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Electing a parliament: an experimental study

Francesco De Sinopoli[a], Giovanna Iannantuoni[b],

M. Vittoria Levati[a,*], Ivan Soraperra[a]

[a] *Department of Economics, University of Verona, Italy*

[b] *Department of Economics, University of Milano-Bicocca, Italy*

Abstract

We use laboratory experiments to explore what electoral outcomes emerge and how voters behave in a setting in which the electorate must determine the number of seats that two parties obtain in the parliament. Previous experimental work has mainly focused on winner-take-all elections and voting over fixed agendas, and has not studied elections where participants decide on the composition of a parliament. We consider two electoral systems, multidistrict majoritarian and single district proportional. Relying on De Sinopoli et al.'s (2013) model of a parliamentary election, we obtain a unique perfect equilibrium outcome under both systems and exploit this uniqueness to gauge, and compare, the predictive value of the equilibrium concept in the two systems. The experimental results are broadly supportive of the theory and reveal that electoral outcomes and individual votes are more often in line with the equilibrium in the proportional than in the majoritarian system.

Keywords: Voting, Majority election, Proportional election, Experiment

JEL Classification: C72, D72

*Corresponding author. University of Verona, Department of Economics, via Cantarane 24, 37129 Verona, Italy. Tel.: 0039 045 8028640; fax: 0039 045 8028524. E-mail address: vittoria.levati@univr.it

1 Introduction

In modern parliamentary democracies where parties compete for seats in a parliament, these seats represent a measure of political power and, in turn, shape the design of public policies. Compared to a party that controls a large number of seats, a ruling party that controls enough seats to just secure a majority will have to implement more moderate policies. A policy-oriented voter who has a most-preferred policy should therefore be concerned with parliament's composition and electoral results. An important question to ask is whether such a voter, when called upon to elect a parliament, behaves rationally (i.e., in his own self-interest trying to maximize his utility given his beliefs about the other voters' behavior, as prescribed by theory) or follows naive strategies.

A number of survey studies of voters' behavior have indicated that generally the electorate has limited capacity to behave rationally (for a comprehensive review of this literature see Kuklinski and Quirk 2000). However, using survey data to test the existence of rational voting behavior is fraught with difficulties because such data do not allow controlling for all assumptions on which the theory is based. To overcome these difficulties, in this paper we analyze voting behavior in a laboratory experiment where we can create an environment similar to that assumed by the theory and control for all potential confounding factors, such as the voters' preferences over policy outcomes and the information they possess (Palfrey 2009). The experiment we propose is expressly designed to test whether in parliamentary elections where electors cast their votes simultaneously to determine the seats distribution in the parliament, the observed voting behavior is consistent with Nash equilibrium and related refinements. While there is a large and growing experimental literature on winner-take-all elections and voting over fixed agendas (see, e.g., Palfrey 2014), to the best of our knowledge, no experiment has so far dealt with elections where participants have to determine the composition of a parliament (i.e., the number of seats allocated to each party).

As the process of translating votes into parliamentary seats is regulated by the electoral system and different electoral systems require different levels of complexity to think strategically,[1] the voters' ability to behave as predicted by theory is likely to be affected by the way in which votes relate to the allocation of seats in the parliament. It becomes therefore important to assess the empirical validity of the predicted equilibrium outcomes under different electoral rules. Herein, we study, and compare, two different electoral

[1] In a recent experiment on multi-candidate competition where the group's preference profile allows for the existence of a Condorcet winner only in one treatment (in the other a cycle of preferences exists), Bassi (2015) showed that voters' strategic behavior depends on the employed electoral system.

systems, the multidistrict majoritarian system and the single district proportional system. Laboratory control will allow us to investigate which one of the two systems, if any, yields behavior closer to the predicted one and to what extent results are robust to differences in preferences and predicted outcomes.

The choice of the majoritarian and proportional systems was driven by the following considerations. First, these are the most widely used electoral systems throughout the world (Golder 2005; Bormann and Golder 2013). A core debate in the political science literature is whether countries should adopt majoritarian systems that prioritize government effectiveness and accountability, or proportional systems that promote a fairer representation of the electorate's interests (e.g., Norris 1997; Blais and Massicotte 2002). Knowing whether or not the two systems are equally effective in generating strategically optimal voting would add useful insights to this debate. Finally, it is exactly for these two systems that we have clear-cut results about the equilibrium outcome. In particular, De Sinopoli et al. (2013) show that, under both majoritarian and proportional systems, there is a unique pure strategy perfect equilibrium outcome. We can therefore exploit the uniqueness of the equilibrium outcome to analyze voters' behavior in the two systems.

De Sinopoli et al. (2013) consider a model of a parliamentary election where there are two parties, left and right, with a fixed policy position over a one-dimensional policy space. The electorate is composed of policy motivated citizens with single-peaked preferences over the policy space. Each voter votes strategically for one of the two parties so as to elect a number of representatives to the national parliament. The electoral system determines how votes to a party are to be translated into parliamentary seats for that party. In the majoritarian system, the electorate is divided into several districts and each district elects one member of parliament by majority rule. In the proportional system, there is just one national district and the mechanism transforming votes into parliamentary seats simply requires a party to obtain a minimum number of votes in order to win a certain number of seats in the parliament.[2] Under both systems, the policy outcome is pinned down by the number of seats the two parties obtain in the election. A basic assumption is that the higher the number of seats obtained by the left, the more leftist the policy outcome.

As in most voting games with a strategic electorate, here too there is a plethora of Nash equilibria. To tackle the multiple equilibria problem, De Sinopoli et al. (2013) turn to a standard refinement of Nash equilibrium, namely trembling-hand perfection, defin-

[2]This mechanism is very general and allows for any majority premium and election threshold. There are considerable variations in how votes are transformed into seats in proportional systems, and many such systems have either partial proportionality or election thresholds.

ing for the majoritarian rule an instrumental solution concept, which they call *district sincerity*. As mentioned above, for both electoral systems the authors prove the existence of a unique perfect equilibrium outcome in pure strategies, which in majoritarian elections is the unique pure strategy district sincere outcome.

Our experimental design builds heavily on De Sinopoli et al.'s (2013) model, even though it follows a common practice in experimental economics and uses a context-free and neutral language. In the experimental elections, not only information is complete and common to all players, but voters are also obliged to cast a vote. Imposing mandatory voting allows us to focus exclusively on voting decisions without having to worry about the interaction between such decisions and turnout.[3] While most democratic governments consider participating in national elections a right of citizenship, a number of countries—including Australia, Belgium, and many states in Latin America—have made voting at elections compulsory.

The main treatment variable, manipulated in a between-subjects design, is the electoral system: twelve-voter electorates play 9 one-shot election tasks under either a majoritarian system or a proportional one. Since the theory tells us that as preferences change in certain ways, the predicted electoral outcomes should change in corresponding ways, we vary the most preferred policies (i.e., the bliss points) of the twelve voters across election tasks so as to examine the robustness of the employed solution concept with respect to variation in preferences and resulting predicted outcomes. Although the voters' bliss points vary from task to task, they are the same between treatments within five election tasks. This allows us to create a vacuum tube-like device for assessing how voting behavior and observed electoral outcomes react to the electoral system in place.

The data from the experiment show that, under both electoral systems, participants vote on average in line with equilibrium prediction. It turns out that in most election tasks the observed outcome coincides with the unique perfect equilibrium outcome. Specifically, district sincerity in majoritarian elections and trembling-hand perfection in proportional elections predict better the electoral outcomes than a simple heuristic, or rule of thumb, requiring participants to vote for the party whose policy position is closest to their own position. Moreover, the experimental results indicate that the proportional system induces more strategic and rational voting than the majoritarian system.

[3] Using both laboratory and real-world election data, Kamm and Schram (2013) show that voluntary voting makes election outcomes more extreme compared to compulsory voting.

1.1 Related literature

The present study is connected to a long strand of experimental literature exploring the cooperative and noncooperative game theoretical predictions about voting behavior.[4] In a seminal article, Fiorina and Plott (1978) tested the basic theory of the core (equivalent to the majority rule equilibrium or Condorcet winner) in small committees. In their experiment, each group decided under an agenda rule in which possible policies were introduced and voted on immediately, against the status quo, until no new proposal won. The experimental results showed that the core, when it existed, was the best predictor of committee outcomes. Yet, even in the absence of a core, outcomes were highly clustered in the policy space and voters had no problem finding an agreed upon outcome. With few exceptions, these observations were found to be robust to a number of variations in the specifications of the design (which considered, for instance, not only open but also fixed agendas) and inspired a great deal of subsequent work aimed at developing models that could explain the experimental results in committee games without a core.[5]

A parallel stream of political economy experiments focused on the empirical relevance of Condorcet winners and the median voter theorem in the context of competitive elections and candidate competition. Experiments in this area used mainly winner-take-all majority-rule elections. The key findings can be summarized as follows. First, in settings where candidates had complete information about voters' preferences, the Condorcet winner was an excellent predictor of outcomes (e.g., McKelvey and Ordeshook 1982). Second, in more challenging settings where the assumption of complete information by candidates was relaxed and only some of the voters knew about the candidates' locations, candidates converged to the Condorcet point with sufficient repetition; moreover, poll information and interest group endorsements led voters to successfully aggregate information (McKelvey and Ordeshook 1985; Plott 1991).[6]

Also related to our work is a strand of research investigating the influence of different electoral rules on voting decisions in winner-take-all elections. Forsythe et al. (1996), for example, explored voters' behavior in three-candidate elections under different election rules and found that Borda count and approval voting outperformed plurality rule, in the sense that the Condorcet loser alternative won less frequently. A recent article by Bassi

[4] Detailed reviews of this literature can be found in Woon (2012) and Palfrey (2014).

