarded the prize and the probability of winning it is equal to the share of that person's investment relative to all investments by all players. An example for easier understanding is also shown (see the screenshots (e) and (f) in Figure C.3 in the appendix).

Players are further reminded at this stage of how much they earned in the benchmarking rounds and of the difference in earnings between the low and high piece rate rounds, i.e. their valuation of the prize. Note that every time before the Real Effort Task (RET) starts, a waiting page makes sure that all participants have completed all previous sections, thus avoiding some participants solving the task while others are reading. Also, a confirmation page is displayed before the start of the RET so that participants are not taken by surprise.

[5]This reduces the impact of other-regarding behavior.

[6]Note that when moving from the introductory section to the competition, two things change in regard to the RET and the performance incentives. First, the competitive aspect of being in the group. Participants will have the possibility to see what others do and will know that the other participants will see their own performance. In fact, last place aversion and the utility of winning itself have been shown to be the driving issues behind overbidding in rent-seeking contests as well as behind performance increase in competitive games (Sheremeta, 2013). Second, in the actual contest, increasing one's earnings can also indirectly increase the chances of winning the prize through a larger available income to invest.
The fact that these two factors change at the same time might make it difficult to pin-point reasons behind a performance change between the benchmarking and the competition rounds. This does, however, not affect any of the main variables I am interested in investigating in this study since we can still precisely determine the optimal investment and switching time for each participant and their difference to the observed values. Furthermore, the effects of competition, inequality, impulsiveness, etc. have already been extensively researched, including in the context of rent-seeking contests. In fact, Sheremeta (2016) shows that the main factor is impulsiveness, which I control as explained in subsection 3.2.3. For these reasons, I do not alter the experiment, but discuss a possible workaround and its drawbacks in chapter 5.

[7]I.e. the net income earned by counting letters plus the redistributed amount.

Beliefs

To test if, and to what extent, players take the behavior of the others into account when choosing their production and investment levels, beliefs about the production, i.e. the number of sequences solved, and the amount invested by the other team members are gathered in every round. A visual clue lets them know which player has a higher piece rate in the current round.

Feedback

After solving the task (as explained in section 3.1.1) and before investing, participants receive feedback on their performance like they did in the benchmarking section. They are provided a summary of: how many sequences were solved, how many seconds spent in "switch" mode and, in the case of the treatment, how much the transfers are.

Investment and Result

On the investment screen, players use a slider to choose their investment in steps of 0.1 tokens. They are informed about their total available income for investment, how much they invest, how much they would keep, and what the prize is. They are also reminded that tokens invested are not refunded, even if the prize is not awarded (see Fig. 3.6).

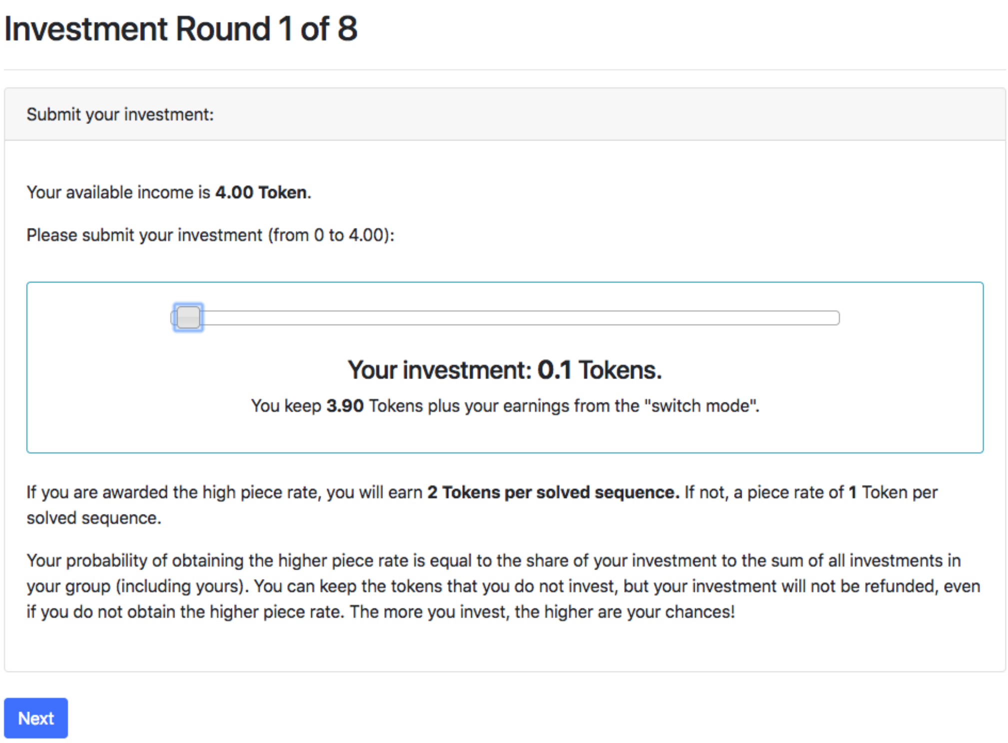
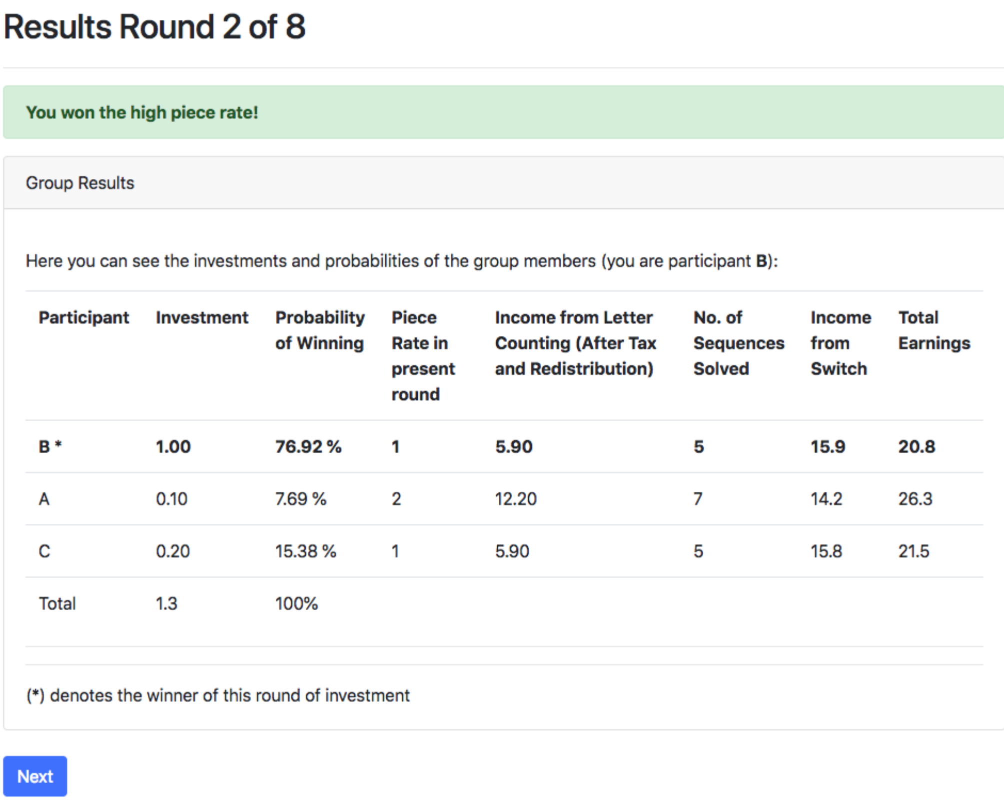


Figure 3.6.: Investment Screen

After the investment, participants receive detailed feedback about the investments and performance of the group and are informed about who won the high piece rate in the following round (see Fig. 3.7).


Results Round 2 of 8

You won the high piece rate!

Group Results

Here you can see the investments and probabilities of the group members (you are participant **B**):

Participant	Investment	Probability of Winning	Piece Rate in present round	Income from Letter Counting (After Tax and Redistribution)	No. of Sequences Solved	Income from Switch	Total Earnings
B *	**1.00**	**76.92 %**	**1**	**5.90**	**5**	**15.9**	**20.8**
A	0.10	7.69 %	2	12.20	7	14.2	26.3
C	0.20	15.38 %	1	5.90	5	15.8	21.5
Total	1.3	100%					

(*) denotes the winner of this round of investment

Next

Figure 3.7.: Results Screen after Investment

3.2.2. Treatment: Taxation and Redistribution of Income

As explained in the introduction to this thesis, understanding how voting would affect the POUM itself requires several layers of examination. In the present work, I look at how the general dynamics of the contest behave and what impact taxation and redistribution have on the distribution of win probabilities and the exertion of effort.

To test this, I introduced a treatment where income from work, that is, from counting letters but not from "switch" mode, is taxed at 60%. The entire tax revenue is then divided equally among all participants so that the total amount of tokens in circulation is constant. Participants can then invest their net income plus transfer to increase their chances of earning the higher piece rate, as explained in section 3.2.1.

In the control group there is no taxation and therefore no redistribution. The available income to invest is exactly equal to the earned tokens from letter counting. Note that the predictions regarding the optimal investment, as derived in chapter 2, are unchanged since taxation and redistribution only affect work income. However, taxation does affect the valuation of the game where $\mathbb{V}$ is no longer equal to just the difference in earnings between the high and low wages, but adds the share of the sum of redistributed income R such that $\mathbb{V}_i = x_{hw} * w_{hw} - x_{lw} * w_{lw} + \frac{R}{n}$.[8]

Taxed Benchmarking

To more effectively measure the valuation of the price in the taxation treatment, two extra rounds paying a wage equal to the effective taxation in the treatment were added to the benchmarking phase for the treated group, as explained in subsection 3.1.3.

Specifically, in between the low piece rate and high piece rate benchmarking another benchmark round was introduced. This round paid, per task, the equivalent of the effective taxed low piece rate after redistribution or $w(1-t)+w(t/n)$,[9] with w being the piece rate, t the tax rate and n the number of players per group. In my case, this means 0.6 tokens per sequence or 1 token minus 40% of 1. The payment for the "switch" mode remained, as in all rounds, constant.

Similarly, an extra round was introduced after the high wage round which paid the equivalent of the effective taxed high piece rate after redistribution, in this case this was 1.2 tokens or 2 tokens minus 40% of 2. These extra rounds were introduced in this order so as not to generate a strong separation between the taxed and the untaxed rounds, as well as to space out the control questions.

To ensure that introducing these extra rounds did not affect the participants' performance, I carried out a Wilcoxon test between the productions of the treated and non-treated groups. This was done once for the low benchmark and once for the high piece rate benchmarking rounds. Both showed no differences between the groups, i.e., no learning or timing effects, nor a significant difference in skill. The test results are summarised in the appendix in Table B.1.

3.2.3. Idiosyncratic Controls

To control the effect of idiosyncrasies, like risk aversion, on players' behavior, I introduced several tests at the end of the experiment which are presented in this section.

Fairness Sentiment

To see how participants themselves perceived the game in terms of what determined success, they were asked to rate from 0 to 7 what determined their success in the game. With 0 being only luck and 7 being only skill. Figure 3.8 shows the voting screen. The

[8] Here, x is the amount of sequences solved, w the paid piece rate, and hw demarks the high and lw the low wages.

[9] If the total tax revenue is divided in equal parts among all individuals, as is the case in my design.

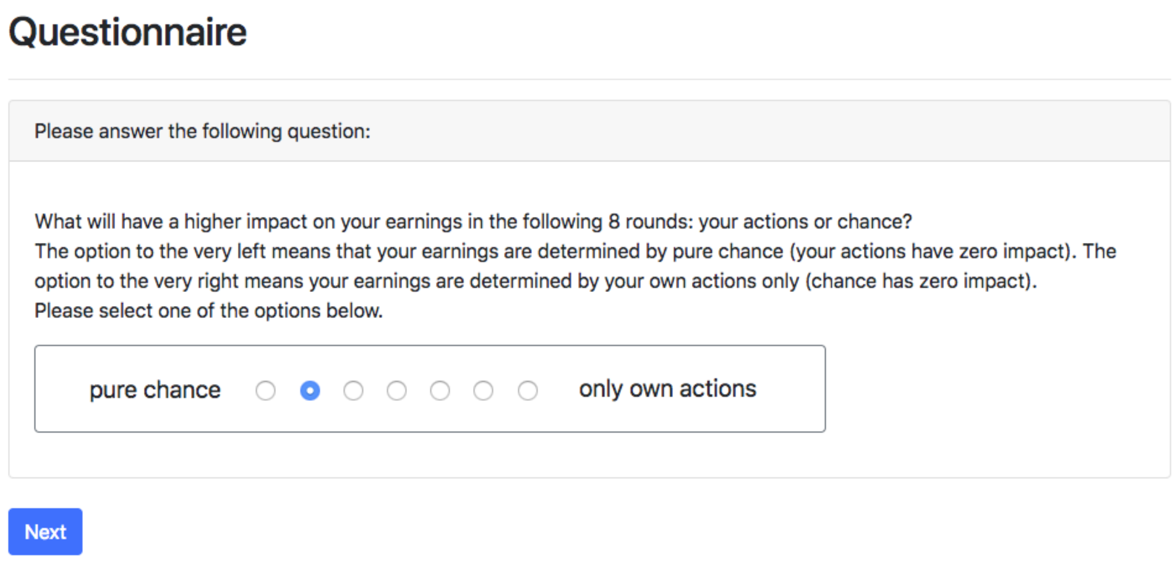


Figure 3.8.: Screen Fairness Questionnaire (beginning)

question was posed both at the beginning and end of the competition. Allowing us to observe not only how the perception changes after experiencing the competition, but if, and to what extent, the fairness perception changes in the presence of redistribution.

This measure can, furthermore, be useful in comparisons with other designs and parametrizations as discussed in chapter 5.

Risk Aversion Measure and Risk Elicitation

During the investment section of the experiment players participate, effectively, in a lottery. The exact terms of that lottery are not known to them in advance and present a strategic decision as well. Their investment choices will therefore not only reflect their strategic considerations, but also their stance on risk taking.

To control the effect of this, I include an incentivised risk elicitation test following the *Multiple Price List* by Holt and Laury (2002) (HL) with the implementation for *oTree* taken from Holzmeister (2017).

I chose the HL method as it, according to Crosetto and Filippin (2016) and Harrison and Rutström (2008), among other reasons:

- allows for risk preferences in both the risk neutral and risk seeking range;
- has a finer categorisation as for instance Eckel and Grossman (2008);
- has constant intervals between the parameters of risk, mapped through discrete choices, which makes it robust against stochastic decision making;

Figure 3.9.: Choices Screen *Multiple Price List*

- does not strongly differentiate between genders – there are no significant differences between genders.