[5] For example, McKelvey et al. (1978) developed the "competitive solution" for N-person games, and Miller (1980) proposed the "uncovered set." In a re-examination of this older work, Bianco et al. (2006) found that the uncovered set was an extraordinarily good predictor of experimental outcomes. Druckman et al. (2014) and Bianco et al. (2015) provide surveys of this literature.

[6] See McKelvey and Ordeshook (1990) for an overview of the early literature on two-candidate elections. More recent experimental studies on three-candidate elections are surveyed by Rietz (2008).

(2015) investigated more thoroughly behavior under these three rules. She considered games with more than three alternatives, thereby adding complexity to the tasks, and adopted the concept of level-k reasoning as opposed to Nash equilibria to explain voting behavior. In her experiment, plurality voting promoted the highest degree of level-k strategic reasoning. Battaglini et al. (2007) compared voters' behavior under simultaneous and sequential voting rules. They generated a number of predictions about the relative efficiency and participation equity of these two rules and found significant departures from the predicted equilibrium strategies under both of them. Van der Straeten et al. (2010) used various electoral systems (one-round plurality, two-round majority, approval voting, and single transferable vote) to test the hypothesis that the complexity of the decisions affects voting behavior. The result of their experiment supported that voters vote strategically insofar as the involved computations is not too demanding (namely under one-round voting and approval voting).

As indicated above, what we add to the existing literature is experimental evidence on voting behavior in parliamentary elections where two parties compete for a number of seats in the parliament. Putting it in other terms, we do not implement winner-take-all elections and participants in our experiment cast their vote to determine the parliament composition. Basing our experimental setup on De Sinopoli et al.'s (2013) model, we obtain unambiguous predictions about electoral outcomes under the majoritarian and proportional systems. By this means, we can test whether or not the likelihood of engaging in strategic voting depends on the used electoral rule.

The remainder of this paper is organized as follows. Section 2 presents the theoretical analysis. Section 3 describes the experimental design and procedures. Section 4 contains the data analysis, the results of which are broadly supportive of theory. Section 5 offers some concluding remarks.

2 The voting model

The model considers a one-dimensional policy space $\mathbb{X} = [0, 1]$ where policy outcomes are described.[7] There are two parties, left (or L) and right (or R), each of which is characterized by a policy position $\theta_p \in \mathbb{X}$, with $p \in \{L, R\}$ and $\theta_L < \theta_R$. There is a finite set of voters $N = \{1, 2, \ldots, n\}$. Each voter $i \in N$ has utility function $u_i : \mathbb{X} \to \mathbb{R}$ describing i's preferences over policy outcomes. Utility functions are assumed to be single-peaked and symmetric with respect to a bliss point $\theta_i \in \mathbb{X}$, representing i's most

[7] The reader is referred to De Sinopoli et al. (2013) for a more detailed exposition.

preferred policy.[8]

Voters have to elect a parliament composed by k representatives. Each voter i casts a single vote for either the left or right party, namely i's pure strategy is $s_i \in S_i = \{L, R\}$. Votes are translated into seats to each party according to the electoral rule in place. The final policy outcome depends only on the parliament's composition. More specifically, there exists a policy outcome function $X : \{0, 1, \dots, k\} \to \mathbb{X}$ that returns the implemented policy given the number of seats obtained by the left. $X(\cdot)$ is assumed to be decreasing in its argument, i.e., the higher the number of leftist representatives in the parliament, the more the policy outcome tends to zero.

For $j \in \{1, \dots, k\}$, let α_j be the midpoint between the policy outcomes that result from having j and $j-1$ members of the left party in the parliament, i.e., $\alpha_j = \frac{X(j)+X(j-1)}{2}$. A simplifying assumption, generically satisfied, is that there is no voter who is indifferent between a parliament with j members of the left party and a parliament with $j-1$ such members, i.e., $\theta_i \neq \alpha_j$ for all $i \in N$ and $j \in \{1, \dots, k\}$.

2.1 Multidistrict majoritarian election

In the multidistrict majoritarian system, the electorate is divided into k districts, indexed by $d \in \{1, 2, \dots, k\}$. Let n_d be the number of voters in district d, where n_d is assumed to be odd. In each district, voters elect a representative belonging to either the left or the right party by majority rule. District d is won by the party that receives more votes. Hence, the number of seats assigned to the left party by the electoral rule is simply the number of districts won by the left.

As in most voting models with a strategic electorate, here too there are many Nash equilibria (every non pivotal vote, for instance, can be modified without affecting the outcome). For multidistrict majoritarian elections, De Sinopoli et al. (2013) provide a solution concept, *district sincerity*, which is extremely simple and easy to apply. Intuitively, a strategy combination is district sincere if, given the strategies of the players in the other districts, every voter who strictly prefers the left (right) to win in his district votes for the left (right). Formally, let $s = (s^{-d}, s^d)$ be a strategy combination where s^{-d} denotes the $(n - n_d)$-tuple of strategies of the players outside district d and s^d is the n_d-tuple of strategies of the players in d. Furthermore, let L^d (R^d) be the n_d-tuple of pure strategies of the players in district d where everyone votes for the left (right) so that the left (right) wins in that district. A strategy combination s is district sincere if,

[8] With these two assumptions, θ_i fully characterizes preferences: given two policy outcomes x and y in $\mathbb{X}$, $x \succsim_i y$ if and only if x is closer than y to i's bliss point.

for every district d and every player i in d, the following holds:

$$\begin{array}{llll} \text{if} & u_i(s^{-d}, L^d) - u_i(s^{-d}, R^d) > 0 & \text{then} & s_i = L \\ \text{if} & u_i(s^{-d}, L^d) - u_i(s^{-d}, R^d) < 0 & \text{then} & s_i = R. \end{array} \tag{1}$$

District sincerity implies that, given the votes in the other districts, players behave as if their vote was pivotal in their district. Note that every district sincere strategy combination is an equilibrium of the game. Hence, district sincerity is a refinement of Nash equilibrium.

De Sinopoli et al. (2013) show that district sincere equilibria induce a unique "pure" outcome and provide a simple formula to calculate it. To give this formula, we need some extra notation. Let then m_d be the bliss point of the median voter in district $d \in \{1, 2, \ldots, k\}$ and assume without loss of generality that $m_1 \leq m_2 \leq \ldots \leq m_k$. Under majoritarian rule (MR), the number of districts—and thus of seats—won by the left in a district sincere equilibrium is

$$\bar{d}^{\mathrm{MR}} = \begin{cases} 0 & \text{if } m_1 > \alpha_1 \\ \max d \ \text{ s.t. } \ m_d \leq \alpha_d & \text{if } m_1 \leq \alpha_1 \end{cases} \tag{2}$$

In words, ordering the districts according to the bliss points of their median voter, from the smallest to the highest, the number of seats won by the left—and hence the electoral result—is uniquely pinned down by the number of median voters with a bliss point m_d to the left of α_d (i.e., the average of the outcomes when the left wins in d and in $d-1$ districts). De Sinopoli et al. (2013) prove that the unique pure strategy district sincere equilibrium outcome, namely $X(\bar{d}^{\mathrm{MR}})$, is also the unique "pure" outcome induced by perfect equilibria. A research question we address is whether district sincerity is a good predictor of behavior when voters decide by majority rule.

2.2 Single district proportional election

In the proportional system, one, national district is inhabited by voters who elect k representatives from the left and right parties to a national parliament. Votes are aggregated and transformed into seats for the left party according to a general rule prescribing that to obtain d representatives ($d = 1, \ldots, k$), the left party needs at least ν_d votes, with $\nu_{d+1} > \nu_d$. While such a rule is very general and allows for any majority premium and election threshold, for the experiment's sake, we must specify a particular electoral rule dictating the minimum number of votes required to elect d leftist representatives.

We chose to use the Hare quota, that is:

$$\nu_d = \left\lfloor \frac{n}{k}(d-1) + \frac{1}{2}\frac{n}{k} \right\rfloor \qquad \forall d. \tag{3}$$

De Sinopoli et al. (2013) show that there exists a unique pure strategy trembling-hand perfect equilibrium outcome. As in the multidistrict majority case, they provide a simple formula to compute this outcome. Let us define the distribution $F(\theta) = \{\#i \in N \text{ s.t. } \theta_i \leq \theta\}$, which gives the number of voters with a bliss point not higher than θ. Under proportional rule (PR), the number of seats won by the left in a pure strategy trembling-hand perfect equilibrium is

$$\bar{d}^{\text{PR}} = \begin{cases} 0 & \text{if } F(\alpha_1) < \nu_1 \\ \max d \ \text{ s.t. } \ F(\alpha_d) \geq \nu_d & \text{if } F(\alpha_1) \geq \nu_1 \end{cases} \tag{4}$$

Practically speaking, the number of seats allocated to the left, and hence the electoral result, can be computed by (i) counting how many voters prefer a parliament with d leftist representatives to one with $d-1$ leftist representatives, and (ii) checking if this number is not less than the minimum number of votes needed to elect d representatives according to the electoral rule.

Compared to the multidistrict majoritarian election, where the solution concept is easy to apply, in this case there is no fast method to determine whether a Nash equilibrium is trembling-hand perfect or not. Herein, we consider a strategy combination where a player votes for the left or the right party depending on whether $\theta_{\nu_{\bar{d}^{\text{PR}}}}$ is greater or smaller than $\alpha_{\bar{d}^{\text{PR}}+1}$ (assuming, as in our experiment, that $\bar{d}^{\text{PR}} < k$). More specifically:

$$\begin{aligned} &\text{if} \quad \theta_{\nu_{\bar{d}^{\text{PR}}}} > \alpha_{\bar{d}^{\text{PR}}+1} \quad \text{then} \quad s_i = \begin{cases} L & \forall\, i = 1, 2, \ldots, \nu_{\bar{d}^{\text{PR}}} \\ R & \forall\, i = \nu_{\bar{d}^{\text{PR}}} + 1, \ldots, n \end{cases} \\ &\text{if} \quad \theta_{\nu_{\bar{d}^{\text{PR}}}} < \alpha_{\bar{d}^{\text{PR}}+1} \quad \text{then} \quad s_i = \begin{cases} L & \forall\, i = 1, 2, \ldots, \tilde{n} \\ R & \forall\, i = \tilde{n} + 1, \ldots, n \end{cases} \end{aligned} \tag{5}$$

where $\tilde{n}$ is the largest i such that $\theta_i < \alpha_{\bar{d}^{\text{PR}}+1}$. Such a strategy combination is trembling hand perfect (see Proposition 6 in De Sinopoli et al. 2013) and is very simple and salient because it identifies a cut-off point such that every voter to the left of the point votes for the left party and every voter to the right of it votes for the right party.

Our experiment allows us to check whether the considered strategy combination is a good predictor of behavior, and whether participants actually play the unique "pure" outcome induced by perfect equilibria.

2.3 Rule of thumb

As a benchmark to which compare the performance of the previously delineated equilibrium concept, we also investigate the predictive power of a simple rule of thumb that makes use only of information about the voters' own preferences.

Over the past three decades, rational choice theory has been challenged by researchers who emphasize that voters generally lack the structure of thinking which is required by the theory's assumptions. It has been argued, in particular, that voters are boundedly rational and, as such, they apply a number of information shortcuts, or heuristics, to make reasonable decisions with minimal cognitive effort (see, e.g., Gigerenzer et al. 1999; Lau and Redlawsk 2001; or Reinermann 2014). If the parties' policy positions are symmetric with respect to 0.5 (like in our setting), a convenient heuristic is a simple rule of thumb that requires a voter—whatever the electoral system in place—to cast a vote for the left or right party depending on whether his bliss point is, respectively, less or greater than 0.5. That is, the rule of thumb prescribes player i to vote as follows:

$$\begin{array}{llll} \text{if} & \theta_i < 0.5 & \text{then} & s_i = L \\ \text{if} & \theta_i > 0.5 & \text{then} & s_i = R. \end{array} \tag{6}$$

It is worth mentioning that in the considered setting the rule of thumb is also a maximin strategy: if the other players choose their strategies to minimize voter i's payoff, the best reply for i is to vote L if his bliss point is less that 0.5; otherwise, he should vote R. Moreover, the identified rule of thumb is the best response strategy when the other voters cast their vote randomly and, thus, it coincides with level-1 reasoning (Stahl and Wilson 1995). The intuition behind this is that if the policy outcome function is symmetric (as it is the case in our experiment), a voter shifts probability mass from less to more preferred outcomes by voting for the party with a policy position closest to his own preferred policy.

3 The laboratory experiment

3.1 Parameters and predictions for the experimental setup

In the experiment, we consider electorates of twelve voters who must elect a parliament of four members, i.e., $n = 12$ and $k = 4$. The two competing parties, left and right, have policy positions $\theta_L = 0$ and $\theta_R = 1$, respectively. To investigate the predictive power of the equilibrium outcomes resulting from (2) and (4) and of the equilibrium strategy combinations (1) and (5), the experimental design consists of two treatments: one using a multidistrict majority rule (hereafter, treatment MR) and another using a single district proportional rule (hereafter, treatment PR).

In treatment MR, the twelve voters are equally divided into four districts of size three, namely $n_d = 3$. Each district elects one member of parliament by majority rule, implying that the left party must obtain at least two votes in a district in order to win in that district and get one seat in the parliament.

In treatment PR, all twelve voters belong to a single district. Given our experimental parameters, electoral rule (3) prescribes that, for each d, at least $3d-1.5$ votes are needed to elect d leftist representatives. Hence, the minimum numbers of votes needed to obtain 1, 2, 3, and 4 seats in the parliament are, respectively, $\nu_1 = 2, \nu_2 = 5, \nu_3 = 8$, and $\nu_4 = 11$.

In both treatments, the policy outcomes (giving the implemented policy as a function of the number of seats the left party has in the parliament) are

$$X(0) = 1,\ X(1) = 0.75,\ X(2) = 0.5,\ X(3) = 0.25,\ X(4) = 0.$$

Thus, the implemented policy is 1 if no member of the left party is elected and decreases proportionally as the number of seats obtained by the left increases, coherently with the model described in Section 2. The resulting values of α_d (identifying the midpoint between the outcome when the left obtains d seats and the outcome when the left obtains $d-1$ seats) are $\alpha_1 = \frac{1+0.75}{2} = 0.875$, $\alpha_2 = \frac{0.75+0.5}{2} = 0.625$, $\alpha_3 = \frac{0.5+0.25}{2} = 0.375$, and $\alpha_4 = \frac{0.25+0}{2} = 0.125$.

For each treatment, we run nine different election tasks, varying the voters' preferred policies, namely their bliss points θ_i $(i = 1, 2, \ldots, 12)$. Table 1 reports the experimentally induced preferences, along with the parliament composition predicted by the equilibrium concept and the rule of thumb, separately for each treatment and each election task. In panel (a), referring to treatment MR, voters are grouped into districts. Just for the reader's convenience, the four districts in MR are ordered according to the bliss points of their median voters, from the left most to the right most; that is, for each of the nine

Table 1: Voters' induced preferences, θ_i ($i = 1, \ldots, 12$), and number of seats the left party is predicted to win in equilibrium—$\bar{d}^{\mathrm{MR}}$ and $\bar{d}^{\mathrm{PR}}$—and according to the rule of thumb—d^{MR}_{RoT} and d^{PR}_{RoT}—in each task of the majoritarian and the proportional treatment

(a) Treatment MR

	District 1			District 2			District 3			District 4				
Task	θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7	θ_8	θ_9	θ_{10}	θ_{11}	θ_{12}	$\bar{d}^{\mathrm{MR}}$	d^{MR}_{RoT}
1	0.287	0.487	0.512	0.188	0.688	0.738	0.537	0.713	0.762	0.237	0.938	0.963	1	1
2	0.212	0.463	0.762	0.438	0.738	0.812	0.062	0.787	0.988	0.688	0.938	0.963	1	1
3	0.012	0.188	0.287	0.062	0.237	0.562	0.263	0.312	0.487	0.438	0.812	0.963	3	3
4	0.037	0.188	0.212	0.012	0.263	0.537	0.237	0.287	0.512	0.362	0.738	0.812	3	3
5	0.037	0.188	0.237	0.012	0.287	0.438	0.263	0.487	0.762	0.463	0.562	0.713	2	3*
6	0.212	0.237	0.537	0.512	0.688	0.738	0.562	0.762	0.938	0.487	0.787	0.963	1	1
7	0.012	0.237	0.688	0.188	0.263	0.312	0.062	0.287	0.963	0.463	0.512	0.787	3	3
8	0.012	0.212	0.562	0.062	0.263	0.287	0.188	0.438	0.988	0.237	0.688	0.738	2	3*
9	0.188	0.212	0.713	0.037	0.312	0.963	0.463	0.512	0.537	0.263	0.688	0.938	2	2

(b) Treatment PR

Task	θ_1	θ_2	θ_3	θ_4	θ_5	θ_6	θ_7	θ_8	θ_9	θ_{10}	θ_{11}	θ_{12}	$\bar{d}^{\mathrm{PR}}$	d^{PR}_{RoT}
1	0.188	0.237	0.287	0.487	0.512	0.537	0.688	0.713	0.738	0.762	0.938	0.963	2	1*
2	0.062	0.212	0.438	0.463	0.688	0.738	0.762	0.787	0.812	0.938	0.963	0.988	1	1
3	0.012	0.062	0.188	0.237	0.263	0.287	0.312	0.438	0.487	0.562	0.812	0.963	2	3*
4	0.012	0.037	0.188	0.212	0.237	0.263	0.287	0.362	0.512	0.537	0.738	0.812	3	3
5	0.012	0.037	0.188	0.237	0.263	0.287	0.438	0.463	0.487	0.562	0.713	0.762	2	3*
6	0.212	0.237	0.312	0.562	0.713	0.738	0.762	0.787	0.812	0.938	0.963	0.988	1	1
7	0.012	0.037	0.438	0.487	0.688	0.713	0.762	0.787	0.812	0.938	0.963	0.988	1	1
8	0.012	0.037	0.188	0.212	0.237	0.263	0.287	0.312	0.562	0.812	0.938	0.988	3	3
9	0.012	0.037	0.062	0.188	0.212	0.237	0.263	0.312	0.438	0.562	0.738	0.787	3	3

Notes: A star in the columns labeled d^{MR}_{RoT} and d^{PR}_{RoT} indicates that the prediction of the rule of thumb for that particular task differs from the equilibrium prediction.

tasks, $m_1 = \theta_2 < m_2 = \theta_5 < m_3 = \theta_8 < m_4 = \theta_{11}$. Similarly, the voters' bliss points in treatment PR (see panel (b) in Table 1) are ordered in an increasing way so that, for each task, $\theta_1 < \theta_2 < \ldots < \theta_{12}$.