In the HL method, players are asked to choose between several pairs of lotteries, A and B. Beginning with a choice where option A is the safer choice, the last choice is between sure outcomes, where B represents the payoff maximizing choice. Between them, there is a point where a participant changes from one option to the other, thus revealing his or her risk preferences.

Figure 3.9 shows the list of choices that participants were presented with. In it, probabilities are visualized with the help of pie charts and all possible decisions are shown at once. Consistent preferences were forced to avoid elimination of data in the already small sample. After choosing, one of the decisions was then selected randomly and the lottery drawn and paid out.

Following the common procedure, I assume participants to have a constant relative

Number of Safe Choices	Range of Relative Risk Aversion	Risk Preference Classification
0-1	r < -0.95	Highly Risk Loving
2	-0.95 < r < -0.49	Very Risk Loving
3	-0.49 < r < -0.15	Risk Loving
4	-0.15 < r < 0.15	Risk Neutral
5	0.15 < r < 0.41	Slightly Risk Averse
6	0.41 < r < 0.68	Risk Averse
7	0.41 < r < 0.97	Very Risk Averse
8	0.41 < r < 1.37	Highly Risk Averse
9-10	1.37 < r	Stay in Bed

Table 3.1.: Risk Aversion Classifications Based on Lottery Choices
(Holt and Laury, 2002)

risk aversion (CRRA) utility function $u(x) = x^{(1-r)}$, which allows me to index each choice by a corresponding r. An individual with an $r < 0$ is categorized as risk averse, with $r = 0$ as risk neutral, and with $r > 1$ as risk seeking. The payoffs are exactly the same as those used by Holt and Laury (2002) and thus imply that someone switching after the fourth lottery to *option B* is assigned an r interval of (-0.15, 0.15), meaning risk neutrality. The list of the implied risk aversion ranges can be seen in Table 3.1, where the number of safe choices is the number of choices made before switching to *option B*.

Cognitive Reflection Test

A tendency to overbid in rent-seeking contests has been well documented (Sheremeta, 2013; Dechenaux et al., 2015). This is particularly critical to consider in my design, as overbidding, both in terms of work supply and investment, would be interpreted as an over-exertion of effort.

While there are several proposals as to what influences this behavior, Sheremeta (2016) suggests that impulsiveness might be the strongest predictor. In fact, he suggests that, when analyzed simultaneously with the utility of winning, systematic biases, relative payoff maximization, and mistakes, only impulsiveness remains statistically significant.

Following his work I therefore include a Cognitive Reflection Test based on Thomson and Oppenheimer (2016). They propose alternative questions to measure cognitive reflection that are less well known as those originally posed by Frederick (2005). Figure 3.10 shows the questions that were presented to participants, although these were presented individually and without the possibility to go back, instead of all at once.

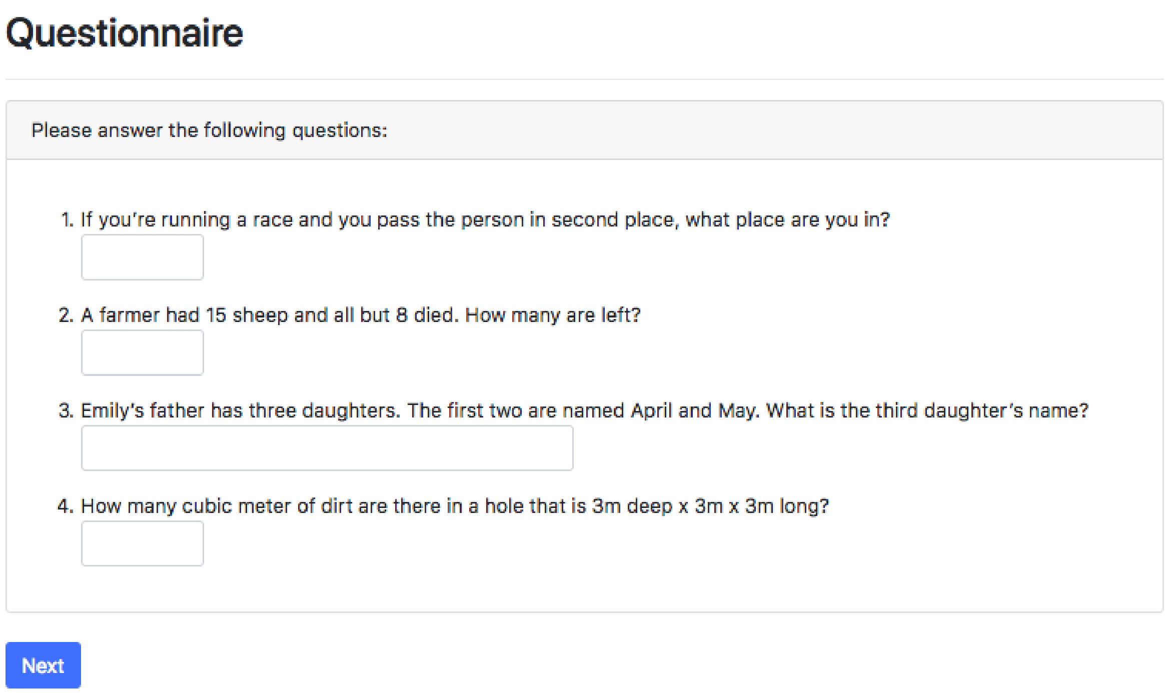


Figure 3.10.: Cognitive Reflection Test (Thomson and Oppenheimer, 2016)

3.3. Hypotheses

I focus in this thesis on the dynamic of repeated Tullock Contests, in particular on the participants' effort provision, and the evolution of winning probabilities across periods in a Tullock contests. As explained in the introduction, those probabilities can be seen as analogous to the Prospect of Upward Mobility while the investments made in each round are analogous to investments made in human capital needed to acquire high earning jobs.

Broadly speaking, my thesis looks at performance values in terms of sequences solved and time spent in leisure mode, and at effort exertion values in form of investments. Comparisons in those regards are made both within and between subjects and groups. Within subjects and groups, I look at the differences between the benchmark and the competitive rounds in general, and within the competition rounds over time. In addition, I introduce a taxation and redistribution intervention which will be studied through a between-subject and group comparison.

How investments develop across periods is the first step to analyze the POUM in my experiment. How much participants invest ultimately determines their probability of winning but, more importantly, it determines the total welfare of the group. Since available income invested is not reimbursed, investments reduce overall welfare. An intervention that reduces over-investment, whilst ensuring winning probabilities that are more fair[10] is therefore desirable.

As described in the model in chapter 2, investments should, in theory, be constant over time, however, as Sheremeta (2016), among others, have shown, participants tend to over-invest. I expect, nevertheless, that over-investment decreases over time, due to income effects or because they develop a better knowledge of the game. This phenomena is shown experimentally by Fallucchi et al. (2013) where, although investment levels stay above optimum, they clearly drop in the presence of full information, as is the case in my design. In that experiment, groups with full information reduced over-investment to around 13% above optimum while those with only feedback about their own performance stayed at levels of 66% above optimum. Formally, as a first answer to Research Question 2 I expect, therefore, that:

Hypothesis 1: *Mean investments will be higher than the expected profit maximizing value for all treatments, but will decrease over time.*

As it has been described in the literature on rent-seeking contests, over-investment can be driven by several aspects, most importantly, impulsiveness, risk incline, competitiveness and inequality aversion. I control risk aversion and impulsiveness with the methods mentioned above in the experimental design section (Cognitive Reflection Test and Multiple Price Listing). Furthermore, if competitiveness plays a major role I should observe no major difference between treatments or over time. Considering the second part of hypothesis 1, that not only do I expect investments to be higher than optimal but to decrease over time, if that decrease is driven mainly by a better understanding of the game or better knowledge of other participant's behaviour, I should not observe any difference in slope between treatments. In the latter case, I would further expect an increase in the accuracy of a participant's belief about the investment *and* performance (since performance determines the valuation) of the group's other participants.

On the other hand, the reduction in investments effect can be driven by an income effect, since in each period only one person wins but two lose. If winners of previous rounds are more likely to invest more and therefore also more likely to win again, losers might invest less each time. In this case, I should observe a significant difference between winners and losers and a significant effect of cumulative wins on the invested amount.

Another possibility as to why mean investments will decrease over time is that participants have a decreasing utility function for winning. In other words, that participants value winning the first round higher than winning the last one. My design does not disentangle this effect from experience effects, yet this issue is discussed for further research in chapter 6.

[10]The definition and analysis of the concept of fairness go far beyond the scope of the present thesis but these are addressed in chapter 6 as part of the discussion.

In case inequality aversion is a driving factor in competition, introducing a redistribution scheme should reduce its effect as income distributions within groups become more equal. Additionally, given that the available income is more equally distributed in the treatment by design I expect investments in the taxed groups to be relatively lower. Similarly as a part answer to Research Question 2, I expect formally, that:

Hypothesis 2: *Participants in the taxation treatment will invest a smaller multiple of their optimal investment.*

In other words, participants in the treatment group will be relatively closer to their optimal investments. Note that the compared measure is the ratio over the optimum since the optimal value of investment is different for both groups. This is because the valuation of the game, i.e. the difference in net earnings between the high and the low wage, is different for each treatment.

An important corollary of hypothesis 2 is that, since players in the taxation treatment are closer to the optimum levels of investment, total welfare for the group in terms of total income generated is larger.

Now, what does the expected lower over-investment for the treatment and the decreasing investments over time mean for the probability of winning? In other words, how do investments change relatively to the other group members in the cross-sectional and longitudinal dimensions?

If investments decrease over time mainly due to subject specific differences (learning, decreasing utility of winning, etc.), I should not observe any significant differences between treatments or over time with regard to the distribution of probabilities since the bids decrease equally for all subjects. If, however, the effect is driven by group dynamics, for instance last place aversion or income effects of cumulative wins, I expect to see a stronger variance in probabilities in the control group while increasing over time. In the redistribution treatment, available income will be more equally distributed and therefore inequality and income effects should be diminished. In other words, probabilities will be closer to each other and to the mean of $1/n$. Formally, answering to Research Question 1, I expect that:

Hypothesis 3: *The coefficient of variation of winning probabilities will be increasing across rounds while being smaller in the treatment group.*

I use the coefficient of variation $c_v = \frac{\sigma}{\mu}$ to test if the distribution of probabilities between the treatments really differ, as for instance in Rassenti et al. (2000), as Bendel et al. (1989) recommends to use this in cases where there is a relatively exact measure of the values, although given the fact that the mean of the probabilities is always equal to $1/n$ the results correspond to the standard deviation of each sample.

4. Results

The participants of the experiment were selected on a first come, first served basis from registered volunteers of the *Vienna Center for Experimental Economics* who spoke English, were under 40 years of age, and had not participated in more than 10 previous experiments. A total of 96 people (55 female and 41 male) with an average age of 25 years took part in a total of four sessions during the second half of 2018. Two of the sessions ran the control while the others two ran the treatment, such that exactly half the participants were in the treatment and half in the control.

At the end of the session, participants were paid anonymously, in private, and in cash, ranging from EUR 12.50 to 31.30 for an average payoff of EUR 22.90.

All the data preparation, analysis and visualization for this thesis was done using the statistical software *R* (R Core Team, 2014).[1]

4.1. Notes on the Methodology

Although ANOVA models are commonly used in behavioral sciences when analyzing treatment differences in repeated measures, several authors have questioned their adequacy (Camilli and Shepard (1987), Vasey and Thayer (1987), Jaeger (2008), Locker et al. (2007), Krueger and Tian (2004)). Especially critical in my design is the fact that participants are matched in groups which do not change during the experiment and may therefore develop their own dynamic. Imagine, for instance, a group in which the majority of participants are very risk friendly or have a high valuation. Investments might increase in total, even for those participants that are not as risk loving.

Instead, linear mixed models as used, for instance, by Szaszi et al. (2018), Holsen et al. (2009) or Yue et al. (2010), are encouraged since they allow the study of the general effect of the variables of interest while allowing random intercepts for groups and participants and also whilst taking the auto-correlation of the repeated measure into account (Gał ecki and Burzykowski (2013), Bolker et al. (2009), McCulloch and Neuhaus (2015), Barr et al. (2013), Baayen et al. (2008), Fitzmaurice and Laird (2015)). I therefore generally use a linear mixed model specification to be compared against a "fixed effects

[1] Packages used: *tidyverse* (Wickham, 2017), *data.table* (Dowle and Srinivasan, 2018), *ineq* (Zeileis, 2014), *stargazer* (Hlavac, 2018), *ggplot2* (Wickham, 2016), *sjstats* (Lüdecke, 2018), *texreg* (Leifeld, 2013), *ggthemes* (Arnold, 2018), *ggridges* (Wilke, 2018), and others which are referenced in due course.

only" model in the results analysis below.

4.2. Preliminary Results

Before diving into the hypotheses regarding investment and winning probabilities as postulated in section 3.3, we want to get a sense of the general behavior patterns participants exhibited during the competition, particularly regarding the solution of the RET and how that behavior differed between treatments.

4.2.1. Task Solving

During the benchmarking rounds, participants solved around 10 sequences and were paid one token per sequence. With the high piece rate of two tokens per sequence, participants solved an average of 15.3 sequences. The mean valuation, that is, the mean difference between the earnings (income from solving sequences plus income from the leisure mode) in the low and the high piece rate was of around 13 tokens. Table 4.1 summarises these findings.

Table 4.1.: Mean Values of Production in Benchmark

	avg. prod. low wage (seqs)	avg. prod. high wage (seqs)	mean valuation (tks)
control	9.77	15.29	12.9
treatment	10.25	15.29	13.09

During the competition, participants solved an average of 11.5 sequences and spent an average of 85.2 seconds in the "switch" mode. There was little difference in production between wages, i.e. between winners and losers, but some difference can be observed between treatments. Subjects in the treatment produced less on average and spent more time in the "switch" mode. Table 4.2 and Figure 4.1 summarize these findings.

To see if the difference in production between the treatments is statistically significant, and to see how other factors play a role, I used a linear mixed model (LMM) with random intercepts evaluated using the *R* package *lme4* (Bates et al., 2015). Since the design only allows for between-group comparisons in the treatment, I do not include a random slope per participant, assuming thus that the effect of time will be the same for all subjects.