The bliss points of the voters are the same in tasks 1 to 5 of the MR and the PR treatment. Yet, because of the voters' distributions across districts, in tasks 1 and 3 the unique equilibrium outcome depends on the electoral rule and—in line with a general presumption of the political science literature (e.g., Norris 1997; Blais and Massicotte 2002) as well as with experimental evidence (e.g., Kartal 2015)—is more moderate under treatment PR than under treatment MR: as the second to last column of Table 1 reveals, $\bar{d}^{\mathrm{PR}}$ equals 2 in both task 1 and task 3 while $\bar{d}^{\mathrm{MR}}$ equals 1 in task 1 and 3 in task 3.

The bliss points were chosen with two primary objectives in mind. First, we wanted a unique district sincere equilibrium in treatment MR.[9] Second, we wanted some variance in the predicted equilibrium outcomes so as to properly test the robustness of the model's predictions. Indeed—as the $\bar{d}^{\mathrm{MR}}$ and $\bar{d}^{\mathrm{PR}}$ values in the second to last column of Table 1 show—under both treatments, the left party is predicted to win 1 seat in three of the nine tasks, 2 seats in three further tasks, and 3 seats in the remaining three tasks.

The bliss points used in treatment MR and treatment PR are shown graphically as dots above the policy space in Figure 1 and Figure 2, respectively. In both figures, the type of the dots indicates what each voter should vote in equilibrium, where a blank dot means that the subject should vote for the left while a filled dot indicates that he should vote for the right. The rule of thumb, on the other hand, prescribes voting for party with the closest policy position.

To see how to use formula (2) in order to compute the parliament composition compatible with district sincerity in MR, take task 1. In this task, $\bar{d}^{\mathrm{MR}} = 1$ because the bliss point of the median voter in district 1 is less than α_1 (i.e., $m_1 = 0.487 < \alpha_1 = 0.875$), whereas the bliss point of the median voter in district 2 exceeds α_2 (in fact, $m_2 = 0.688 > \alpha_2 = 0.625$). Similarly, in task 3, $\bar{d}^{\mathrm{MR}} = 3$ because the median voter's bliss points in districts 1, 2, and 3 are to the left of the corresponding α_d (i.e., $m_1 = 0.188 < \alpha_1 = 0.875$, $m_2 = 0.237 < \alpha_2 = 0.625$, and $m_3 = 0.312 < \alpha_3 = 0.375$), while the median voter's bliss point in district 4 is to the right of α_4 (specifically, $m_4 = 0.812 > \alpha_4 = 0.125$). The value of $\bar{d}^{\mathrm{MR}}$ in the other tasks can be computed in a similar manner.

Turning to treatment PR, we can easily apply formula (4) in order to compute $\bar{d}^{\mathrm{PR}}$ in each of the nine different tasks. Consider, for instance, task 1 and observe that $F(\alpha_1) = 10 > \nu_1 = 2$, $F(\alpha_2) = 6 > \nu_2 = 5$, and $F(\alpha_3) = 3 < \nu_3 = 8$, meaning that

[9] Recall that, under majoritarian rule, different district sincere and perfect equilibria may support the unique equilibrium outcome.

Figure 1: Voters' induced preferences and equilibrium strategies in treatment MR (blank dots stand for 'left' and filled dots for 'right')

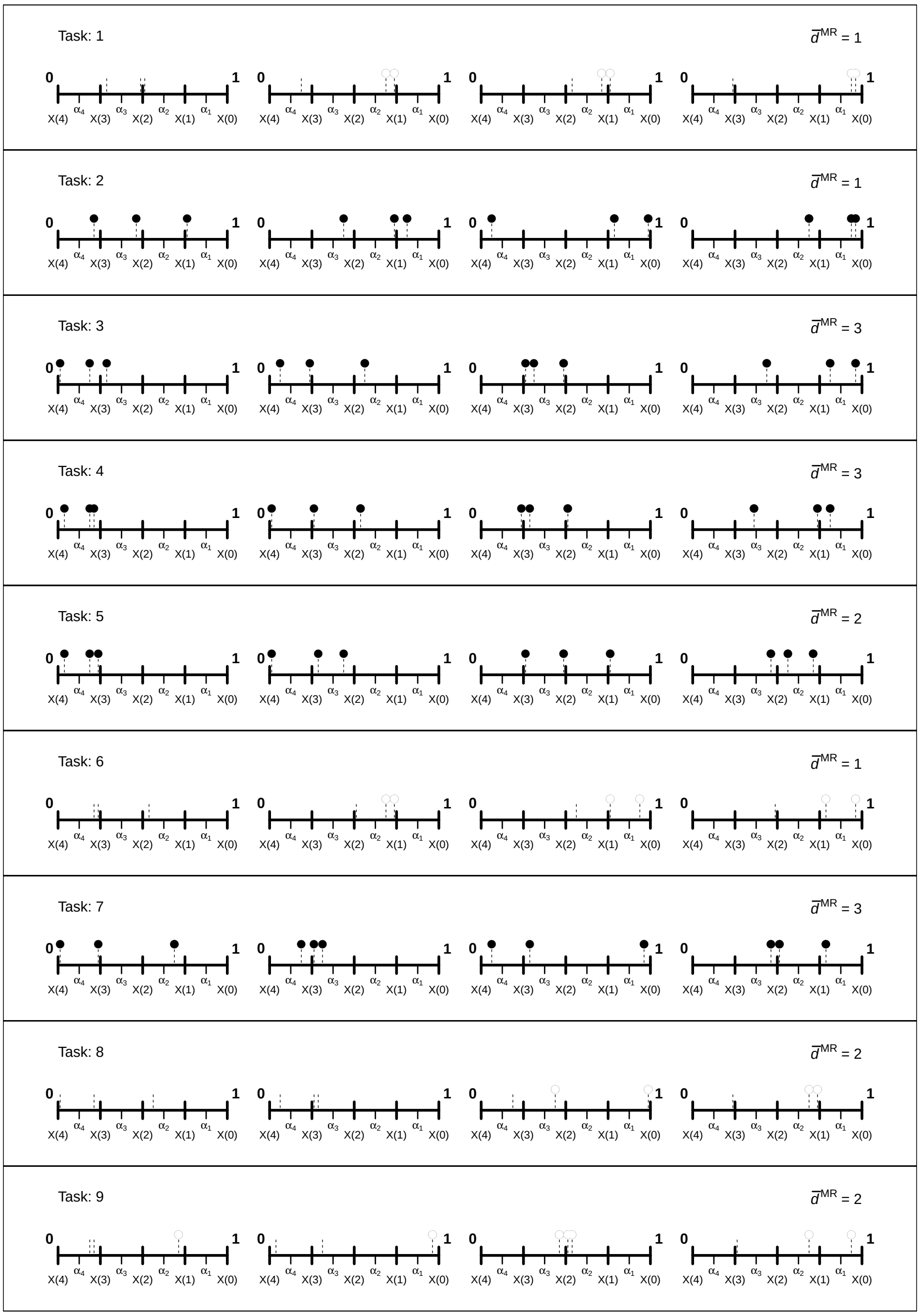
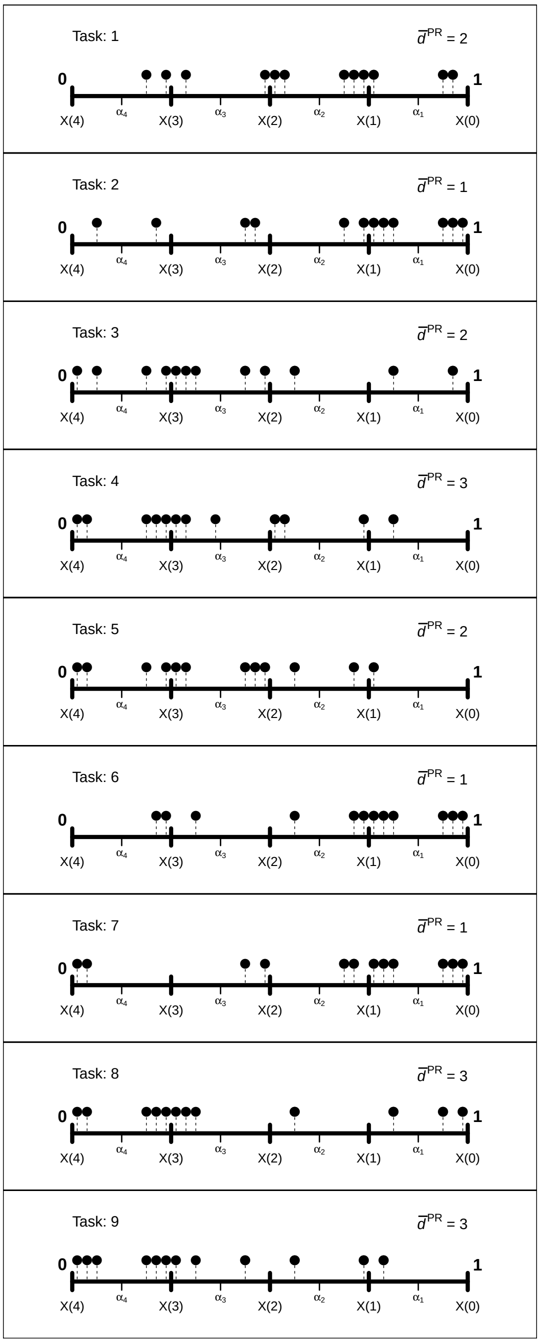


Figure 2: Voters' induced preferences and equilibrium strategies in treatment PR (blank dots stand for 'left' and filled dots for 'right')



while there are enough voters preferring a parliament with two—rather than one—leftist representatives, the number of voters preferring a parliament with three—rather than two—leftist representatives is less than the number of votes needed to elect three such representatives. Hence, in task 1, $\bar{d}^{\mathrm{PR}} = 2$. In task 2, on the other hand, we have $F(\alpha_1) = 8 > \nu_1 = 2$, but $F(\alpha_2) = 4 < \nu_2 = 5$; thus, in task 2, only one member of party L should be elected in equilibrium.