In this model, the fixed effects are: the *treatment*, *was winner* (if a participant won the previous round and is playing with the high wage), and the *round* number. The random effect is the *subjects id* nested within the *group*. Results are largely reported

Table 4.2.: Mean Values of Production
standard errors are reported in parentheses ()

	wage	mean of solved sequences	mean of time spent in "switch"
control	1	12.02	78.66
		(0.23)	(3.13)
control	2	11.91	79.09
		(0.3)	(4.22)
treatment	1	11.1	92.28
		(0.21)	(2.86)
treatment	2	11.12	90.23
		(0.33)	(4.42)

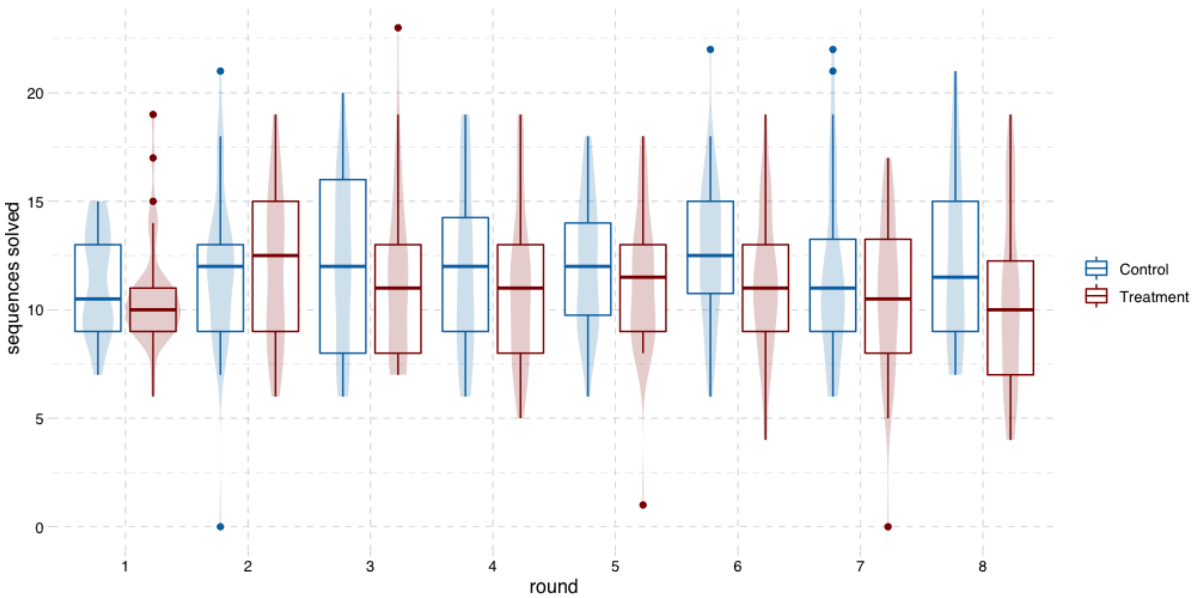


Figure 4.1.: Number of Sequences Solved per Round and Treatment

following Barr et al. (2013) and are summarized in Table 4.3 in the *sequence production* column. P-values were calculated using the likelihood ratio test of the *R* package *lmerTest* (Kuznetsova et al., 2017).

Treatment has a small effect, though significant at the 10% level, with subjects in the control group solving just shy of 1 sequence more per round (+0.872). All the other fixed effects have no significant or large effect with the model in total explaining 42% of the observed variance in which the fixed effects explain 1.52% (conditional R-squared and marginal R-squared respectively, calculated using the *psycho* package (Makowski, 2018)). The variables with no effect include, interestingly, the wage at which participants played.

It is important to remember that in this experimental design, payoffs are not exclusively determined by the amount of sequences solved. They depend also on: the time spent in the "switch" mode and therefore on the optimal change to it, the invested amount in human capital, and, in the treatment, how much the other players worked. The boxplot in Figure 4.2 seems to suggest that the net income is higher in the treatment groups and that, apart from the transition from round 1 to round 2, it does not change over time. Note that, here, net income describes income after taxation *and* redistribution, but before investment. The variance of the treatment is smaller since, in that group, by definition, net incomes are closer to each other.

In order to see if there were significant differences in net income between treatments, I use a model with fixed effects (*treatment, was winner* and *round*) and summarise the findings in the *net income* column of Table 4.3.

Winning the previous round, i.e. playing with the high wage has a strong and significant effect on net income while time, although marginally significant, has only a small effect. The introduction of a tax and redistribution scheme, on the other hand, does not have a significant effect. The model helps explaining 50.11% (restricted R-squared) of the variance with the fixed effects accounting for 33.73% (marginal R-squared) of the variance.

4.2.2. Switching Time

During the competition, participants appear willing to work more than their optimum in order to achieve a higher available income. Remember, participants should switch as soon as the time they need to solve a given task surpasses the earnings in the "switch" mode for the corresponding time. In the control group, players with the low wage should change as soon as they take longer than 10 seconds to solve the task and, in the treatment, as soon as they need more than six seconds. In each treatment, players with the high wage should switch at twice the respective time. Figure 4.3 shows the time needed for each task per round and marks the 10 and 20 seconds cut-offs.

Table 4.3.: Linear Mixed Model - Sequence Production and Net Income

	Dependent Variable:	
	Sequence Production	Net Income
treatment	-0.872^{*}	0.598
	(0.499)	(0.471)
was winner	0.028	5.977^{***}
	(0.231)	(0.289)
round	-0.003	0.090^{*}
	(0.043)	(0.054)
Constant	11.985^{***}	21.434^{***}
	(0.408)	(0.422)
Observations	768	768
Log Likelihood	$-1{,}943.528$	$-2,098.867$
Akaike Inf. Crit.	3,901.055	4, 211.735
Bayesian Inf. Crit.	3,933.525	4, 244.241
Var: participant|group (Intercept)	5.08	3.86
Var: group (Intercept)	0.00	0.00
Var: Residual	7.28	11.77
Note:		*p<0.1; **p<0.05; ***p<0.01

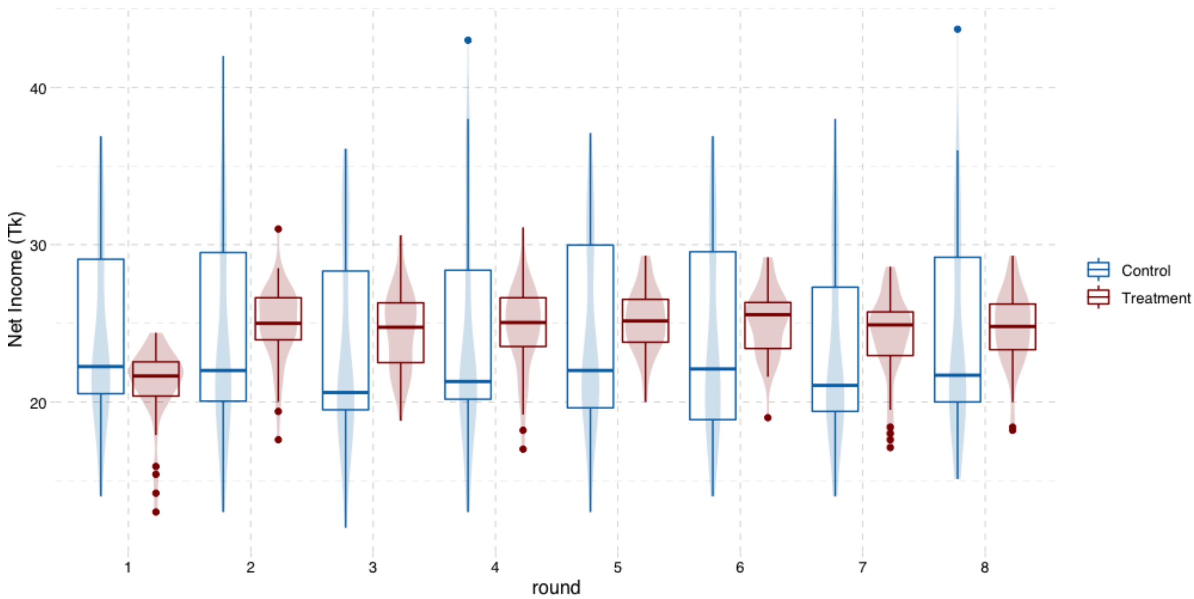


Figure 4.2.: Income after Taxation and Redistribution, and Before Investment

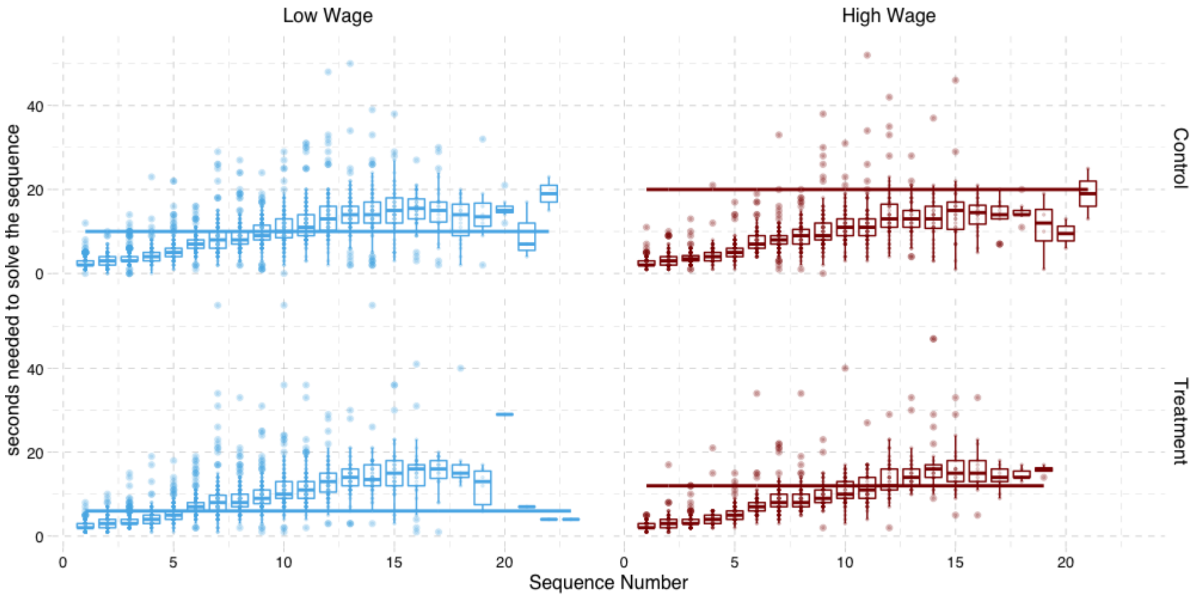


Figure 4.3.: Seconds Needed to Solve Sequences

It seems as if, in fact, the time needed to solve each sequence is more compressed to the middle in the control group. That is, fewer people are taking time above the cut-offs to solve sequences before switching. However, a Wilcoxon test[2] cannot reject the null hypothesis (p = 0 .283) of no shift with regard to the overall seconds over the 10 or 20 cut-offs. In chapter 5, I address a design change that could make it easier to identify if there are general changes to the switching point when taxation is introduced.

4.2.3. Controls

In the *Cognitive Reflection Test*, participants answered, out of a maximum of four, on average 2.22 (s.e. 0.1) questions correctly. Men answered, on average, 0.3 (s.e. 0.15) more questions correctly, with women giving 2.09 (s.e. 0.13) correct answers on average.

In the *Risk Elicitation* task, participants decided to switch on average on row 6.6, which according to Table 3.1 indicates a risk averse to very risk averse behaviour. Men generally showed a more risk averse behaviour, switching on average at row 6.93 (s.e. 0.32), while women switched on average already at row 6.36 (s.e. 0.33). Figure 4.4 shows a histogram of the row at which participants switched.

[2]This is conducted using the *stats* package R Core Team (2014).

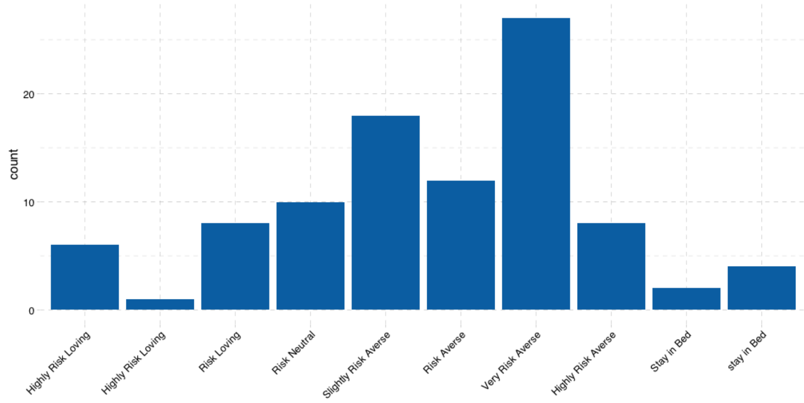


Figure 4.4.: Histogram of Choice of Switching Row

Participants did not seem to change their views on the fairness of the game. Figure 4.5 shows a boxplot of their assessment at the beginning and at the end of the competition rounds with 0 being only luck and 7 being only skill that determined the outcome of the game. Table 4.4 lists the results of a linear regression. However, no characteristic shows any significant effect on the change in fairness sentiment.

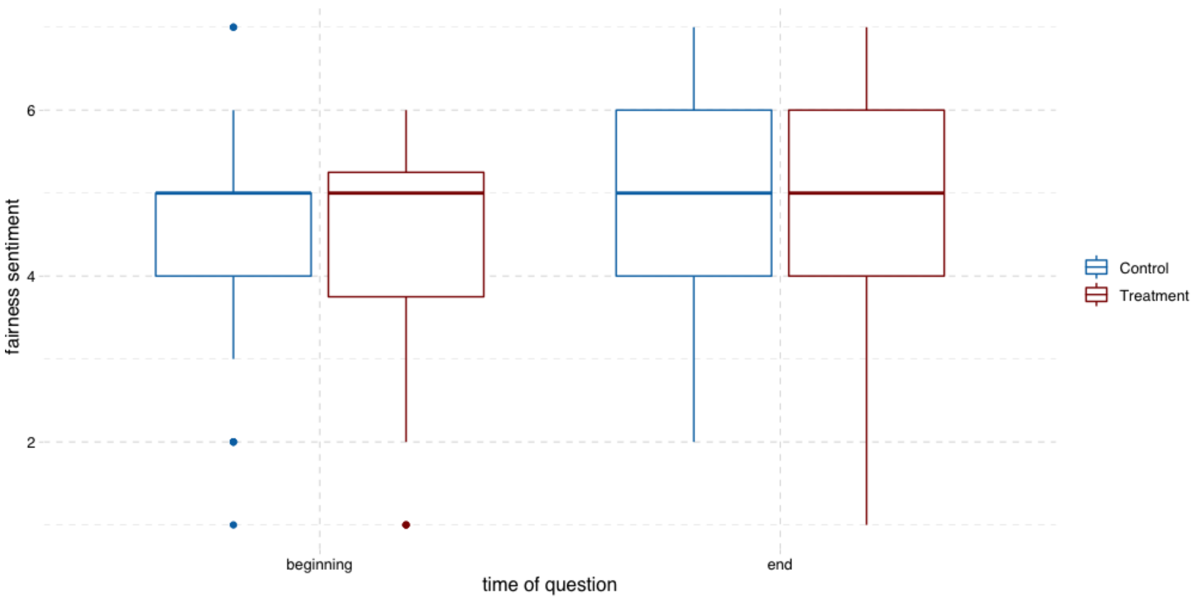


Figure 4.5.: Fairness Sentiment Voting

4.3. Hypotheses Testing

In this section, we will look at the results regarding, first, the distribution of probabilities and its change across rounds, and, second, the factors affecting the probability of winning for a given individual according to the hypotheses postulated in section 3.3.