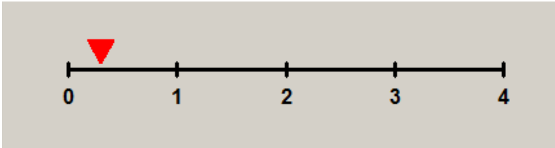
3.2 Experimental protocol

The experiment was programmed in z-Tree (Fischbacher 2007) and conducted in the experimental laboratory of the University of Milano Bicocca (Italy). The participants were undergraduate students from the same university. They were recruited using the ORSEE software (Greiner 2004) and had no previous experience with the game in question. Upon entering the laboratory, the subjects were randomly assigned to visually isolated computer terminals. The instructions (which are reproduced, translated from Italian, in the supplement) were distributed and then read aloud to establish public knowledge. Subjects were required to answer three sets of control questions correctly before the experiment began.

A total of 216 students participated in 6 sessions, with 36 subjects (and thus 3 12-person electorates) per session. Three sessions were devoted to treatment MR and three to treatment PR. In each session, participants went through 9 rounds in which they played the 9 election tasks described in Section 3.1. The sequence of the tasks was randomized across sessions to minimize order effects. Only one round was randomly selected for payment at the end of each session. Paying out only one round mimics a one-shot game and allows minimizing portfolio effects (see, e.g., Cox et al. 2015).

In the experimental instructions, we used a neutral language in order to limit possible uncontrolled effects due to reference to votes and political parties. At the beginning of each session, participants were informed that they were members of a community of 12 people, which had to determine the color—yellow or blue—of 4 disks. The decision to vote for the left corresponded to choosing yellow, whereas the decision to vote for the right corresponded to choosing blue. Abstention was not allowed. All decisions were simultaneous and anonymous (i.e., participants never learned which person made any particular decision). Participants in treatment MR knew that the community was divided into four groups of size three and that each group determined the color of one disk by majority rule. Participants in treatment PR were explained the relationship between the color indicated by the 12 community members and the color of the 4 disks

Figure 3: Experimental representation of the game



via the following table:

<table>
<tr><td rowspan="2">No. of members selecting</td><td>blue</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td></tr>
<tr><td>yellow</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">No. of disks</td><td>blue</td><td colspan="2">0</td><td colspan="3">1</td><td colspan="3">2</td><td colspan="3">3</td><td colspan="2">4</td></tr>
<tr><td>yellow</td><td colspan="2">4</td><td colspan="3">3</td><td colspan="3">2</td><td colspan="3">1</td><td colspan="2">0</td></tr>
</table>

To facilitate comprehension of the payoff implications of different choices, Figure 3 was used to describe how payoffs were computed. In the figure, the segment represents the policy space and the vertical dashes indicate the number of blue (rather than yellow) disks chosen by the community. Basically, to make the game easier to understand, we presented the policy space in the reverse direction and explained payoffs in terms of number of seats obtained by the right party. The red triangle above the segment shows the subject's position, namely his bliss point. Participants knew that the closer their own position to the number of blue disks chosen by their community, the higher was their payoff. In particular, participants were told that they would be paid €20, €16, €12, €8, or €4 depending on whether—compared to their own position—the number of blue disks chosen by the community was, respectively, the first closest, the second closest, the third closest, the fourth closest, or the furthest. In line with De Sinopoli et al.'s (2013) complete information model, each participant was also informed about the preferences of the other 11 members of his community by means of black triangles on the segment.[10] In treatment MR, different segments were used for different groups (see the figure in the Instructions supplement).

We employed a stranger design, i.e. after each round new communities of twelve were

[10] Although it could be argued that the assumption of complete information is unrealistic, voters are often given the opportunity to learn about the preferences of other voters via, e.g., publishing exit poll results before elections. In a voting model where two parties have fixed positions on a one-dimensional policy space and the implemented policy is the convex combination of the two positions, Mavridis (2015) has shown that a sequence of polls is able to turn all undecided citizens to voters and, under these circumstances, the election outcome is the same as in the case of complete information.

randomly determined. The sequence of events in each round was as follows. First, the participants were randomly matched into communities of twelve (which, in treatment MR, were further divided into four groups of three) and informed about their own bliss point and the bliss points of the other 11 members of their community. To induce participants to think carefully about the task at hand, they had to wait one minute before making their choice between yellow and blue. Then, once everyone had decided on a color, each participant was told the total number of blue disks chosen by his community and his own resulting payoff. Participants in treatment MR were also informed about how many people in their 3-person group had chosen blue and how many had chosen yellow. After having provided this information, the software moved to the next round, subjects were randomly re-matched, and the process started over again.

Upon completion of the ninth round, participants were administered a post-experimental questionnaire asking them to indicate (i) their gender, (ii) their age, (iii) whether or not they had attended a microeconomics and/or game theory class, and (iv) the number of experiments they had taken part in. The percentage of female participants was 38% in treatment MR and 42.6% in treatment PR. The mean age of our sample was 22.42 years (s.d. 3.06) in MR and 21.94 years (s.d. 1.82) in PR. The percentage of participants who took a course in microeconomics and/or game theory was 85.2% in MR and 75% in PR. Treatments are also balanced with respect to past participation in other experiments: the MR sample reported to have participated, on average, in 2.70 experiments (s.d. 1.60), the PR sample in 2.81 experiments (s.d. 1.76).

At the end of each session, a randomly selected participant determined the round that was paid out by drawing one of nine cards numbered 1–9 from an opaque bag. Experimental sessions lasted about 75 minutes. Average earnings per subject were €17.54 (inclusive of a €3.00 show-up fee).

4 Results

The results are presented in two subsections. First, we present results on electoral outcomes and check whether the observed parliament compositions in the nine election tasks of the MR and PR treatments are in line with the predicted values of, respectively, $\bar{d}^{\mathrm{MR}}$ and $\bar{d}^{\mathrm{PR}}$ (reported in Table 1). Then we turn to discuss the results on individual votes and examine whether individual votes comply with the equilibrium strategies shown in Figures 1 and 2 for treatments MR and PR, respectively.

Table 2: Percentages of experimental outcomes in line with the equilibrium prediction by election task and averaged over all tasks

	Treatment MR		Treatment PR	
Task	$\bar{d}^{\mathrm{MR}}$	% correct	$\bar{d}^{\mathrm{PR}}$	% correct
1	1	55.6	2	88.9
2	1	33.3	1	88.9
3	3	33.3	2	77.8
4	3	66.7	3	77.8
5	2	55.6	2	66.7
6	1	33.3	1	55.6
7	3	66.7	1	33.3
8	2	55.6	3	77.8
9	2	66.7	3	77.8
All	—	51.8	—	71.6

4.1 Electoral outcomes

Table 2 displays the percentages of electoral outcomes correctly predicted by the theoretical model per election task and over all tasks, separately for treatment MR and treatment PR. Looking at the overall prediction accuracy, we note that the model succeeds in correctly predicting the electoral outcome most of the time, even though the level of accuracy is higher in PR than in MR (71.6% vs 51.8%). As a matter of fact, the percentage of correct predictions is above 50% in all but one task under PR, while it is below 50% in three out of the nine tasks, and never exceeds 66.7%, under MR.

The superiority of PR over MR as way to induce the equilibrium outcome is especially evident in the five election tasks that are directly comparable because the voters' (induced) preferences are the same across treatments, i.e., tasks 1 to 5. To assess whether in these five election tasks the performance of the model differs significantly depending on the treatment, we run a mixed effect logit regression where the dependent variable is a dummy taking value 1 when the observed number of seats allocated to the left is as predicted by the model. Denoting by t the treatment, with $t \in \{\mathrm{MR}, \mathrm{PR}\}$, the only explanatory variable is a dummy that equals 1 if $t = \mathrm{PR}$. The regression model accounts for two random effects to control for intraclass correlation, one at the task level and the other at the session level. The estimation results, reported in panel (a) of Table 3, indicate that the coefficient of the treatment dummy is positive and significant, thus supporting the observation that electoral outcomes are better explained by the equilibrium concept in PR than in MR.

Panel (b) and panel (c) in Table 3 present the results of two additional mixed effect

Table 3: Random effect logit regressions; dependent variable: $\mathrm{d}(d^t = \bar{d}^t)$, where d^t ($\bar{d}^t$) denotes the observed (predicted) number of seats to the left in treatment $t \in \{\mathrm{MR}, \mathrm{PR}\}$

	(a) MR & PR (tasks 1–5)		(b) MR (all tasks)		(c) PR (all tasks)	
	Coef.	(s.e.)	Coef.	(s.e.)	Coef.	(s.e.)
(Intercept)	−0.044	0.300	0.399	0.516	1.253	0.463**
d(t =PR)	1.431	0.482**				
d($\bar{d}^t = 1$)			−0.806	0.569	−0.878	0.606
d($\bar{d}^t = 3$)			−0.163	0.565	−0.000	0.655
σ_{Task}	0.000		0.000		0.000	
$\sigma_{\mathrm{Session}}$	0.056		0.561		0.000	
log Lik	−53.70		−53.79		−46.85	
N	5×6×3		9×3×3		9×3×3	

Significance codes: *** 0.001 ** 0.01 * 0.05 ° 0.10

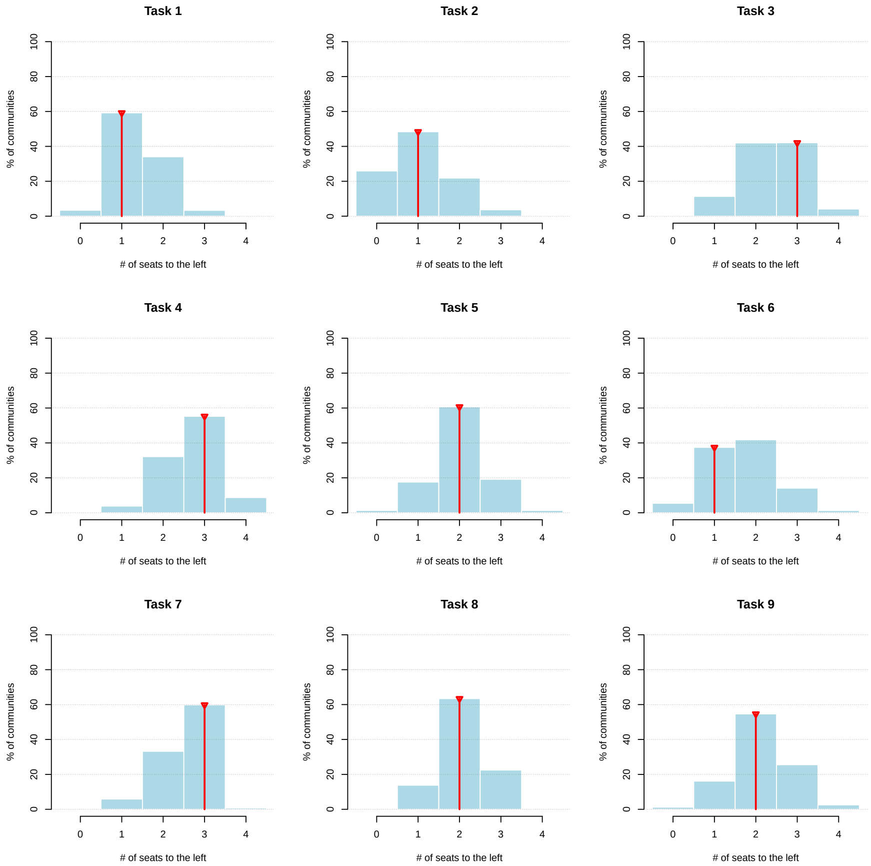
logit regressions that examine whether the prediction accuracy of the model varies with the $\bar{d}^{\mathrm{MR}}$ and $\bar{d}^{\mathrm{PR}}$ values in, respectively, treatment MR and treatment PR. In each regression—which includes, once again, random effects at task and session level—the dependent variable is the same as that in panel (a). Explanatory variables are dummies capturing the possible values of $\bar{d}^t$ with t = MR (PR) for the regression referring to treatment MR (PR). Since the dummy coefficients are not significant in both regressions, this suggests that, whatever the electoral rule in place, the probability of occurrence of the equilibrium outcome is unaffected by different values of $\bar{d}^{\mathrm{MR}}$ and $\bar{d}^{\mathrm{PR}}$. Additionally, the significant intercept coefficient for the PR regression indicates that, in proportional—but not majoritarian—elections, the probability of correctly predicting the outcome is significantly higher than 0.5.

To further validate the predictive power of the theoretical model in terms of electoral outcomes, we performed a simulation exercise which takes into account the fact that, in the experiment, the observed numbers of seats obtained by the left, and thus the observed electoral outcomes, crucially depend on how the computer randomly matches participants into 12-person electorates (given a participant's choice, a different matching can result in a different parliament composition).

We estimate, for each election task, a distribution of numbers of seats for the left party by randomly sampling 500,000 electorates from the set of all possible combinations of 12-person electorates.[11] The resulting distributions by task are presented in Figures 4

[11] Each one of the 12 bliss points in any election task was assigned to 9 different participants (recall that we ran 3 sessions per treatment and each session had 3 electorates). The very high number of

Figure 4: Distributions of simulated numbers of seats for the left party by task in treatment MR

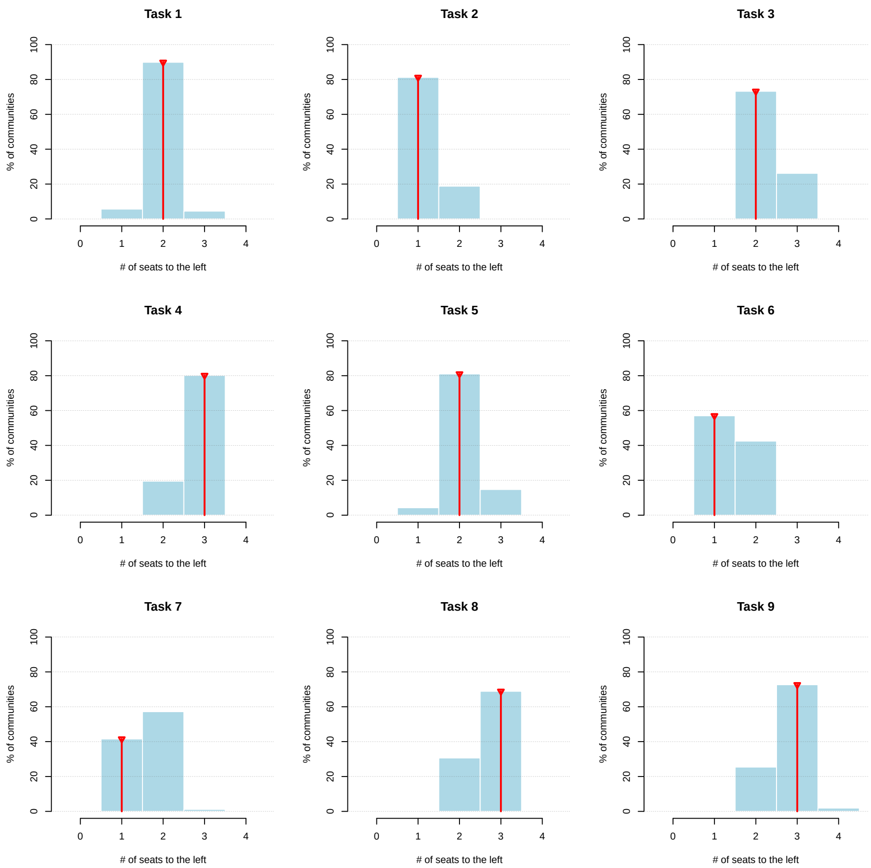


and 5 for, respectively, the MR and PR treatments. In both figures, the vertical line in each histogram indicates the numbers of seats that the left is predicted to win in equilibrium. With two exceptions (one per treatment), we have that the mode of the distributions is always at the predicted value, confirming that in both treatments the good performance of the model is independent of the specific $\bar{d}^{\mathrm{MR}}$ and $\bar{d}^{\mathrm{PR}}$ values—and thus of the parameterization of preferences—that we used.

Finally, we compare the performance of the strategic voting model with that of the simple rule of thumb defined in Section 2.3. For the tasks where equilibrium and rule of thumb predict differently, i.e., tasks 5 and 8 in MR and tasks 1, 3, and 5 in PR (see Table 1), the percentage of correct predictions of the rule of thumb is always 22.2%,

electorates that can therefore be formed per election task (namely 9^{12}) renders the calculation of the left party seat distribution for all possible combinations infeasible.

Figure 5: Distributions of simulated numbers of seats for the left party by task in treatment PR



except for task 1 in PR where no outcome is consistent with the rule of thumb prediction. The equilibrium concept clearly outperforms the rule of thumb in predicting the outcome of the elections.

Having established that the model predicts observed electoral outcomes quite well, it is important to ascertain whether participants' individual votes are in line with the equilibrium strategies indicated in Figures 1 and 2, as different strategies may support the unique equilibrium outcome. We therefore turn, in the next section, to a detailed analysis of individual behavior.

4.2 Individual voting behavior

Table 4 and Figure 6 summarize the results on individual votes. Table 4 shows, for each single election task and over all tasks, the percentages of times participants cast

Table 4: Percentages of individual choices in line with the equilibrium prediction by task and averaged over all tasks

Task	Treatment MR	Treatment PR
1	88.0	81.5
2	75.0	97.2
3	80.6	88.0
4	82.4	90.7
5	80.6	86.1
6	78.7	88.0
7	86.1	86.1
8	78.7	87.0
9	83.3	85.2
All	81.5	87.8

votes that are consistent with the equilibrium strategy, separately for treatment MR and treatment PR.[12] Figure 6 displays the distribution of the number of equilibrium votes by treatment; for each participant, the number goes from 0 (if the participant never casts a vote consistent with equilibrium) to 9 (if the participant votes as predicted by the model consistently, i.e., in all 9 tasks).