Table 4.4.: OLS Change in Fairness Sentiment

	Change in Fairness Sentiment
treatment	−0.183
	(0.391)
payoff	0.015
	(0.052)
CRT score	0.063
	(0.188)
risk aversion	0.013
	(0.084)
gender (male)	−0.181
	(0.366)
valuation	0.048
	(0.063)
Constant	−0.971
	(1.298)
Observations	96
R^2	0.016
Adjusted R^2	−0.051
Residual Std. Error	1.733 (df = 89)
F Statistic	0.235 (df = 6; 89)
Notes:	*p<0.1; **p<0.05; ***p<0.01

4.3.1. Hypotheses 1 and 2

Hypothesis 1: *Mean investments will be higher than the expected profit maximizing value for all treatments, but will decrease over time.*
Hypothesis 2: *Participants in the treatment group will invest a smaller multiple of their optimal investment.*

The first step needed to test these hypotheses is to determine the optimal investment value for each participant. Running a t-test on the hypothesis that the distance to the mean of valuations is 0, in other words, that there is no difference in valuation between participants, supports this assumption (p = 1 for control and p = 0.85 for the treatment). This result greatly simplifies the process by allowing the use of formula 2.4.

Furthermore, since the treatment and control groups have different valuations, to more easily compare the results I analyze the mean difference over optimal investment for both groups instead of the nominal amount of over-investment. Note that the valuation for the treated groups is calculated from the difference in the taxed benchmark rounds as explained in section 3.2.2.

Consistent with expectations, participants bid on average significantly more than their optimum but decreasingly so over time, as Figure 4.6 shows. It plots each round to the mean per treatment of the over investment ratio, i.e., how many times more than the optimum was invested on average.

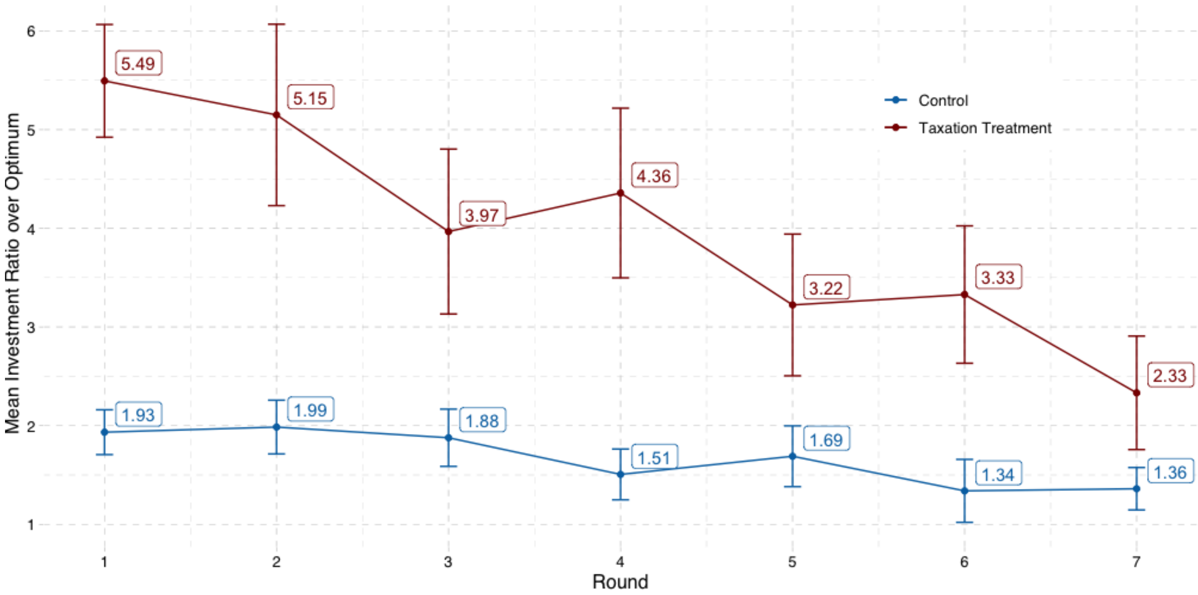


Figure 4.6.: Ratio of Over Investment per Round

Interestingly, participants in the taxation treatment invest both nominally and relatively more than those in the control, with treatment participants bidding on average 5 and a half times their optimal investment in the first round and 2.3 times their optimum in the last round. Participants in the control, on the other hand, invest from 1.93 times their optimum in the first round, to 1.36 times in the last round.

A possibility for why participants in the treatment invest relatively more is that subjects in both groups apply a simple heuristic of a given proportion of available income to invest. Given the fact that taxed players have a lower valuation but a higher disposable income, their bids are a higher proportion of the optimum. Running a regression on the investment ratio of available income in fact deletes the effect of all fixed effects but time, suggesting that participants tend to invest the same amount of their available income, regardless of their earnings or idiosyncratic features (see Table B.2). Figure 4.7 shows a plot of the mean shares of the available income invested. The shares decrease with time in similar fashion for both treatments and, apart from the final investing round, within a standard error from each other.

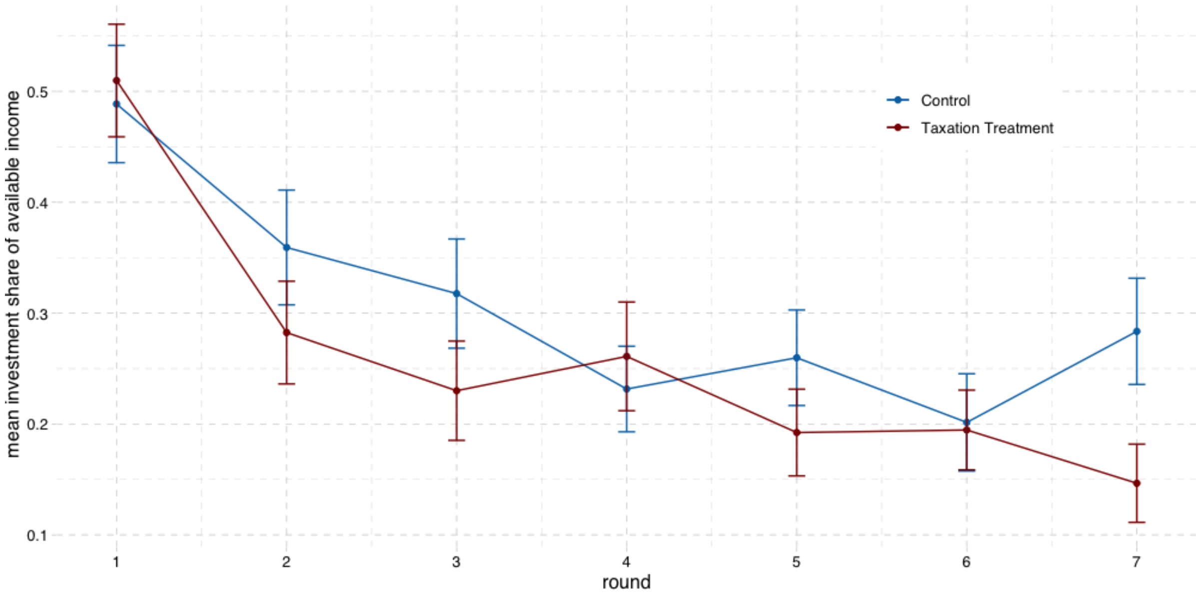


Figure 4.7.: Investment Share of Available Income per Round

Table 4.5 presents a linear mixed model dissecting the most important causes for over-investing. The random effects are *participants* nested in *group*s.

The first and second models have a total explanatory power of around 52% (conditional R-squared) in which the fixed effects of the first explain 10.03% and the second 14.5% of the variance (marginal R-squared). The effect of the treatment is significant and large for both models with participants investing, contrary to hypothesis 2, almost double as much over the optimum as subjects in the control group. Round repetition and risk averse behavior have both a significant, although relatively small, effect in the expected negative direction. The CRT score and whether a participant was playing with a high wage did not have a significant effect on the over-investment ratio.

Figure 4.8 plots the differences between the estimation made by participants before the investment round and the actual investments made. A perfect guess would be located at 0 in the y-axis. In the plot, a reduction in the mean over-estimation can be seen. It indicates better knowledge of other's behaviour with progressing rounds. It is nevertheless surprising how little accuracy participants appear to gain even after playing seven rounds and having been shown all relevant information.

A Wilcoxon rank test (p = 0.01) suggests, furthermore, that total welfare (the total amount of tokens paid out during competition) is larger in the treatment than in the control. Higher welfare in the treatment seems to be driven by working closer to the optimum.

Table 4.5.: Linear Mixed Model: Over Investment Ratio

	Ratio of Investment Over Optimum	
	(1)	(2)
treatment	2.314***	2.075***
	(0.698)	(0.678)
round	−0.307***	−0.307***
	(0.055)	(0.055)
was winner	0.256	0.281
	(0.271)	(0.271)
CRT score		−0.183
		(0.289)
risk aversion		−0.375***
		(0.126)
gender (Male)		0.284
		(0.583)
Constant	2.813***	5.689***
	(0.546)	(1.097)
Observations	672	672
Log Likelihood	−1,751.726	−1,747.753
Akaike Inf. Crit.	3,517.453	3,515.506
Bayesian Inf. Crit.	3,549.024	3,560.608
Var: participant|group (Intercept)	5.66	5.17
Var: group (Intercept)	1.62	1.48
Var: Residual	8.14	8.14
Notes:		*p<0.1; **p<0.05; ***p<0.01

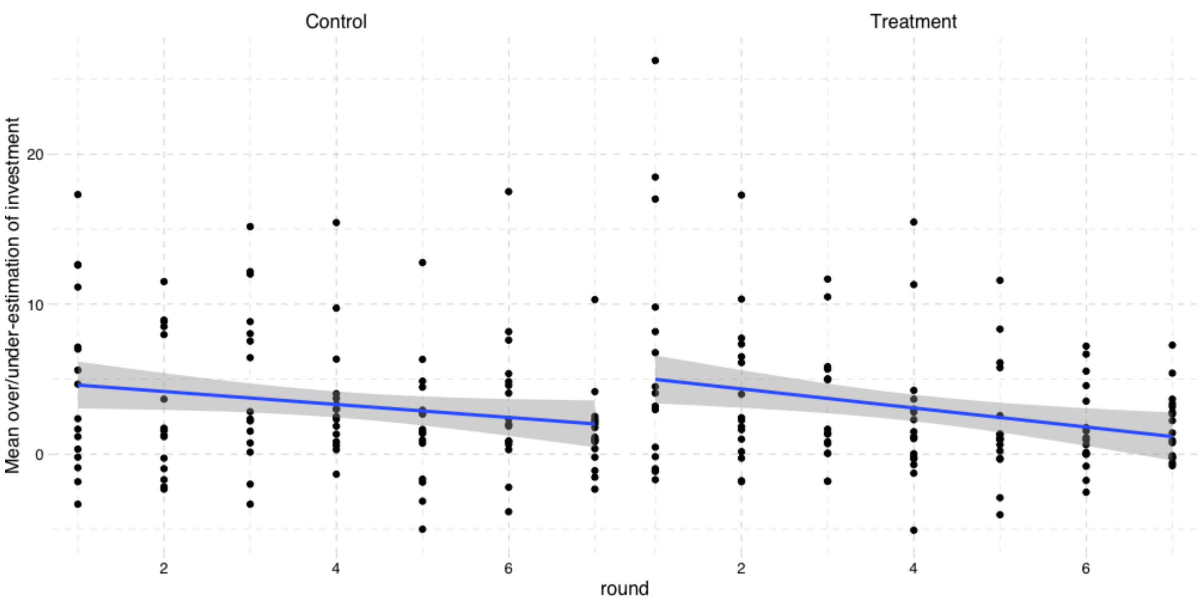


Figure 4.8.: Mean Absolute Over or Under-estimation of Other's Investments by Group and Round

4.3.2. Hypothesis 3

Hypothesis 3: *The coefficient of variation of winning probabilities will be increasing across rounds while being smaller in the treatment group.*

Participants appear to invest less with each round as the histogram in Figure 4.9 shows. Indeed, several participants do not invest anything at all and their number increases with each repetition which leads to the pattern shown in Figure 4.10: With increasing rounds, the relationship between the invested amounts and the probability obtained grow apart. This means, in particular, that with each passing round, more lower investments had a higher probability of winning.

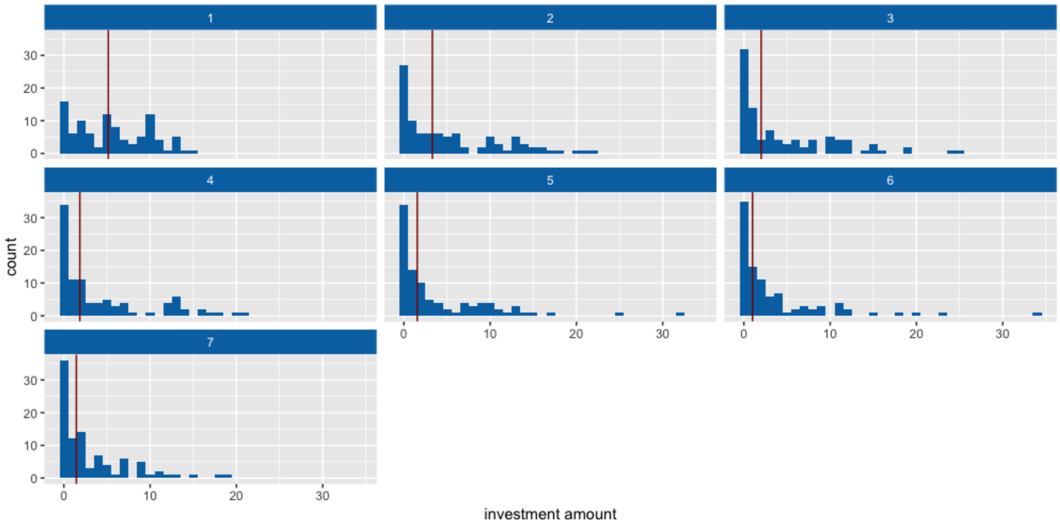


Figure 4.9.: Histogram of Investment Amounts by Round. The Red Line Demarks the Median of the Distribution.