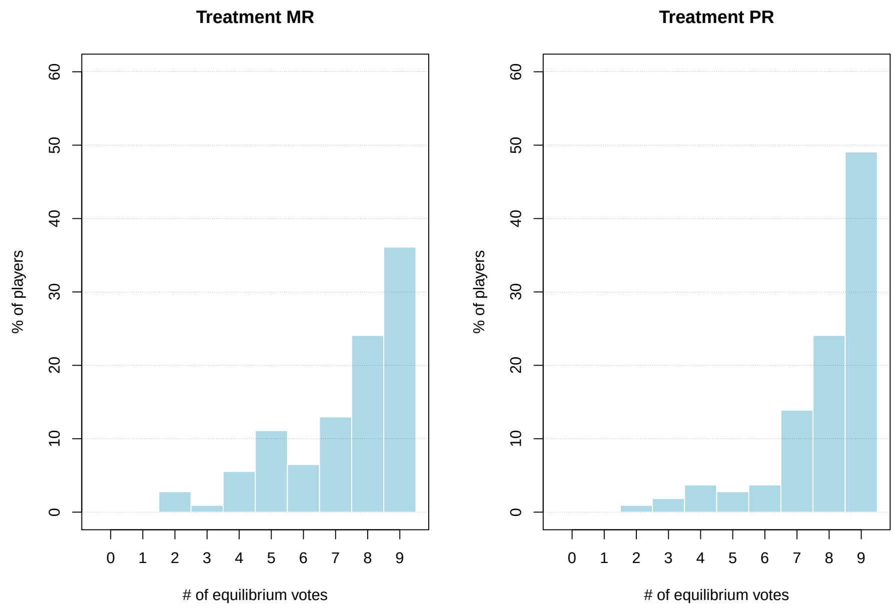
Looking at Table 4, two things are noteworthy. First, out of all 972 individual observations per treatment, 792 (81.5%) are in line with district sincerity in MR and 853 (87.8%) with trembling hand perfection in PR. Second, in all but two tasks the percentages of correctly predicted choices are higher in PR than in MR. Inspection of Figure 6 clearly shows that the percentage of participants playing consistently the equilibrium strategy is higher in PR than in MR (49.1% vs 36.1%). These observations indicate that—in line with the results on electoral outcomes—the equilibrium concept predicts better in the PR than in the MR treatment.

To test whether this difference is statistically significant, we perform a linear regression with random effects at the session level and the number of equilibrium votes per individual, calculated over comparable tasks (i.e., tasks 1–5), as dependent variable. Besides the intercept, we only add a treatment dummy that is equal to 1 for the PR treatment. The estimated values for the intercept and the treatment dummy are 4.065 (s.e. $= 0.097$; p-value < 0.001) and 0.370 (s.e. $= 0.137$; p-value < 0.01), respectively. Thus, the null hypothesis of no difference in individual numbers of equilibrium votes between treatments can be rejected.[13]

[12] In both treatments, the total number of observations per task is 108 (12 voters $\times$ 3 electorates $\times$ 3 sessions).

[13] Using all nine tasks, rather than only comparable tasks, gives the following estimates for the intercept

Figure 6: Distribution of numbers of equilibrium votes by treatment

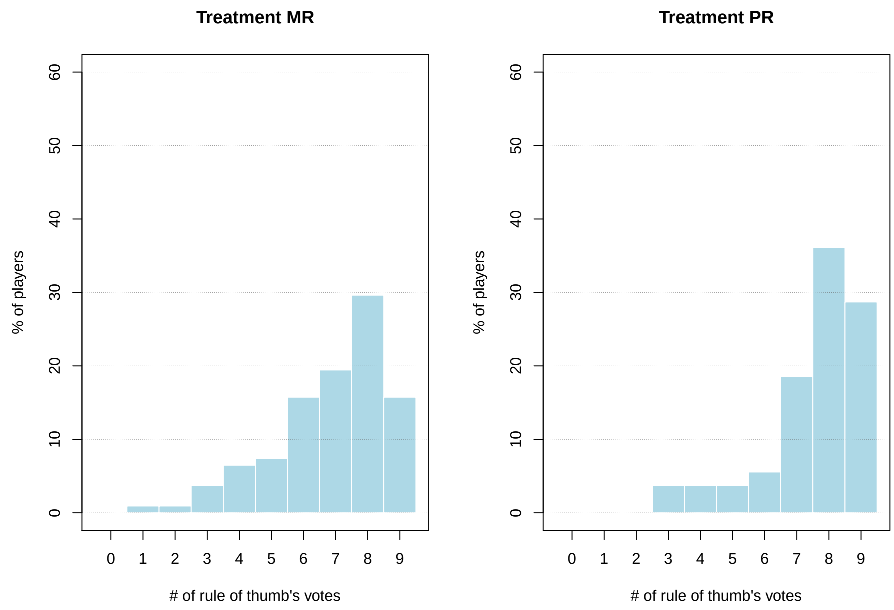


We now turn to analyze how well the equilibrium concept performs relative to the rule of thumb as regards individual votes. Figure 7 shows the distribution of the number of votes that are in line with the rule of thumb, separately for each treatment. Comparing Figure 7 with Figure 6, we can see that, whatever the electoral system, the percentages of participants who follow the rule of thumb 9 times out of 9 (15.7% in MR and 28.7% in PR) are lower than the percentages of participants who play their equilibrium strategy 9 times out of 9 (36.1% in MR and 49.1% in PR). Consistent with the analysis of electoral outcomes, individual voting behavior appears to be more accurately predicted by the equilibrium concept than by the rule of thumb.

Support for this observation stems from an analysis of the cases in which equilibrium play and rule of thumb yield different predictions, which are—over all 9 tasks and 9 electorates—135 in treatment MR and 72 in treatment PR. Looking only at these cases, the percentages of times votes agree with equilibrium behavior, rather than with rule of thumb behavior, are 68.9% in MR and 76.4% in PR. To determine whether these proportions differ from 0.5, we run, for each treatment, a logit model with random effects at subject, task, and session level. In both models, the dependent variable is a dummy indicating whether the choice agrees with the equilibrium predictions and the

and the treatment dummy: 7.333 (s.e. $= 0.172$; p-value < 0.001) and 0.565 (s.e. $= 0.243$; p-value< 0.10).

Figure 7: Distribution of numbers of rule of thumb votes by treatment



only explanatory variable is the intercept. The estimated intercepts are 0.850 (s.e. = 0.344; p-value < 0.050) and 1.604 (s.e. = 0.649; p-value < 0.050) for, respectively, MR and PR. As both estimates are significantly different from zero, we conclude that, in both electoral systems, the equilibrium predictions outperform those obtained by applying the rule of thumb.

Let us then examine the determinants of the choice to cast an equilibrium vote. Table 5 reports the results of two random effect logit models—one model for each treatment—having as dependent variable a dummy equal to 1 if the vote casted is an equilibrium vote. Also in this case we consider random effects at subject, task, and session level. Explanatory variables are the distance of the participants' bliss points from 0.5, a gender dummy taking value 1 for males, a dummy that equals 1 for those who took a course in microeconomics and/or game theory, the age (demeaned) of the participants, and the number of experiments they participated in.

In both regressions, the coefficient of "$|\theta_i - 0.5|$" is positive and significant, meaning that the farther the bliss point from 0.5, the higher the likelihood to cast an equilibrium vote. This is perhaps not surprising, because voters with more extreme preferences may find it easier to work out their optimal strategy. The likelihood to cast an equilibrium vote is also found to increase with experimental experience. This effect is significant at

Table 5: Random effect logit regressions; dependent variable: d(vote = eq. vote)

	MR (all tasks)		PR (all tasks)	
	Coef.	(s.e.)	Coef.	(s.e.)
(Intercept)	0.543	(0.517)	0.295	(0.505)
$\lvert\theta_i - 0.5\rvert$	2.992	(0.694)***	3.772	(0.858)***
d(male)	0.480	(0.326)	0.368	(0.368)
d(micro/game th)	−0.076	(0.447)	0.790	(0.405)°
age (demeaned)	−0.117	(0.048)*	0.025	(0.102)
# previous exp	0.186	(0.100)°	0.234	(0.110)*
σ_{Subject}	1.216		1.308	
σ_{Task}	0.230		0.312	
σ_{Session}	0.000		0.000	
log Lik	−414.44		−313.67	
N	36×9×3		36×9×3	

Significance codes: *** 0.001 ** 0.01 * 0.05 ° 0.10

the 5% level in PR and at the 10% level in MR. As for the other explanatory variables, we do not find a consistent pattern across treatments. The coefficient of the dummy "d(micro/game th)" is positive and marginally significant for PR, but is insignificant for MR. Conversely, the coefficient of "age" is negative and significant for MR, but is insignificant for PR. As a final consideration, we note that the magnitude of the random effect parameter σ_{Subject}—capturing the between-subject variance—suggests that the likelihood of casting an equilibrium vote varies considerably from subject to subject.

5 Concluding remarks

We study a voting environment in which the electorate is composed of policy motivated citizens who are faced with the task of determining the number of seats that two political parties obtain in the parliament. Each party is characterized by a policy position over a one-dimensional policy space. Voters have single-peaked preferences over this space and cast their vote for one of the two parties under either a multidistrict majoritarian system or a single district proportional system. The policy outcome is a function of the number of seats won by each party. Under both systems, voting strategically yields a unique perfect equilibrium outcome in pure strategies, which in majoritarian elections is the unique pure strategy district sincere outcome (De Sinopoli et al. 2013).

Our goal has been to establish via experimental elections whether, in the above setting, electoral outcomes are as predicted and players vote in accordance with Nash equilibrium refinements. Laboratory control has also allowed us to shed light on whether the observed voting behavior hinges on the implemented electoral system. These are empirical questions that warrant answers because rational choice has been challenged by findings that voters lack the capacity required for figuring out their equilibrium strategies (e.g., Reinermann 2014). Additionally, a number of experimental studies have found that the more complex the voting environment, the lower the likelihood that people vote strategically (see, e.g., Van der Straeten et al. 2010; Bassi 2015). However, this previous work has focused on winner-take-all elections and voting over fixed agendas.