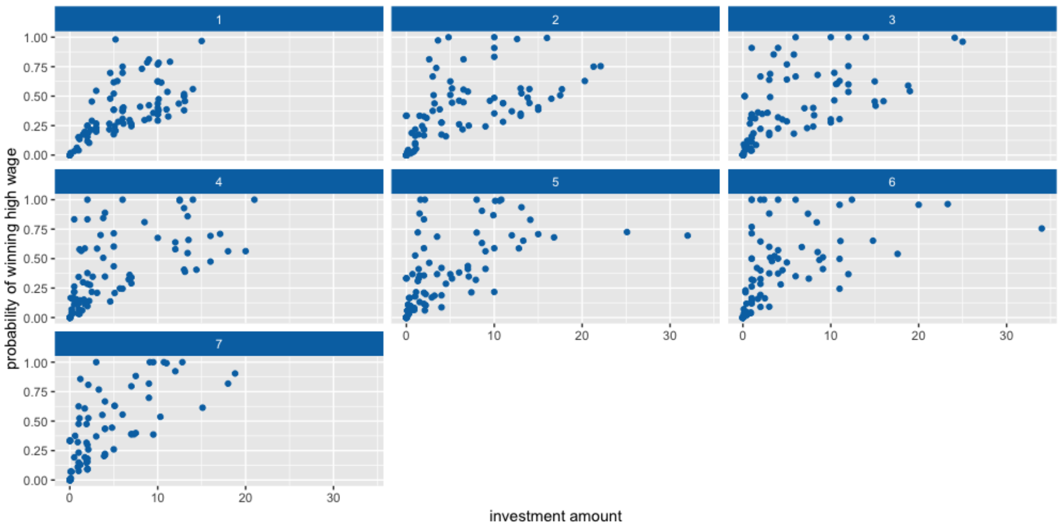


Figure 4.10.: Plot of the Probability Achieved by a Given Investment per Round

In terms of probabilities, I am interested in how their distribution change. Naturally, the mean probability of earning the high wage is always equal to $1/n$, but its distribution can vary from exactly $1/n$ for each participant, to only one person in the group having a probability of 1 and all the rest a probability of 0. Figure 4.11 shows the density plots for each round. A completely equal distribution would have its maximum at 0.33 with no values around it, while a completely unequal distribution would see two peaks at each extreme with the one at 0 being twice the size of the the one at 1.

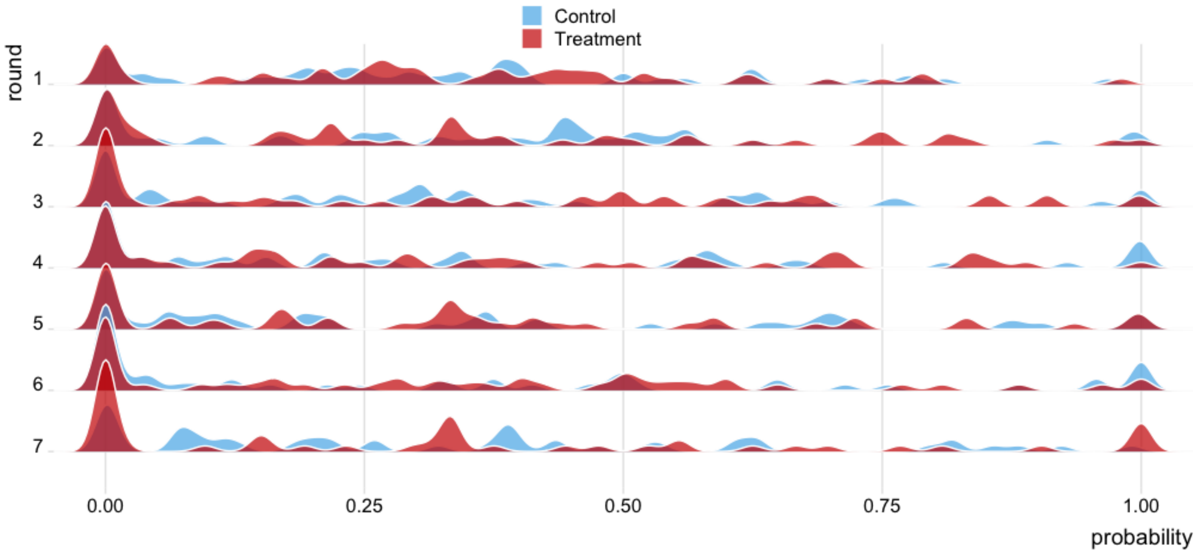


Figure 4.11.: Density Plots of Probability across Rounds

Figure 4.11 seems, in fact, to show an increase of density at the ends of the distribution with round 1 having a rather flat shape and round 7 stronger peaks at both 0 and 1 probability. Figure 4.12 shows a box plot of the coefficient of variations across rounds for both treatments. In fact, it seems to increase across rounds but not significantly between treatments.

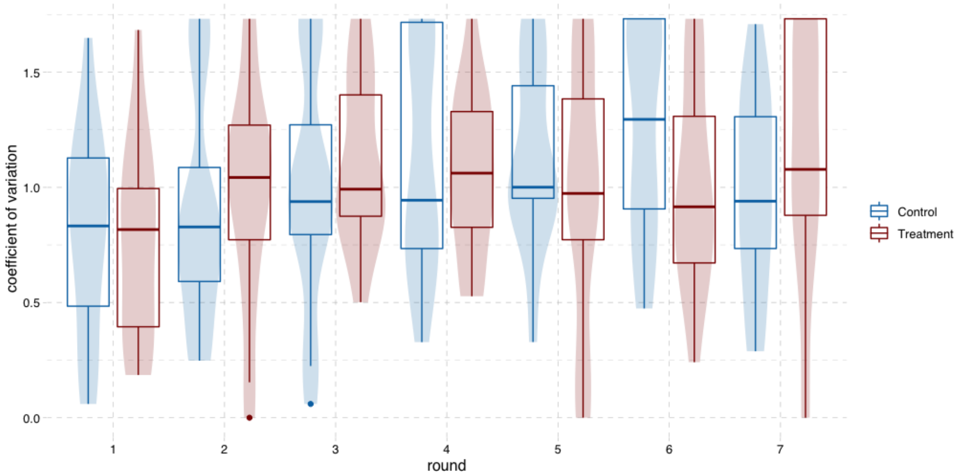


Figure 4.12.: Boxplot Coefficient of Variation

Table 4.6 shows the results for an OLS regression of two models explaining the difference across groups in the coefficient of variation for the probabilities of winning. A linear mixed model is left out here since each group is part of only one treatment and the variables are all aggregated at the group level. Only round repetition appears to have a significant, although small effect (in our setting, the coefficient of variance can fluctuate between 0 and 1.73) on the coefficient of variation. Idiosyncratic group values like the mean value of valuation, CRT score or risk aversion do not play a significant role in the variation of probabilities. Taxation and redistribution also do not play a role. In other words, introducing a redistribution scheme does not avoid the fact that, with time, the distribution of probabilities will go to extremes with some participants having most of the chance to win and the rest having almost none.

Of course, this does not tell us much about what determines the probability of a given participant to win a contest. To analyze it, I suggest again a linear mixed model, although this time a generalized mixed model from a beta distribution as the results represent a distribution of probabilities with values restricted from 0 to 1(Krishnamoorthy, 2016, Chapter 17).[3] Table 4.7 shows the results.

The only variable that shows a significant, although small, effect on the probability of winning is the size of the available income. Note, in particular, that having won alone has no significant effect on the probability of winning. This is in part because participants who are working with the lower rate can still achieve a large available income if they switch above their optimal point and thus forfeit time in the leisure mode. An alternative model including cumulative wins also showed no influence on the probability of winning.[4]

[3]Since several participants did not invest at all and thus had a probability of winning of 0, this led to some other participants having a probability of winning of 1. Those values were transformed to 0.0000000000001 and 0.0000000000009 respectively to allow them to fit a beta distribution. The analysis was conducted with the *glmmTMB* package (Brooks et al., 2017).

[4]The regression table is in the Appendix B.3.

Table 4.6.: OLS Coefficient of Variation

	Coefficient of Variation	
	(1)	(2)
treatment	−0.025	−0.031
	(0.063)	(0.065)
round	0.043***	0.043***
	(0.016)	(0.016)
mean CRT score		0.092
		(0.059)
mean risk aversion		−0.020
		(0.025)
mean valuation		−0.033
		(0.023)
Constant	0.856***	1.218***
	(0.077)	(0.338)
Observations	224	224
R^2	0.034	0.053
Adjusted R^2	0.025	0.031
Residual Std. Error	0.468 (df = 221)	0.467 (df = 218)
F Statistic	3.857** (df = 2; 221)	2.431** (df = 5; 218)
Notes:		*p<0.1; **p<0.05; ***p<0.01

Table 4.7.: GLMM Probability of Winning

	Probability of Winning	
	(1)	(2)
treatment	−0.139	−0.087241
	(0.22)	(0.218)
available income	0.045***	0.045***
	(0.008)	(0.008)
was winner	−0.084	−0.083
	(0.119)	(0.119)
gender (male)		0.356
		(0.223)
CRT score		−0.051
		(0.113)
risk aversion		−0.034
		(0.049)
valuation		0.056
		(0.038)
mean investment belief		0.003
		(0.008)
Constant	−1.413***	−2.454***
	(0.209)	(0.647)
Observations	672	672
Log Likelihood	3798.4	3801.0
Akaike Inf. Crit.	−7580.9	−7575.9
Bayesian Inf. Crit.	−7544.8	−7517.3
Num. groups: participant:group	96	96
Num. groups: group	32	32
Num. groups: round	7	7
Var: participant:group (Intercept)	0.93	0.02
Var: group (Intercept)	0.00	0.00
Var: round (Intercept)	0.00	0.00
Var: Residual	0.00	0.02
Notes:	*p<0.1; **p<0.05; ***p<0.01	

5. Discussion and Further Research

Since, to my knowledge, this is the first study of its type, the presented thesis starts from sensible parameters that can be adapted by future researchers to dive deeper into different aspects of the model. In this chapter, I list some of the questions that arose from the results, as well as suggest some design and parameter changes to answer them.

Changing, for instance, the difference between the high and low wages could lead to stronger reactions in work supply when winning, and to the sentiment of fairness of the game. Remember from section 2.1 that given a high enough high valuation, losing players will have no possibility to invest their optimal investment. This could furthermore exacerbate the tendency of probabilities to grow apart from each other.

In a related manner, but more complex to model, the prize can be increased with each passing round. Alternatively, the contest success function can be altered to be more or less deterministic by changing the exponent r in the equation:

$$p(I_i, I_{-i}) = \begin{cases} \frac{1}{n}, & \text{if } I_i = I_{-i} = 0 \\ \frac{I_i^r}{I_i^r + \sum_{j \neq i}^{n} I_j^r}, & \text{otherwise} \end{cases} \tag{5.1}$$

A result that also pointed the way to a design expansion was the apparent available income share heuristic. In future experiments, one could control, for instance, if participants are aware of how much the prize is worth by eliciting beliefs about the valuation of the game before the investment screen. This would further reveal how much of the over-investment is due to competition properties like last place aversion and winning utility. Likewise, the slider interface for investing could be changed to a number input which could help mitigate the visual effect of choosing a share of the available income instead of a particular value that maximizes expected earnings.

A comparison between the present design, which included full information about the participant's own performance as well as the performance of others, and a treatment design with no information could also help to disentangle the impact of learning, a decreasing utility function for winning, as well as competition properties like inequality or last place aversion.

In the same manner, a specific workaround to the problem posed in chapter 3.2.1 could have been to add two rounds without an investment or prize option, but with information about the performance of group members. However, this could nevertheless have been used by a participant to send signals about their own valuation of the prize to other participants. Since a participant with a higher valuation would also invest more, sending signals about his or her own valuation might be rewarding even if no prize is to be immediately won. But considering, as shown in section 2.1, that participants will always be able to invest their optimal amount, the impact of this in the present thesis would have been moderate. Given a high prize, however, the effect would be significant.

Other parameter changes that might have a strong repercussion – the modelling of which is beyond the scope of this thesis – are, for instance, the number of people in the group or the number of winners per round. Furthermore, one could model the invested amounts as a public good, in a similar way as investment in education works in the real world, such that the investments are either redistributed to the winner(s) or to the entire community.

On the policy end, looking back at the original postulates of the Prospect of Upward Mobility, it is difficult to make a prediction as to which way voting would go in a dynamic setting. Considering that the majority of probabilities tended to go to 0, we could expect votes in support of taxing to go up in the long run. On the other hand, as smaller investments also lead to higher probabilities of winning with each subsequent round, taxation could be voted down whenever players have a positive probability of obtaining the prize. Which of the two directions dominates will be strongly dependant on the determinism of the contest expressed through the exponent $\mathtt{r}$ of equation 5.1 and the valuation of the prize. A design that internalizes both voting on taxation and the POUM would be an interesting way to see how these two factors play into each other, but it would require a better knowledge of the dynamics of several taxation schemes and $\mathtt{r}$ parameters beforehand.

Finally, an issue of extreme importance that could not be addressed in this thesis is the efficiency of the wins. One could argue that ideally, the participant who wins the contest should be the one who gets the most out of it i.e. the one who earns the most under the high piece rate. This kind of efficiency could also be interpreted as fairness since it not only maximises total welfare but awards the prize to the most deserving participant. It could be perceived as fair, particularly when investments and income are reinvested in the form of a public good. The current design and analysis assumes an equal valuation among participants due in large part to the selection of the real effort task and the relatively low valuation of the prize. Adjusting the difference in wages between winners and losers and calculating the optimal investments according to equation A.12 would make it possible to judge the efficiency of the wins and help find interventions that foster fairness.

Many other changes and extensions are possible which will hopefully help to better understand the dynamics of Tullock contests in various real-world scenarios, from public education, to the labor market and the provision of public goods.

6. Conclusion

This thesis presented an experimental design aimed at analysing the dynamics of inequality, taxation, and redistribution, in a repeated Tullock Contest with full information. It builds in particular upon the work of Sheremeta and Chowdhury (2010), Fallucchi and Ramalingam (2017) and Benabou and Ok (2001) as detailed in the introductory section.

The contest at the core of this thesis differs from other repeated rent-seeking contests in that the groups are kept equal and the prize is expressed in a higher wage for the next working period. In other words, the prize of the contests allows the winner to earn more and increase his or her available income, or to spend more leisure time while keeping earnings constant. This system made income inequality in earnings and in the Prospect of Upward Mobility endogenous to the group. Moreover, in the treatment group, a redistribution scheme was introduced in order to test the effects of taxation on work supply and effort provision.

The results of the experimental sessions presented in Chapter 4 both confirmed and contradicted some of the initial hypotheses regarding the distribution of probabilities and the dynamics of investments, as postulated in section 3.3. Consistent with previous literature, participants across treatments invested more than their respective optimal amounts. In particular, in the experiment I found that participants tend to invest a fixed amount of their available income, regardless of the potential win. Since participants in the taxation treatment have a larger available income but lower expected income, taxed participants invest a relatively larger amount.

Although it is not possible to pin-point the mechanism behind this heuristic (anchorage, endowment effect, bounded rationality, etc.), the result suggests that redistributing assets to be invested in Tullock-like contests would increase, rather than decrease, inefficiency by over-investing.

Over time, investment does decrease. This leads, on the one hand, to smaller investments carrying a greater probability of winning and, on the other, to a more skewed distribution of winning probabilities with more and more participants with either a very low or very high chance of obtaining the prize. This effect was observed in both treatments suggesting that the redistribution of income does not necessarily lead to a more equal distribution of opportunity in Tullock-like contests.

The overall results of the thesis suggest, in summary, that repeated rent-seeking contests do not necessarily lead to a perpetuation of the winning status, even when winning increases the endowment of participants, as long as they are always able to invest their optimal bid. Furthermore, not only do Tullock-like contests induce great inefficiencies, but the game organiser, the State for instance, could even exacerbate the problem by increasing available income through a redistribution scheme.

The impact that the changing distribution of winning probabilities would have on the voting behavior would likely depend on the deterministic index of the contest function. A contest function that awards higher weight to the invested amount would make it more difficult for those with less available income to win. Voters would therefore, according to the Prospect of Upward Mobility of Benabou and Ok (2001), be more inclined to implement a taxation and redistribution scheme.

From this perspective, programs like student loan schemes can be viewed critically as they induce people to invest more than their expected return. In contrast, programs that tax over-bidding could help reduce inefficiencies by redistributing “excess” investments. It would be advisable, however, to redistribute through financing of non-investable assets, like infrastructure, to avoid the problem of increased available income.

The study of repeated Tullock contests is essential in understanding the dynamics of multiple group selection processes. Education and work promotions are two of the most prominent examples. With this thesis, I hope to have provided a glimpse into the ramifications of possible design changes and how these can be used to create more fair and more efficient competition.

Appendices

A. Derivations

Investment Optimization in Tullock Contests

A player i wants to find the I^* that maximizes his or her expected profit as expressed in the maximization problem:

$$\max_{I_i} \quad \mathbb{E}\Pi_i(I_i, I_j) = \frac{I_i}{I_i + \sum_{j \neq i}^{n} I_j}\mathbb{V} - I_i \tag{A.1}$$

Here, n is the number of participants in the game.
Let us assume that the valuation of the game $\mathbb{V}$ is equal for all players and hence, that the optimal investment I^* is equal for everyone. At the maximum of function A.1 holds:

$$\frac{d}{dI_i}\left(\frac{I_i\mathbb{V}}{I_i + \sum_{j \neq i}^{n} I_j} - I_i\right) = 0$$

which after deriving using the quotient rule results in:

$$\frac{\mathbb{V}(I_i + \sum_{j \neq i}^{n} I_j) - I_i\mathbb{V}}{(I_i + \sum_{j \neq i}^{n} I_j)^2} - 1$$

Since we know that at the maximum $I_i^* = I_{-i}^* = I^*$ holds, we can simplify:

$$\frac{n\mathbb{V}I^* - \mathbb{V}I^*}{(nI^*)^2} - 1 = 0$$

We further simplify to:

$$\frac{\mathbb{V}\cancel{I^*}(n-1)}{n^2 I^{*\cancel{2}}} = 1$$

Which gives equation 2.4:

$$I^* = \frac{n-1}{n^2}\mathbb{V}$$

Asymmetric Valuations

An important conundrum that the approach presented in this thesis makes easier to solve than Koch's proposal Koch (2017) is a possible difference in valuation of the prize in terms of higher wage since participants with higher ability or higher utility from consumption will profit more from it. Nti (1999) shows that in the two player case:

> "The player who values the prize more expends more effort in equilibrium but both players allocate the same fraction of their valuations to the contest".[1]

To show this, we just need to write the FOC for the two players explicitly:[2]

$$\frac{I_j}{(I_j + I_i)^2}\mathbb{V}_i - 1 = 0$$
$$\frac{I_i}{(I_j + I_i)^2}\mathbb{V}_j - 1 = 0$$

By equalizing we obtain:

$$\frac{I_i}{\mathbb{V}_i} = \frac{I_j}{\mathbb{V}_j} \tag{A.2}$$

Now let us consider the case of $n = 3$ for $i \in (a, b, c)$ with exactly one winner.[3] Using the same process as above we obtain the equation system:

$$\frac{(I_a + I_b)}{(I_a + I_b + I_c)^2}\mathbb{V}_c = 1 \tag{A.3}$$
$$\frac{(I_a + I_c)}{(I_a + I_b + I_c)^2}\mathbb{V}_b = 1 \tag{A.4}$$
$$\frac{(I_b + I_c)}{(I_a + I_b + I_c)^2}\mathbb{V}_a = 1 \tag{A.5}$$

To more easily visualize the results, we assume w.l.o.g that $I_a = I$, $I_b = \beta_b I$ and $I_c = \beta_c I$, and that $\mathbb{V}_a = \mathbb{V}$, $\mathbb{V}_b = \alpha_b\mathbb{V}$ and $\mathbb{V}_c = \alpha_c\mathbb{V}$. The equation system thus is simplified to:

$$\frac{(1 + \beta_b)}{(1 + \beta_b + \beta_c)^2}\alpha_c\mathbb{V} = I \tag{A.6}$$
$$\frac{(1 + \beta_c)}{(1 + \beta_b + \beta_c)^2}\alpha_b\mathbb{V} = I \tag{A.7}$$
$$\frac{(\beta_b + \beta_c)}{(1 + \beta_b + \beta_c)^2}\mathbb{V} = I \tag{A.8}$$

After setting (A.7) = (A.8) we obtain:

$$\beta_b = (1 + \beta_c)\alpha_b - \beta_c \tag{A.9}$$

[1] Nti (1999, p. 419).
[2] See Appendix A for a derivation of the FOC.
[3] Stein (2002) offers a general derivation for N players.

Similarly, we set (A.6) = (A.8) and obtain $(1+\beta_b)\alpha_c = \beta_b + \beta_c$ in which we can replace β_b by (A.9). Solving for β_c we get:

$$\beta_c = \frac{\alpha_b - \alpha_c - \alpha_b\alpha_c}{\alpha_b\alpha_c - \alpha_c - \alpha_b} \tag{A.10}$$

Which inserted back in (A.9) gives us:

$$\beta_b = \alpha_b + \alpha_b \frac{\alpha_b - \alpha_c - \alpha_b\alpha_c}{\alpha_b\alpha_c - \alpha_c - \alpha_b} - \frac{\alpha_b - \alpha_c - \alpha_b\alpha_c}{\alpha_b\alpha_c - \alpha_c - \alpha_b} \tag{A.11}$$

Finally, from (A.11) and (A.10) we know that $\beta_b + \beta_c = 1 + \alpha_b \frac{\alpha_b - \alpha_c - \alpha_b\alpha_c}{\alpha_b\alpha_c - \alpha_c - \alpha_b}$ and we can replace in A.8 to obtain:

$$I = \frac{\alpha_b + \alpha_b \frac{\alpha_b - \alpha_c - \alpha_b\alpha_c}{\alpha_b\alpha_c - \alpha_c - \alpha_b}}{(1 + \alpha_b + \alpha_b \frac{\alpha_b - \alpha_c - \alpha_b\alpha_c}{\alpha_b\alpha_c - \alpha_c - \alpha_b})^2} \mathbb{V} \tag{A.12}$$

Now, to more easily see how this function behaves let us assume that only participant c has a different valuation and therefore $\alpha_b = 1$. It follows:

$$I_a = I_c = \frac{2\alpha_c}{(1+2\alpha_c)^2} \mathbb{V} \tag{A.13}$$

The denominator will grow faster for increasing α_c which means that I_a will tend to 0.

The general case is more cumbersome but we can still find some conditions for the relationship between α_b and α_c. Requiring that $\alpha_b, \alpha_c \in \mathbb{R}^+$ and that $\alpha_b\alpha_c - \alpha_c - \alpha_b \neq 0$, it can be shown that, in order for $I \geqslant 0$, then $\alpha_b\alpha_c > \alpha_c + \alpha_b$.

This means, in particular, that there are some levels for which an investment is no longer profitable, take for instance $\alpha_b = 2$ and $\alpha_c = 4$.

A look at the function graph A.1 gives us a better understanding of its behavior. For very low levels of others' valuations the investment value is close to zero but increases with α_b and α_c. After achieving a maximum of $\frac{1}{4}$, or the equivalent to the two player game, the function decreases monotonically.

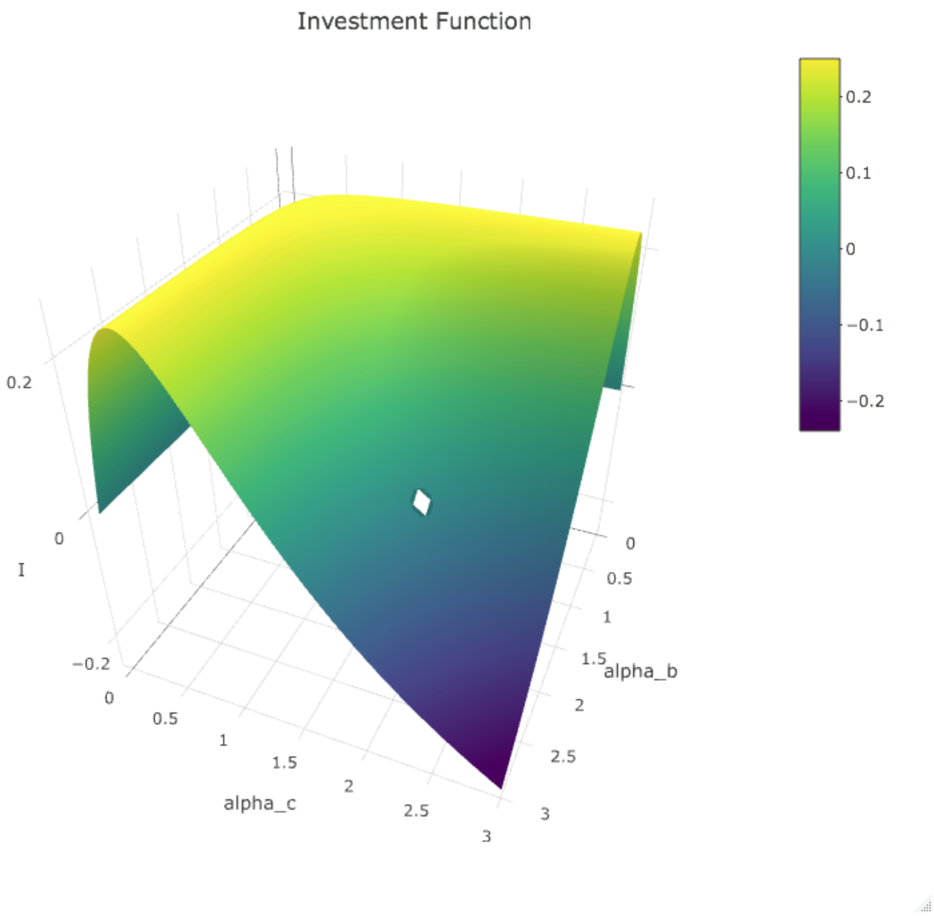


Figure A.1.: Investment function dependant on the share of others' valuation

B. Tables

Wilcoxon rank sum test with continuity correction

Piece Rate	Statistic	p-value
High	1186.5	0.8006
Low	1070	0.5462

Null Hypothesis: Difference in production between treatments is equal to 0

Table B.1.: Comparison of productions in the benchmarking rounds between treated and non-treated groups

Section	Page	Comments	Repetitions
Introduction	Introduction	*A general introduction to the experiment and the norms*	1
	Task Instructions	*The real effort task of counting letter "a" is explained*	
	Trial Round	*Participants do 5 sequences with different lengths. Not paid.*	
	Switch Instructions	*The leisure moe and the payment scheme are presented*	
	Control Questions	*Participants are asked several questions to test if they have understood the game properly*	
	Confirmation Submit	*Participants have to enter the Letter Counting Task actively*	
	RET	*This is the first benchmarking round. It is paid and works exactly like all following rounds. Without competition. It pays the low wage.*	
	Feedback	*Feedback about output and earnings in RET are shown*	
	Low Taxed Wage	*The low **taxed** wage is presented. Only included in the second treatment.*	
	Confirmation Submit	*Participants have to enter the Letter Counting Task actively*	
	RET	*This round pays the low **taxed** wage.*	
	Feedback	*Feedback about output and earnings in RET are shown*	
	High Wage Instructions	*The high wage is presented*	
	Control Questions	*Participants are asked several questions to test if they have understood the game properly and taken into account the increased wage*	
	Confirmation Submit	*Participants have to enter the Letter Counting Task actively*	
	RET	*Same RET but will pay the high wage per sequence*	
	Feedback	*Feedback about output and earnings in Trial Round 2 are shown*	
	High Taxed Wage	*The high **taxed** wage is presented. Only included in the second treatment.*	
	Confirmation Submit	*Participants have to enter the Letter Counting Task actively*	
	RET	*This round pays the high **taxed** wage.*	
	Feedback	*Feedback about output and earnings in RET are shown*	
	Grouping and Redistribution	*Information about grouping and about the taxation and redistribution scheme*	
	Investment and Award	*Instructions and an example of how the Tullock Contest works are shown*	
	Experiment Structure	*Participants are informed about the next steps in the session*	
Competition	Fairness Questionnaire	*Participants are asked to rate, from 1 to 10, how much luck and how much skill will play a role in their success*	8
	Round Start Confirmatio	*Information about the number of the current round and the wage it is going to be played in is shown*	
	Production Beliefs	*Beliefs about the potential production of the other 2 participants are asked. Information about the wage of the other participants is provided*	
	Confirmation Submit	*Participants have to enter the Letter Counting Task actively*	
	RET	*Duration of 3 minutes*	
	Feedback	*Production feedback, prize award*	
	Investment Beliefs	*Beliefs about the potential investments of the other 2 participants are asked*	
	Investment	*Participants have the opportunity to invest some of their earnings to increase their probability of winning*	
	Results	*Participants are informed about the investments of the group and about the winner*	
	Fairness Questionnaire	*Participants are asked to rate, from 1 to 10, how much luck and how much skill played a roll in their success*	
Controls	CRT Test	*Four questions to test the participants cognitive reflection are asked*	1
	Multiple Price Lottery	*To control for risk aversion a multiple price lottery is presented and conducted.*	
	Demographics	*Year of birth and Gender Identity are asked*	