The key findings of our experiment can be summarized as follows. We show that both actual and simulated electoral outcomes are in line with the predicted equilibrium outcomes. This result is robust to different parameterizations of preferences. Although, in theory, a number of strategies may support the unique equilibrium outcome, we have identified a specific pure strategy combination that is compatible with district sincerity in the majoritarian treatment and with trembling hand perfection in the proportional treatment. The experimental data reveal that a majority of individuals (overall, 81.5% in treatment MR and 87.8% in treatment PR) cast votes that are in line with the considered equilibrium strategies. The results on electoral outcomes as well as those on individual voting behavior clearly indicate that the equilibrium concept outperforms a simple rule of thumb requiring participants to vote for the party with policy position closest to their own ideal point.

Although the strategic voting model performs quite well in explaining experimental outcomes under both electoral systems, equilibrium outcomes and individual votes are more frequent in the proportional system than in the majoritarian one. It appears that the voters' ability to think strategically and to play equilibrium strategies declines significantly when the electorate is divided into several districts and each voter has to consider the strategies of players in districts other than his own. Insofar as majoritarian elections are seen as more complex than proportional ones, our results confirm previous evidence of a negative relationship between capacity of thinking strategically and complexity of the electoral rule.

A downside of using laboratory experiments is that we were forced to analyze small size electorates. Yet, experimental elections—as compared to real world elections—permit controlling for preferences and information available to the voters and, consequently, allow for a clean test of the theoretical predictions.

Future research is needed to extend the present research and to verify the robustness of its results. It may be interesting, for instance, to consider settings with incomplete information where voters have an opportunity to communicate their preferences to the others, e.g. via opinion polls. Such an extension would have the merit of bringing the setting closer to real world elections. Another possible future extension would be to make voting voluntary. This could help shed light on the interaction between turnout and equilibrium play in settings (like the one we have studied here) in which voters must elect a parliament.

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S1 Experimental instructions (originally in Italian)

Welcome! You are about to participate in an experiment on group decision making. Please remain silent and switch off your mobile. If you have any questions during the experiment, please raise your hand. One of the experimenters will come to you and answer your question privately.

You will receive €3.00 for participating in this experiment and, beyond this, you can earn more money. Your earnings will depend partly on your decisions and partly on the decisions of other participants. Read these instructions carefully to understand how your and the others' decisions affect your earnings.

Group formation and decisions to make

The experiment consists of 9 rounds. In each round, you will be placed in a community of 12 people that have to choose the color of 4 disks. The disks can be either blue or yellow.

[*Participants in treatment MR read:* The 12 members of the community will be divided into 4 groups of 3 and each group will decide on the color of one of the 4 disks. To determine the color of the disk chosen by the group, each member must select a color: either blue or yellow. The color selected by the majority of the group members will determine the color of the disk chosen by that group.]

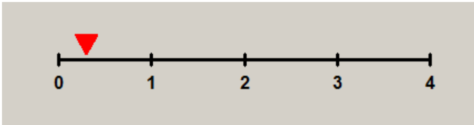
[*Participants in treatment PR read:* To determine the color of the disks chosen by the community, each member must select a color: either blue or yellow. The color selected by the 12 community members will determine the number of blue and yellow disks chosen by the community according to the following table:

<table>
<tr><td rowspan="2">No. of members selecting</td><td>blue</td><td>0</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td></tr>
<tr><td>yellow</td><td>12</td><td>11</td><td>10</td><td>9</td><td>8</td><td>7</td><td>6</td><td>5</td><td>4</td><td>3</td><td>2</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">No. of disks</td><td>blue</td><td colspan="2">0</td><td colspan="3">1</td><td colspan="3">2</td><td colspan="3">3</td><td colspan="2">4</td></tr>
<tr><td>yellow</td><td colspan="2">4</td><td colspan="3">3</td><td colspan="3">2</td><td colspan="3">1</td><td colspan="2">0</td></tr>
</table>

The table shows the number of blue and yellow disks chosen by the community given the number of times its members select the colors. For example, if 3 members select blue and 9 yellow, the community chooses 1 blue disk and 3 yellow disks. If 7 members select blue and 5 yellow, the community chooses 2 blue disks and 2 yellow disks.]

Your earnings

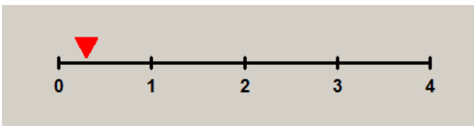
[*Participants in treatment MR read:* The amount of money you will earn depends on the number of blue (and yellow) disks chosen by the 4 groups in your community. Hence, your earnings will differ depending on whether 0, 1, 2, 3, or 4 blue disks are chosen. The following figure will be used to compute your earnings:



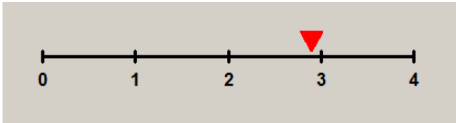
The figure shows a segment with vertical dashes numbered 0–4. The dashes indicate the number of blue disks chosen by the 4 groups in your community. For example, the number 3 means that three groups in your community choose the blue disk and one group chooses the yellow disk. Similarly, the number 1 means that one group in your community chooses the blue disk and three groups choose the yellow disk.

The red triangle above the segment shows your position. Your earnings are determined by the distance between your position and the number of blue disks chosen by the 4 groups in your community. The closer your position to the number of blue disks chosen by the 4 groups, the higher will be your earnings. In particular, you will earn €20 if the number of blue disks chosen by the groups is the closest to your position, €16 if it is the second closest, €12 if it is the third closest, €8 if it is the forth closest, or €4 if it is the furthest. The following examples should help you better understand the calculation of your earnings.

EXAMPLE 1: In the situation represented in the following figure, you earn €20 if the groups choose 0 blue disks, €16 if the groups choose 1 blue disk, €12 if the groups choose 2 blue disks, €8 if the groups choose 3 blue disks, and €4 if the groups choose 4 blue disks.



EXAMPLE 2: In the situation represented in the following figure, you earn €20 if the groups choose 3 blue disks, €16 if the groups choose 2 blue disks, €12 if the groups choose 4 blue disks, €8 if the groups choose 1 blue disk, and €4 if the groups choose 0 blue disks.

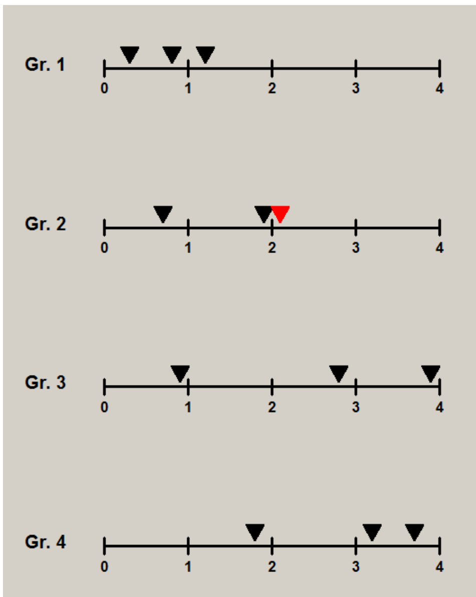


The earnings of the other members of your community will depend as well on the distance between their position and the number of blue disks chosen by the 4 groups in your community.]

[*Participants in treatment PR read the same information but with reference to "community" rather than "groups."*]

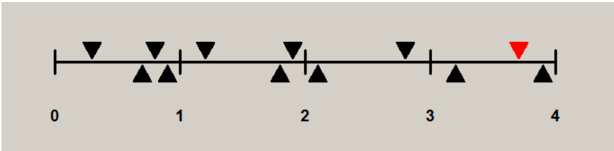
How you are informed about your position and the position of the others

[*Participants in treatment MR read:* At the beginning of each round, you will be informed—by means of the graphical representation previously shown—about your own position and that of the other 2 members of your group as well as about the position of each member of the other 3 groups. Specifically, the different groups will be represented by different segments and the positions of the 3 members of a same group will be indicated on the same segment. Your position will be indicated by a red triangle while the others' positions by black triangles. In the following example, you belong to group 2 and the positions of the members of the different groups are indicated on the respective segments:



]

[*Participants in treatment PR read:* At the beginning of each round, you will be informed—by means of the graphical representation previously shown—about your own position and that of the other 11 members of your community. The positions of the 12 community members will be indicated on the same segment. Your position will be indicated by a red triangle while the others' positions by black triangles, like in the following example:



]

Sequence of events in each round

The sequence of events in each one of the 9 rounds will be as follows.

- At the beginning of each round, the computer software will randomly select the 12 members of a community [*Participants in treatment MR read:* and determine the division of the 12 members into 4 groups of 3 persons].
- Then, the computer software will inform each member about his own position and the position of the other members of his community [*Participants in treatment MR read:* separated by group].
- After receiving this information, each member will select a color (blue or yellow). Each member will have to wait one minute before being able to make his choice of color.
- At the end of the round, each member will be informed about [*Participants in treatment MR read:* the color of the disk chosen by each group in his community,] the total number of blue disks chosen by his community, and his own earnings in that round.

Notice that the 12 members of a community, [*Participants in treatment MR read:* the composition of the 4 groups within it,] and each member's position can change from one round to the next. That is, the other 11 members of your community and their (as well as your) positions can differ from round to round.

Final payoff

At the end of the experiment, one of the 9 rounds will be randomly selected for payment. This random selection will be done by a (randomly chosen) participant who will have to draw a card from an urn containing 9 cards numbered 1 to 9. The outcome of the draw will apply to all participants. Your earnings in the randomly selected round will be paid to you in cash and privately together with the €3 show-up fee.

The instructions are over. If you have any questions, please raise your hand. We will now ask you to answer some control questions to ensure that you understand the instructions completely. Please click "OK" (on your computer screen) when you have finished reading the instructions.