Figure B.1.: Detailed structure of the experiment

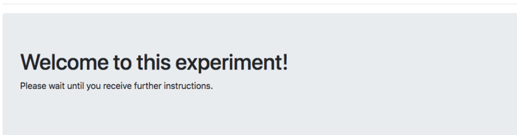
Table B.2.: LMM: Available Income's Share of Investment

	Share of Available Income Invested
treatment	−0.05
	(0.05)
round	−0.04***
	(0.00)
was winner	0.03
	(0.02)
CRT score	−0.03
	(0.02)
risk aversion	−0.01
	(0.01)
gender (Male)	0.03
	(0.04)
Constant	0.61***
	(0.08)
Observations	672
Log Likelihood	−132.10
Akaike Inf. Crit.	284.20
Bayesian Inf. Crit	329.29
Num. groups: participant:group	96
Num. groups: group	32
Var: participant:group (Intercept)	0.03
Var: group (Intercept)	0.01
Var: Residual	0.07
Note:	*p<0.1; **p<0.05; ***p<0.01

Table B.3.: GLMM Probability of Winning

	Probability of Winning
	(3)
treatment	−0.091
	(0.218)
available income	0.044***
	(0.008)
was winner	−0.056
	(0.121)
gender (male)	0.317
	(0.225)
CRT score	−0.036
	(0.113)
risk aversion	0.036
	(0.049)
valuation	0.060
	(0.038)
mean investment belief	0.002
	(0.009)
cumulative wins	−0.037
	(0.028)
Constant	−2.364***
	(0.650)
Observations	672
Log Likelihood	3801.8
Akaike Inf. Crit.	−7575.6
Bayesian Inf. Crit.	−7512.5
Num. groups: participant:group	96
Num. groups: group	32
Num. groups: round	7
Var: participant:group (Intercept)	0.872
Var: group (Intercept)	0.00
Var: round (Intercept)	0.00
Note:	*p<0.1; **p<0.05; ***p<0.01

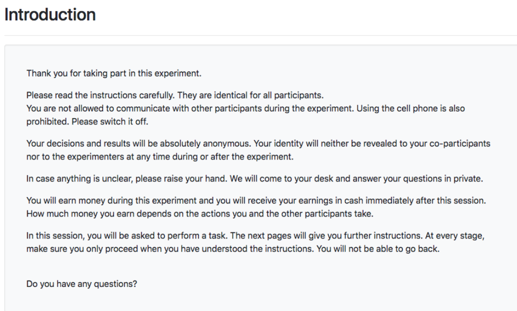
C. Screenshots



Welcome to this experiment!

Please wait until you receive further instructions.

(a) Welcome Screen



Introduction

Thank you for taking part in this experiment.

Please read the instructions carefully. They are identical for all participants.
You are not allowed to communicate with other participants during the experiment. Using the cell phone is also prohibited. Please switch it off.

Your decisions and results will be absolutely anonymous. Your identity will neither be revealed to your co-participants nor to the experimenters at any time during or after the experiment.

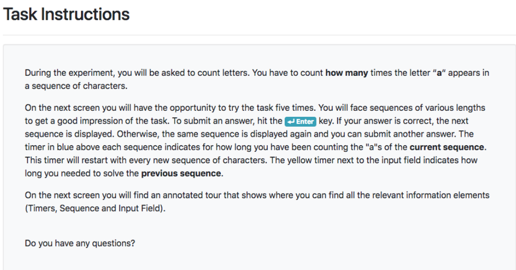
In case anything is unclear, please raise your hand. We will come to your desk and answer your questions in private.

You will earn money during this experiment and you will receive your earnings in cash immediately after this session. How much money you earn depends on the actions you and the other participants take.

In this session, you will be asked to perform a task. The next pages will give you further instructions. At every stage, make sure you only proceed when you have understood the instructions. You will not be able to go back.

Do you have any questions?

(b) Introduction Screen



Task Instructions

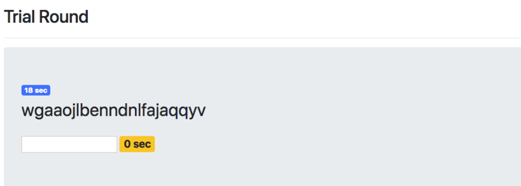
During the experiment, you will be asked to count letters. You have to count **how many** times the letter "**a**" appears in a sequence of characters.

On the next screen you will have the opportunity to try the task five times. You will face sequences of various lengths to get a good impression of the task. To submit an answer, hit the ↵ Enter key. If your answer is correct, the next sequence is displayed. Otherwise, the same sequence is displayed again and you can submit another answer. The timer in blue above each sequence indicates for how long you have been counting the "a"s of the **current sequence**. This timer will restart with every new sequence of characters. The yellow timer next to the input field indicates how long you needed to solve the **previous sequence**.

On the next screen you will find an annotated tour that shows where you can find all the relevant information elements (Timers, Sequence and Input Field).

Do you have any questions?

(c) RET Instructions



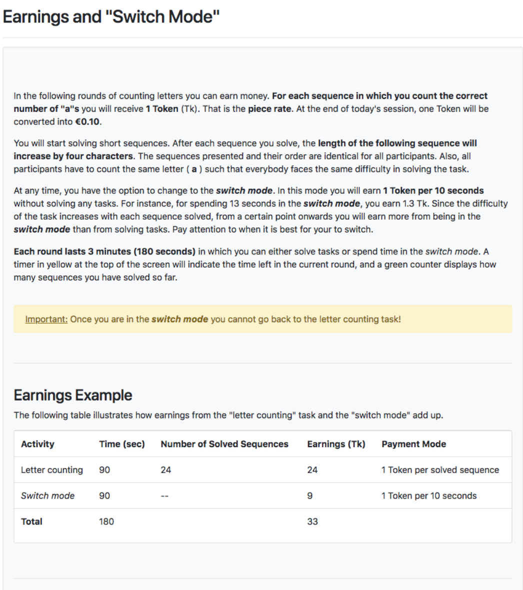
Trial Round

18 sec

wgaaojlbenndnlfajaqqyv

0 sec

(d) Test Run Screen



Earnings and "Switch Mode"

In the following rounds of counting letters you can earn money. **For each sequence in which you count the correct number of "a"s** you will receive **1 Token** (Tk). That is the **piece rate**. At the end of today's session, one Token will be converted into **€0.10**.

You will start solving short sequences. After each sequence you solve, the **length of the following sequence will increase by four characters**. The sequences presented and their order are identical for all participants. Also, all participants have to count the same letter (**a**) such that everybody faces the same difficulty in solving the task.

At any time, you have the option to change to the ***switch mode***. In this mode you will earn **1 Token per 10 seconds** without solving any tasks. For instance, for spending 13 seconds in the ***switch mode***, you earn 1.3 Tk. Since the difficulty of the task increases with each sequence solved, from a certain point onwards you will earn more from being in the ***switch mode*** than from solving tasks. Pay attention to when it is best for your to switch.

Each round lasts 3 minutes (180 seconds) in which you can either solve tasks or spend time in the *switch mode*. A timer in yellow at the top of the screen will indicate the time left in the current round, and a green counter displays how many sequences you have solved so far.

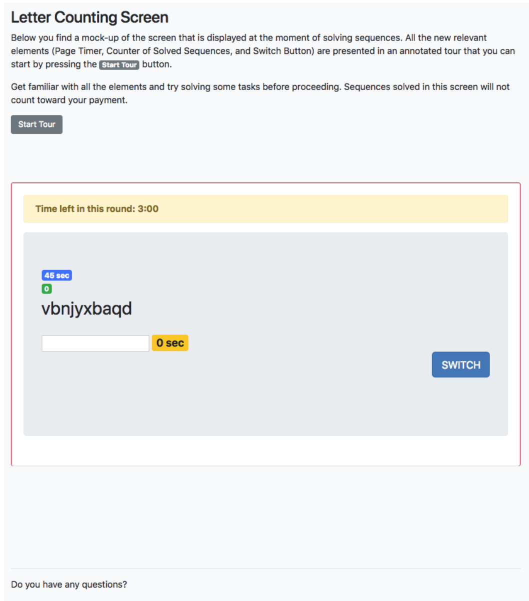
Important: Once you are in the ***switch mode*** you cannot go back to the letter counting task!

Earnings Example

The following table illustrates how earnings from the "letter counting" task and the "switch mode" add up.

Activity	Time (sec)	Number of Solved Sequences	Earnings (Tk)	Payment Mode
Letter counting	90	24	24	1 Token per solved sequence
Switch mode	90	--	9	1 Token per 10 seconds
Total	180		33	

(e) Payment Instructions Screen



Letter Counting Screen

Below you find a mock-up of the screen that is displayed at the moment of solving sequences. All the new relevant elements (Page Timer, Counter of Solved Sequences, and Switch Button) are presented in an annotated tour that you can start by pressing the Start Tour button.

Get familiar with all the elements and try solving some tasks before proceeding. Sequences solved in this screen will not count toward your payment.

Start Tour

Time left in this round: 3:00

45 sec

0

vbnjyxbaqd

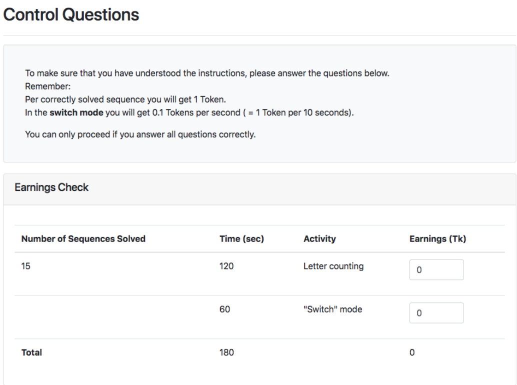
0 sec

SWITCH

Do you have any questions?

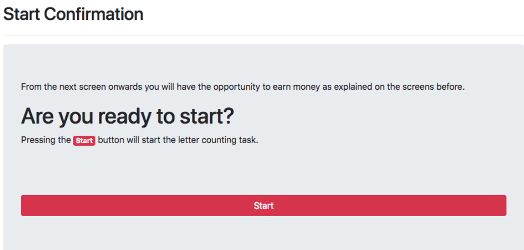
(f) Payment Instructions Screen

Figure C.1.: Screenshot Selection

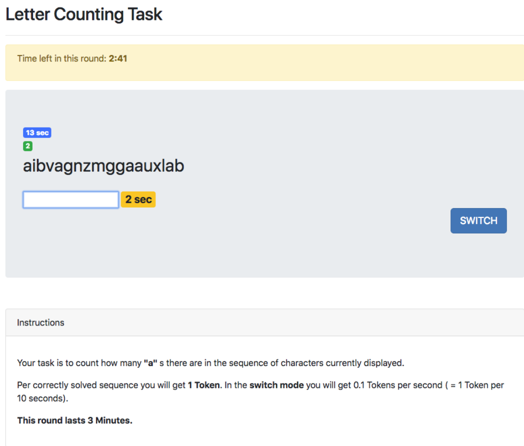


(a) Control Questions

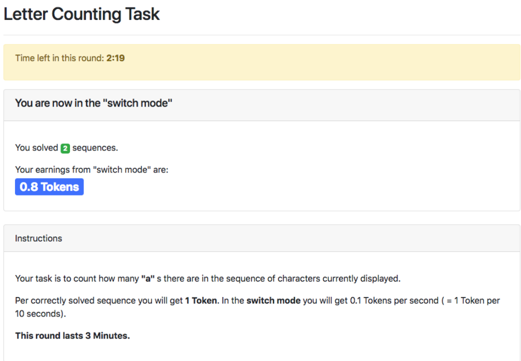
(b) Control Questions



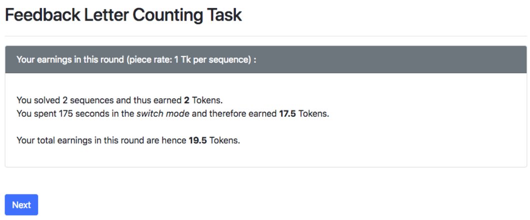
(c) Start of Task Confirmation Screen



(d) RET Screen

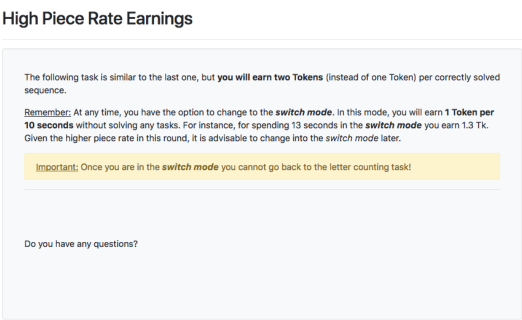


(e) RET Switch Mode



(f) RET Feedback Benchmarking

Figure C.2.: Screenshot Selection



High Piece Rate Earnings

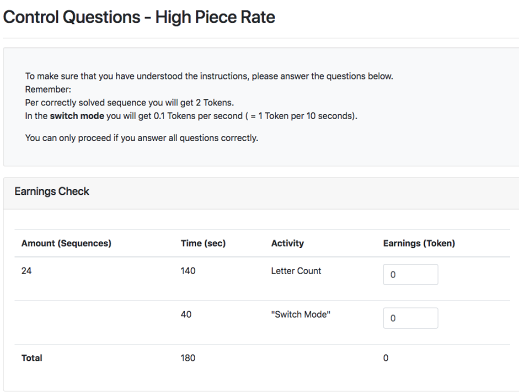
The following task is similar to the last one, but **you will earn two Tokens** (instead of one Token) per correctly solved sequence.

Remember: At any time, you have the option to change to the ***switch mode***. In this mode, you will earn **1 Token per 10 seconds** without solving any tasks. For instance, for spending 13 seconds in the ***switch mode*** you earn 1.3 Tk. Given the higher piece rate in this round, it is advisable to change into the *switch mode* later.

Important: Once you are in the ***switch mode*** you cannot go back to the letter counting task!

Do you have any questions?

(a) High Piece Rate Earning Instructions



Control Questions - High Piece Rate

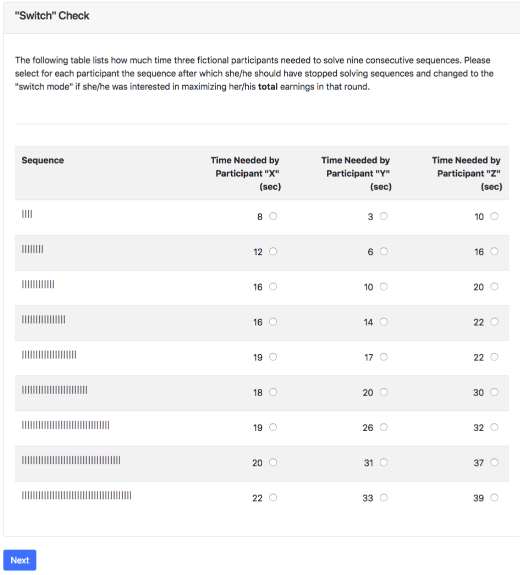
To make sure that you have understood the instructions, please answer the questions below.
Remember:
Per correctly solved sequence you will get 2 Tokens.
In the **switch mode** you will get 0.1 Tokens per second (= 1 Token per 10 seconds).

You can only proceed if you answer all questions correctly.

Earnings Check

Amount (Sequences)	Time (sec)	Activity	Earnings (Token)
24	140	Letter Count	0
	40	"Switch Mode"	0
Total	180		0

(b) Control Questions



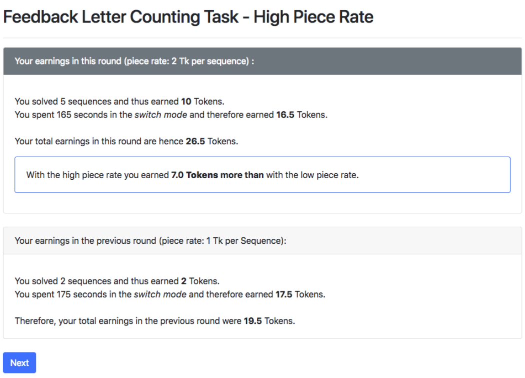
"Switch" Check

The following table lists how much time three fictional participants needed to solve nine consecutive sequences. Please select for each participant the sequence after which she/he should have stopped solving sequences and changed to the "switch mode" if she/he was interested in maximizing her/his **total** earnings in that round.

Sequence	Time Needed by Participant "X" (sec)	Time Needed by Participant "Y" (sec)	Time Needed by Participant "Z" (sec)
||||	8	3	10
||||||||	12	6	16
||||||||||||	16	10	20
||||||||||||||||	16	14	22
||||||||||||||||||||	19	17	22
||||||||||||||||||||||||	18	20	30
||||||||||||||||||||||||||||||||	19	26	32
||||||||||||||||||||||||||||||||||||	20	31	37
||||||||||||||||||||||||||||||||||||||||	22	33	39

Next

(c) Control Questions



Feedback Letter Counting Task - High Piece Rate

Your earnings in this round (piece rate: 2 Tk per sequence) :

You solved 5 sequences and thus earned **10** Tokens.
You spent 165 seconds in the *switch mode* and therefore earned **16.5** Tokens.

Your total earnings in this round are hence **26.5** Tokens.

With the high piece rate you earned **7.0 Tokens more than** with the low piece rate.

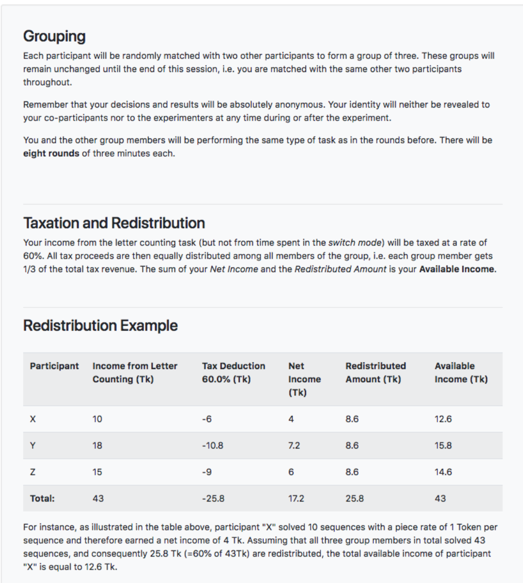
Your earnings in the previous round (piece rate: 1 Tk per Sequence):

You solved 2 sequences and thus earned **2** Tokens.
You spent 175 seconds in the *switch mode* and therefore earned **17.5** Tokens.

Therefore, your total earnings in the previous round were **19.5** Tokens.

Next

(d) RET Feedback Benchmarking



Grouping

Each participant will be randomly matched with two other participants to form a group of three. These groups will remain unchanged until the end of this session, i.e. you are matched with the same other two participants throughout.

Remember that your decisions and results will be absolutely anonymous. Your identity will neither be revealed to your co-participants nor to the experimenters at any time during or after the experiment.

You and the other group members will be performing the same type of task as in the rounds before. There will be **eight rounds** of three minutes each.

Taxation and Redistribution

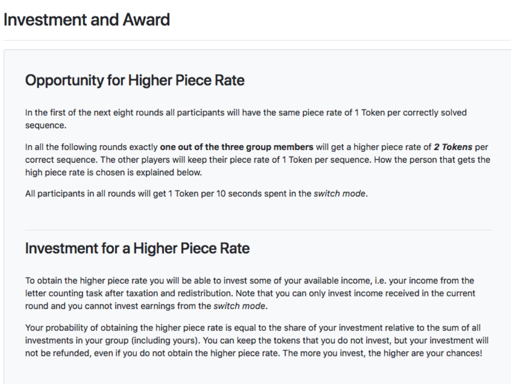
Your income from the letter counting task (but not from time spent in the *switch mode*) will be taxed at a rate of 60%. All tax proceeds are then equally distributed among all members of the group, i.e. each group member gets 1/3 of the total tax revenue. The sum of your *Net Income* and the *Redistributed Amount* is your **Available Income.**

Redistribution Example

Participant	Income from Letter Counting (Tk)	Tax Deduction 60.0% (Tk)	Net Income (Tk)	Redistributed Amount (Tk)	Available Income (Tk)
X	10	-6	4	8.6	12.6
Y	18	-10.8	7.2	8.6	15.8
Z	15	-9	6	8.6	14.6
Total:	43	-25.8	17.2	25.8	43

For instance, as illustrated in the table above, participant "X" solved 10 sequences with a piece rate of 1 Token per sequence and therefore earned a net income of 4 Tk. Assuming that all three group members in total solved 43 sequences, and consequently 25.8 Tk (=60% of 43Tk) are redistributed, the total available income of participant "X" is equal to 12.6 Tk.

(e) Competition Instructions



Investment and Award

Opportunity for Higher Piece Rate

In the first of the next eight rounds all participants will have the same piece rate of 1 Token per correctly solved sequence.

In all the following rounds exactly **one out of the three group members** will get a higher piece rate of ***2 Tokens*** per correct sequence. The other players will keep their piece rate of 1 Token per sequence. How the person that gets the high piece rate is chosen is explained below.

All participants in all rounds will get 1 Token per 10 seconds spent in the *switch mode*.

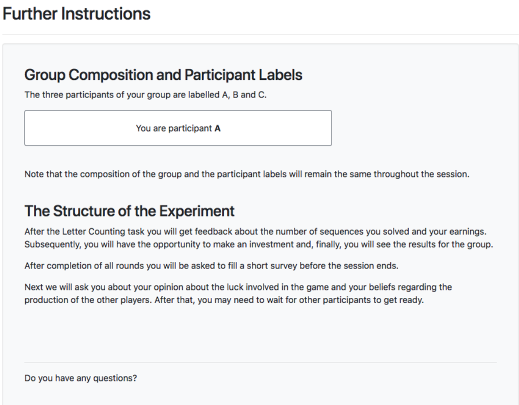
Investment for a Higher Piece Rate

To obtain the higher piece rate you will be able to invest some of your available income, i.e. your income from the letter counting task after taxation and redistribution. Note that you can only invest income received in the current round and you cannot invest earnings from the *switch mode*.

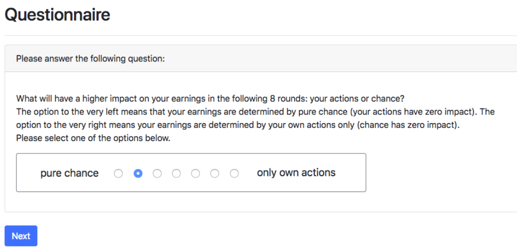
Your probability of obtaining the higher piece rate is equal to the share of your investment relative to the sum of all investments in your group (including yours). You can keep the tokens that you do not invest, but your investment will not be refunded, even if you do not obtain the higher piece rate. The more you invest, the higher are your chances!

(f) Investment Instructions

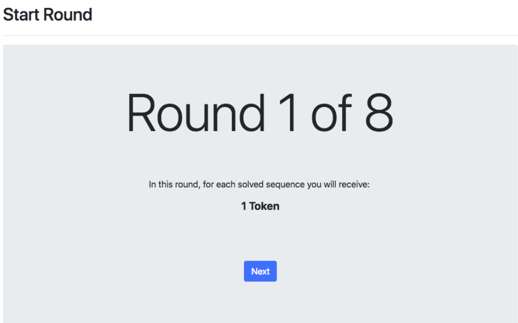
Figure C.3.: Screenshot Selection



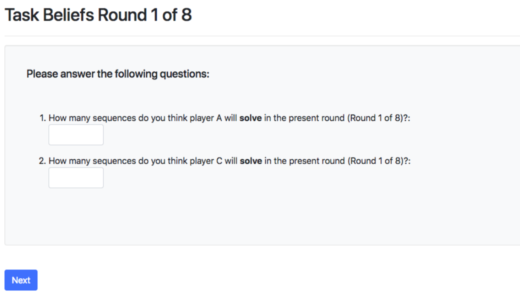
(a) Structure of Experiment Screen



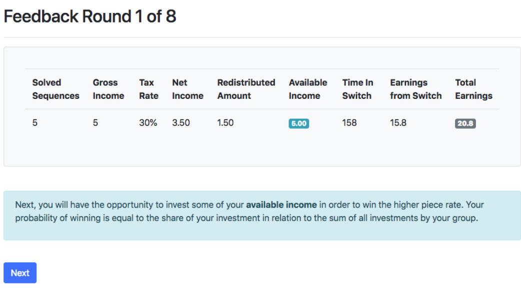
(b) Fairness Questionnaire



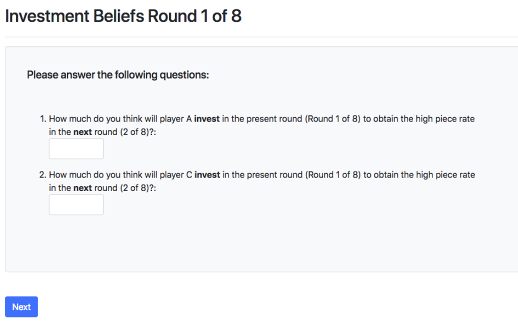
(c) Round Marker Screen



(d) Production Beliefs Elicitation screen

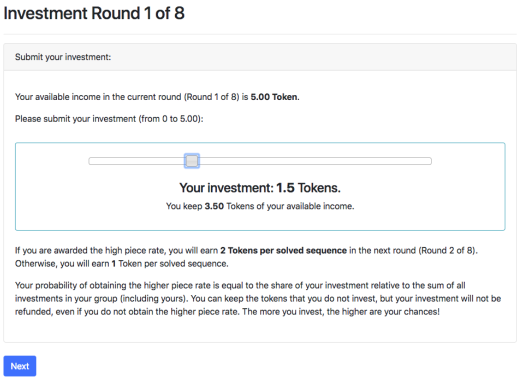


(e) RET Feedback Screen

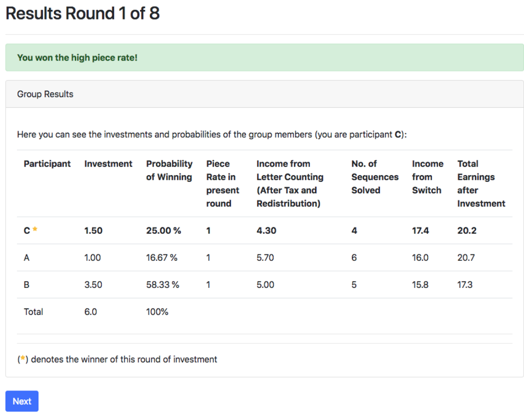


(f) Investment Beliefs Elicitation

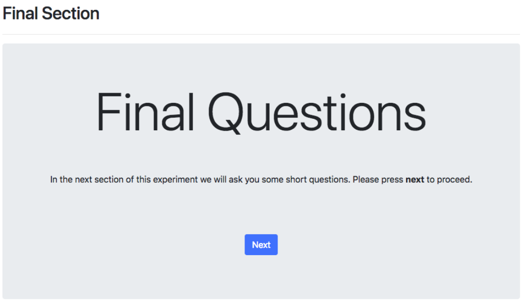
Figure C.4.: Screenshot Selection



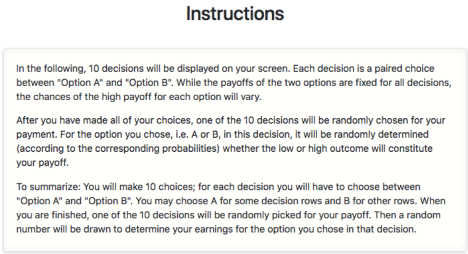
(a) Investment Screen



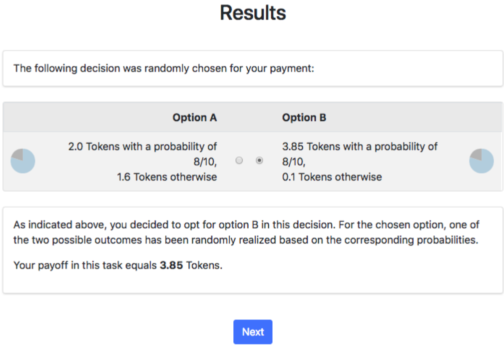
(b) Investment Feedback Screen



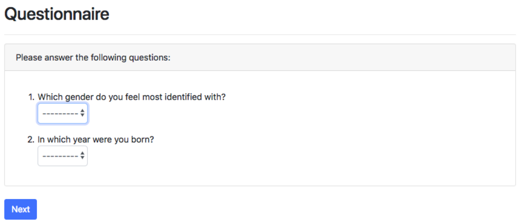
(c) Control Questions Marker Screen



(d) MLP Instructions



(e) MLP Screen



(f) Demographics Questionnaire

Figure C.5.: Screenshot Selection

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